Name	Class	Index Number

ANG MO KIO SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
SECONDARY FOUR EXPRESS

CHEMISTRY **6092/02**

Paper 2

Total Mark: 80

31 August 2022 / Wednesday

1 hours 45 minutes

Setter: Ms Audrey Ferng

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST
Write your Name, Class and Index Number in the spaces at the top of this paper.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A (Page 1 to Page 12)
Answer **all** the questions in Section A in the spaces provided.

Section B (Page 13 to Page 24)
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

At the end of the examination, hand in Section A and Section B separately.

For Examiner's use	
Section A	
Section B	
TOTAL	

This document consists of **24** printed pages, including the cover page.

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 **(a)** Name the following chemical processes.

	reaction	name of chemical process
(i)	$Cr^{3+} \rightarrow Cr^{6+} + 3e$	
(ii)	$H_2SO_4 + CaCl_2 \rightarrow CaSO_4 + 2HCl$	
(iii)	$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$	
(iv)	$C_3H_6 + H_2O \rightarrow C_3H_7OH$	
(v)	$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$	

[5]

(b) Explain the following statements.

(i) It is hazardous to burn charcoal in an enclosed room.

....

....

.... [2]

(ii) It is not suitable to prepare sodium chloride salt by reacting an acid with excess solid sodium carbonate followed by filtering to collect the filtrate.

....

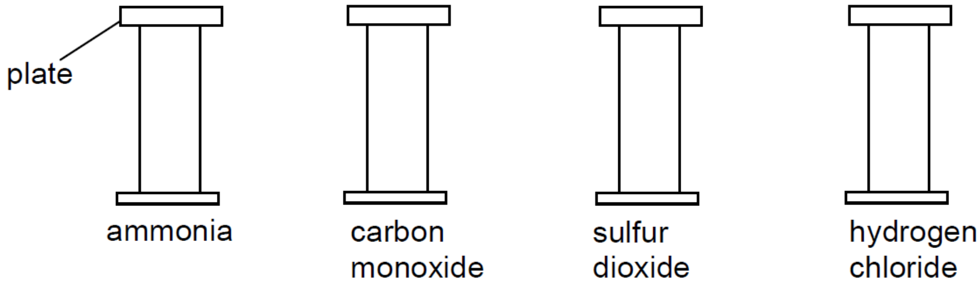
....

....

.... [2]

[Total: 9]

A2 Four identical jars are filled with the same volume of ammonia, carbon monoxide, sulfur dioxide and hydrogen chloride, measured at room temperature and pressure, as shown below.



(a) Describe and explain what would happen when a few drops of Universal Indicator are added into to the jars filled with ammonia, carbon monoxide and sulfur dioxide gas.

ammonia: …………………………………………………………………….…………….

………………………………………………………………………………………………

carbon monoxide: ………………………………………………………………………..

………………………………………………………………………………………………

sulfur dioxide: …………………………………………………………………...………

……………………………………………………………………………………………… [3]

(b) If the plates are removed from the four gas jars, state and explain which gas jar would contain the least air in it after several hours.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

[Total: 5]

A3 Lead has a metallic structure. It has a proton number 82.

There are four relatively stable isotopes of lead and their relative abundance are given in the table:

isotope	relative abundance/%
^{204}Pb	1.4
^{206}Pb	24.1
^{207}Pb	22.1
^{208}Pb	52.4

(a) Use the Periodic Table to state the number of occupied electron shells in an atom of lead.

………………………………………………………………………………………… [1]

(b) **(i)** Define the term isotopes.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(ii) Calculate the relative atomic mass of lead. Give your answer to 1 decimal place.

[1]

(c) **(i)** With the aid of a labelled diagram, describe the bonding in lead.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(ii) Explain what happens when an electric current passes through lead.

……………………………………………………………………………………….

……………………………………………………………………………………….

………………………………………………………………………………………. [1]

(d) Lead(II) ethanoate is a white crystalline soluble salt.
Name a suitable combination of an acid and an insoluble base which is used to prepare lead(II) ethanoate.

acid: ……………………………………………………………………………………...

base: ……………………………………………………………………………………. [1]

(e) In an experiment, 5 cm^3 of aqueous lead(II) ethanoate was added to 5 cm^3 of aqueous ammonia.

(i) Describe your observation in the reaction.

……………………………………………………………………………………….

………………………………………………………………………………………. [1]

(ii) Write an ionic equation for the reaction in **(e).**

………………………………………………………………………………………. [1]

[Total: 9]

A4 In industry, ammonia can be produced by the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The table shows the yield of ammonia produced at different temperatures by this process.

temperature/°C	percentage yield of ammonia/%
100	97
200	87
400	46
500	28
600	17
700	0

(a) Describe the relationship between temperature and percentage yield of ammonia.

....

.... [1]

(b) Nitrogen and hydrogen are mixed in definite volume percentage of 25% and 75% respectively before they enter the reactor.
Explain why the two gases are mixed in this proportion.

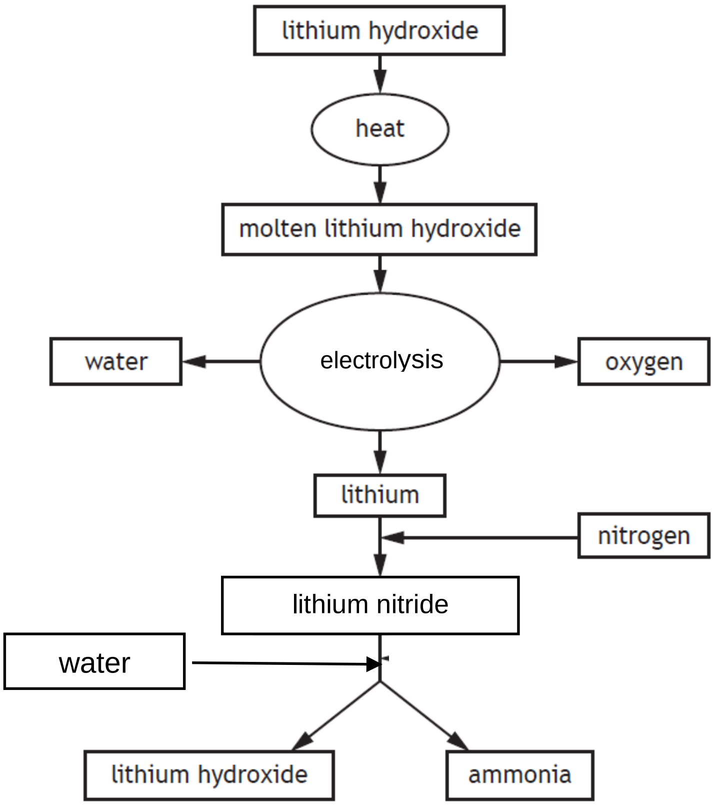
....

....

.... [2]

(c) Scientists are developing an alternative industrial process to produce ammonia, which is more efficient than the Haber process. This involves the electrolysis of molten lithium hydroxide to produce lithium, water and oxygen. Lithium is then reacted with nitrogen gas, which is obtained from air, to produce lithium nitride. Ammonia and lithium hydroxide are produced when lithium nitride reacts with water.

The flow diagram for the process is as follow:



(i) On the flow diagram, draw an arrow to show how the process can be made more economical. [1]

(ii) Write a balanced chemical equation for the reaction between lithium nitride and water.

.... [1]

[Total: 5]

7

A5 Zinc reacts with aqueous iodine to form zinc iodide.
Fig. 5.1 shows an apparatus that was used to measure the rate of the reaction between zinc and aqueous iodine at 25 °C.

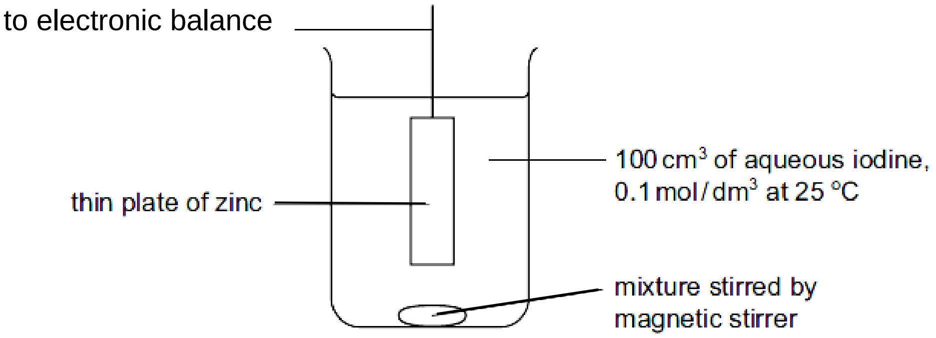


Fig.5.1

The mass of the zinc plate was measured every minute with an electronic balance until the reaction was complete.

(a) **(i)** Describe what test can be done to confirm the presence of iodide ions in the zinc iodide solution formed.

....

.... [2]

(ii) Write a balanced chemical equation, with state symbols, for the reaction in **(a)(i).**

.... [2]

(b) From the results of this experiment, two graphs were plotted as shown in **Fig. 5.2.**

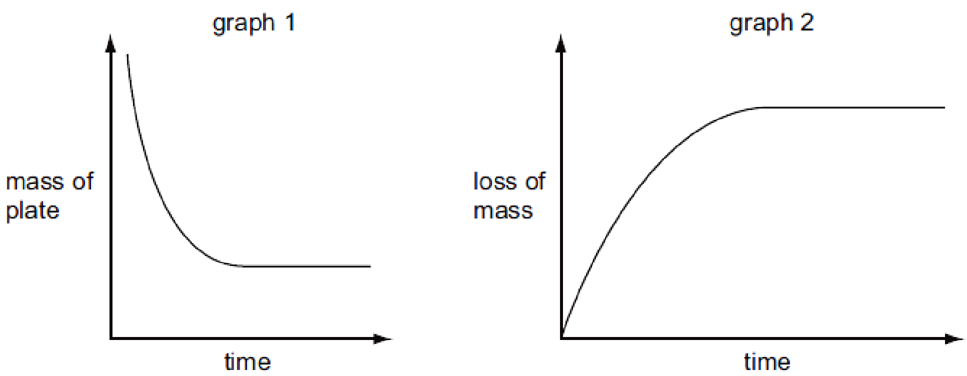


Fig.5.2

(b) **(i)** Which reagent, iodine or zinc, was in excess? Give a reason for your choice with reference to the graphs above.

………………………………………………………………………………………….

…………………………………………………………………………………………. [1]

(ii) Explain why the mass of the zinc plate decreased.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(c) The experiment was repeated with 100 cm^3 of 0.05 mol/dm^3 iodine, keeping all other conditions the same.
Sketch the curve that would be obtained on graph 1 and label it '**X**'. [1]

(d) In another experiment, the aqueous iodine was replaced with 100 cm^3 of 0.1 mol/dm^3 aqueous chlorine. Sketch the curve that would be obtained on graph 2 and label it '**Y**'. [1]

(e) Describe and explain your observation when aqueous chlorine is added to zinc iodide solution.

……………………………………………………………………………………………

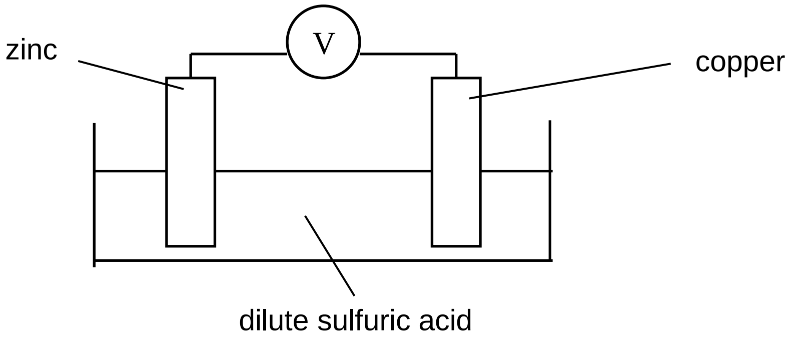
……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Total: 10]

A6 The following electrochemical cell was set up between a zinc and copper electrode.



(a) In the diagram above, draw an arrow on the wires to show the direction of electron flow through the voltmeter. [1]

(b) Construct an ionic equation for the reaction at the positive electrode.

…………………………………………………………………………………………… [1]

(c) The zinc electrode is now replaced by iron.

(i) What change in voltmeter reading would be obtained. Explain your answer.

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

………………………………………………………………………………………. [2]

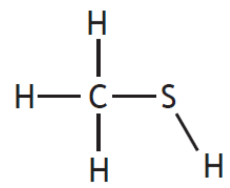
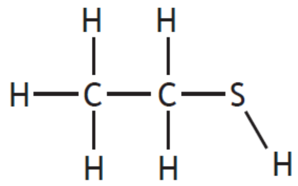
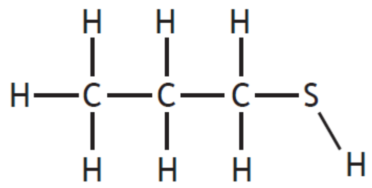
(ii) State one other observation that will be different from zinc-copper cell.

Observation: ……………………………………………………………………….

………………………………………………………………………………………. [1]

[Total: 5]

A7 The thiols are a family of compounds containing carbon, hydrogen and sulfur. They are generally colourless but have strong odours. They are less soluble in water than alcohols of similar relative molecular mass.

Name	*Full structural formula*
methanethiol	
ethanethiol	
propanethiol	

(a) Thiols have the same general formula and similar chemical properties.

(i) Suggest a general formula for this family.

.... [1]

(ii) Give the name of the member after propanethiol of this homologous series.

.... [1]

(b) Draw the full structural formula for an isomer of propanethiol which belongs to the same homologous series.

[1]

(c) Ethanethiol can react with oxygen as shown.

ethanethiol + oxygen → carbon dioxide + water + **Y**

(i) Suggest an identity of **Y**.

.... [1]

(ii) Write a balanced chemical equation for the reaction in **(c)**.

.... [1]

(d) Methanethiol, which smells like rotting cabbage, is added to natural gas to allow gas leaks to be detected.
It is prepared industrially by the reaction of methanol with hydrogen sulfide gas.

$$CH_3OH + H_2S \rightarrow CH_3SH + H_2O$$

Calculate the mass of methanethiol, in grams, produced when 650 g of methanol reacts with 680 g of hydrogen sulfide.

[2]

[Total: 7]

End - of - Section A

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SECTION B

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Write in dark blue or black pen.
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Section B (Page 13 to Page 24)
Answer all **three** questions. The last question is in the form either/or.
Write an **E** (for EITHER) or an **O** (for OR) next to the number **B10** in the grid below to indicate which part you have answered.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
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For Examiner's use		
B8		
B9		
B10		
TOTAL		

This booklet consists of **Pages 13 – 24**, including the cover page.
[Turn over

Section B

Answer all **three** questions from this section.

The last question is in the form **either/or** and only **one** of the alternatives should be attempted.

The total mark for this section is 30.

B8 Ozone, O_3 is a much less stable triatomic form of oxygen, O_2.
Fig. 8.1 below shows the bonding in ozone molecules.

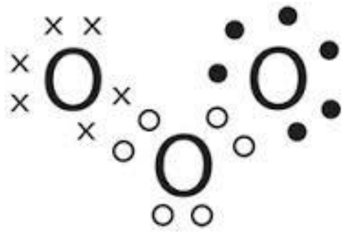


Fig. 8.1

It is a pale blue gas present at low concentrations throughout the atmosphere (around 0.375 parts per million for O_3 compared to 21% for O_2).
In the troposphere, ozone is an air pollutant which can damage the respiratory systems of humans and other animals. The ozone in the stratosphere however is beneficial.

Fig. 8.2 shows how the concentration of ozone varies in the troposphere and stratosphere.

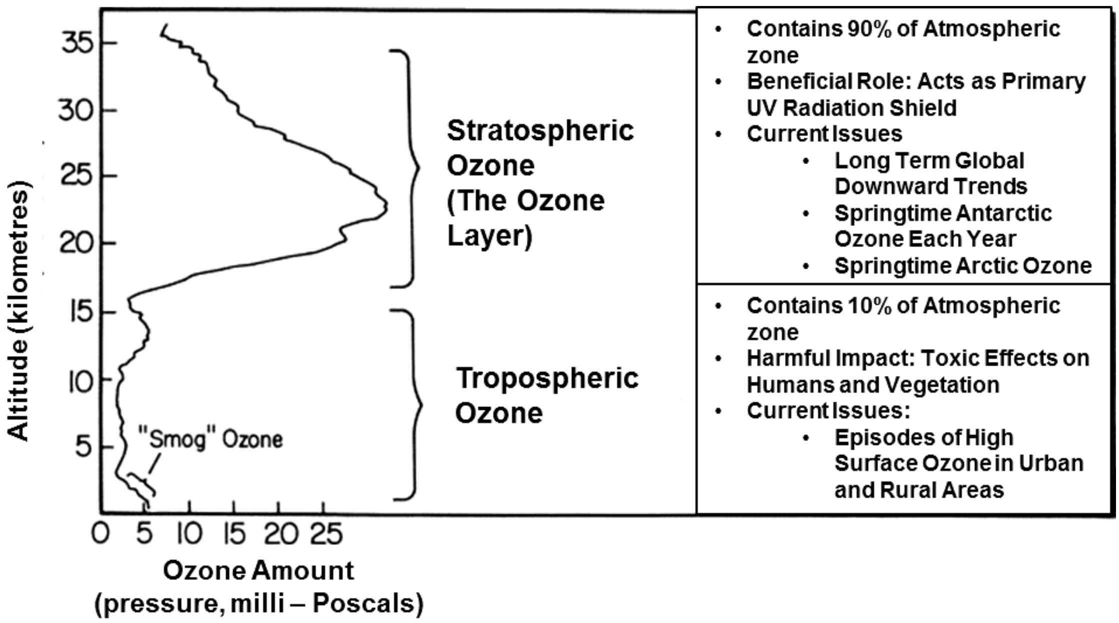


Fig. 8.2

Ozone is formed as part of a natural cycle which is similar to the nitrogen and carbon cycle.

The first step in the formation of ozone is the decomposition of an oxygen molecule into two atoms by low energy ultraviolet (UV) light (reaction **1**). The higher the altitude, the faster is this reaction.

Each of these oxygen atoms can combine with another oxygen molecule to form an ozone molecule (reaction **2**). The rate of reaction **2** is faster where the pressure is higher.

The ozone molecule formed absorbs UV radiation and splits to form an oxygen atom and oxygen molecule which produces a lot of heat (reaction **3**). For every mole of ozone that splits up, 90kJ of energy is given off. Reaction **2** and **3** rapidly interconverts oxygen atoms and ozone.

There is another slow reaction, though, which is known to destroy both oxygen atoms and ozone (reaction **4**).

Reactions **1** to **4** are summarised in **Fig. 8.3** below.

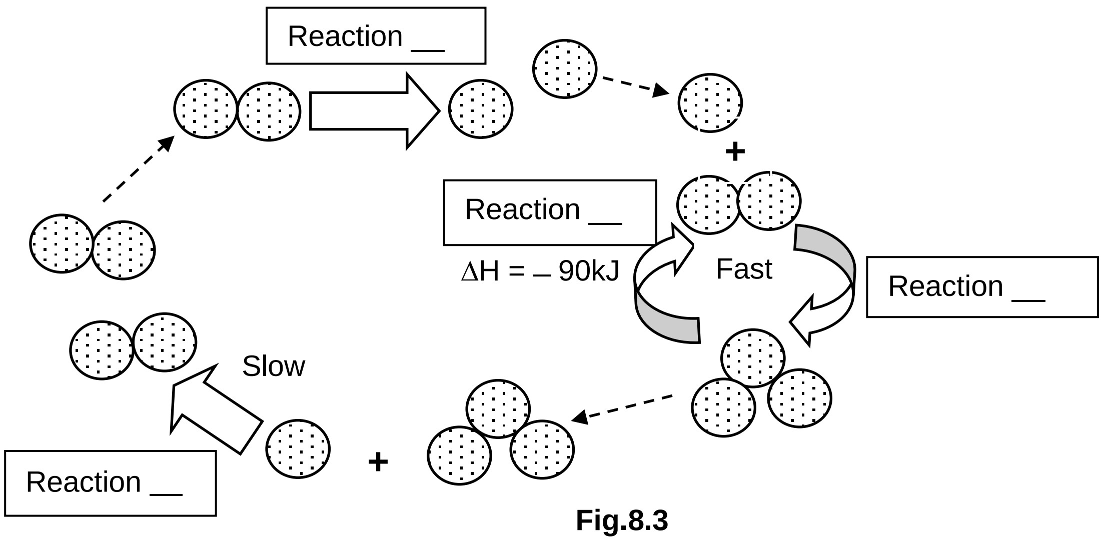
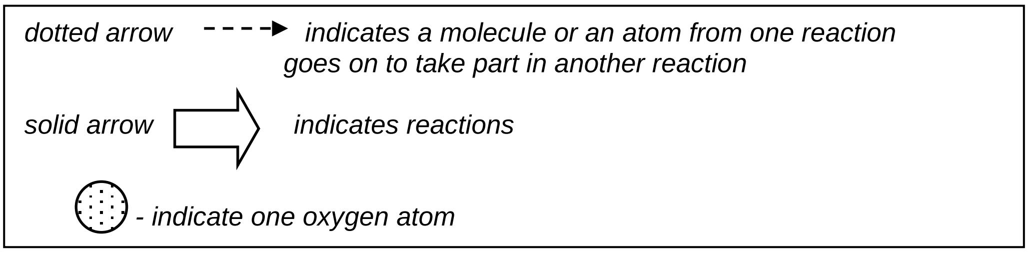


Fig.8.3



Chlorofluorocarbons, CFCs, destroy ozone in the upper atmosphere. Once the CFC vapour reaches the upper atmosphere the following reactions occur in order.

Reaction **5**: CFC + UV light $\rightarrow$ CFC fragment + Cl

Reaction **6**: Cl + O_3 $\rightarrow$ ClO + O_2

Reaction **7**: ClO + O $\rightarrow$ Cl + O_2

One example of CFC is the compound CFC 113. CFC 113 is an inert, synthetic compound used in the electronics industry. **Fig. 8.4** shows the structure of CFC 113 below.

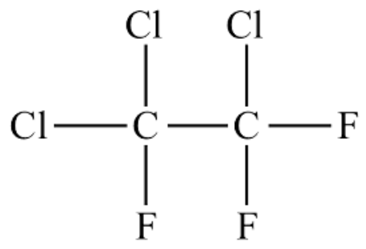


Fig. 8.4

Some data about the bond strength in these molecules are given below.

bond	bond strength/ kJ per mole
C – Cl	330
C – C	346
C – F	450
C – H	412

(a) Calculate the percentage of ozone in the atmosphere.

[1]

(b) At which altitude is the rate of ozone formation maximum?

.... [1]

(c) With the help of information provided, suggest why the stratosphere is a warmer layer than the top of troposphere.

....

....

.... [1]

(d) The formation of ozone in the upper atmosphere can be represented by a single equation shown below.

$$3O_2\,(g) \rightarrow 2O_3\,(g)$$

(i) What is the value for enthalpy change for the reaction shown?

……………………………………………………………………………………….. [1]

(ii) Hence, using the information provided, draw the energy profile diagram for this reaction. Include appropriate data in your diagram.

[2]

(e) Using the data provided, number clearly the reactions 1, 2, 3 and 4 involving ozone and oxygen in **Fig. 8.3**. [1]

(f) Which two reactions, **5, 6** or **7**, when taken together are equivalent to reaction **4** which destroys the ozone?

…………………………………………………………………………………………… [1]

(g) The energy of the UV light is equivalent to 400kJ per mole.

(i) Suggest why CFC 113 is decomposed by UV light to form chlorine atoms rather than fluorine atoms.

………………………………………………………………………………………….

…………………………………………………………………………………………. [1]

(ii) Suggest a further bond change you would expect to occur in CFC 113 molecule.

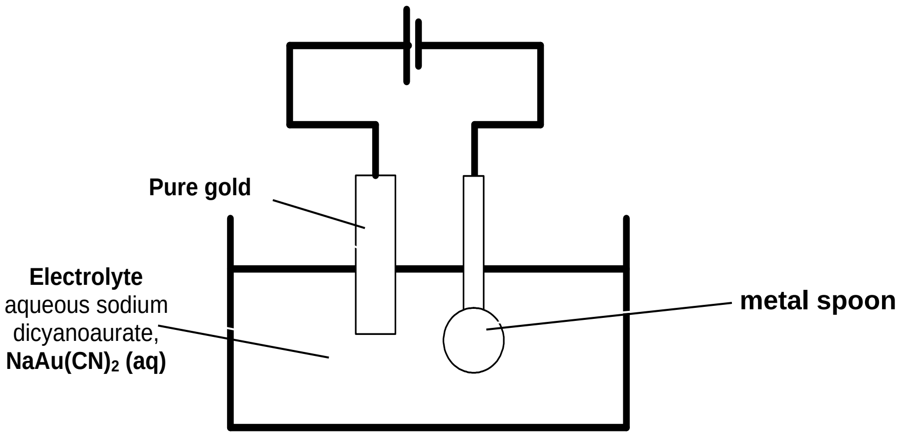
………………………………………………………………………………………….

…………………………………………………………………………………………. [1]

[Total: 10]

B9 Electroplating is a process of using electrical current to deposit a thin layer of metal onto an electrically conductive object. Gold plating is one such example.

In the gold plating of a spoon, aqueous sodium dicyanoaurate, **$NaAu(CN)_2$**, is used as the electrolyte. The spoon is placed at the cathode and a piece of gold is used as the anode.



(a) The cyanide ion has the formula CN^-. Given that sodium dicyanoaurate ionises in water to form sodium ions, gold ions and cyanide ions, CN^-, give the oxidation state of the elements in the electrolyte.

element	oxidation state in $NaAu(CN)_2$
carbon	
gold	
nitrogen	-3
sodium	

[2]

(b) State the formulae of all the ions which are attracted to the cathode.

.... [1]

(c) Gold is discharged at the cathode.

(i) Write the half equation for this reaction at the cathode

.... [1]

(ii) Explain why gold ions are discharged in preference over any other ions at the cathode.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(d) Does the concentration of the electrolyte change throughout the plating process? Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(e) If the experiment was repeated by replacing the gold electrode with graphite electrode, with all other factors remain constant. State and explain what would happen at the cathode initially, and after a long period of time.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Total: 10]

EITHER

B10 The first ionisation energy of elements is defined as the energy required for one mole of gaseous atoms to lose one mole of electrons, forming one mole of gaseous ions with a charge of +1.

The first ionisation energy for hydrogen and lithium is shown below.

$H\ (g) \rightarrow H^{+}\ (g) + e^{-}$ ionisation energy = 1310 kJ/mol

$Li\ (g) \rightarrow Li^{+}\ (g) + e^{-}$ ionisation energy = 520 kJ/mol

The first ionisation energies of some elements are given in the following table.

element	proton number	first ionisation energy (kJ/mol)
lithium	3	520
beryllium	4	900
sodium	11	496
magnesium	12	738
potassium	19	419
calcium	20	590
argon	18	1521

(a) Suggest why the first ionisation energy of alkali metals decreases down the group.

....

....

....

.... [2]

(b) Explain why argon has the highest first ionisation energy as compared to the other elements.

....

.... [1]

(c) It was found that 212.5 g of gaseous rubidium atoms required 1007.5 kJ of energy to ionise into rubidium ions.

Calculate the first ionisation energy of rubidium.

[2]

(d) Using the data provided, compare the reactivity of calcium, beryllium and magnesium. Arranged them from the least reactive to the most reactive.

………………………………………………………………………………………………… [1]

(e) Lithium can react with sulfur to form lithium sulfide.

Draw a 'dot and cross' diagram to show the arrangement of electrons in lithium sulfide.

[2]

(f) Both magnesium and calcium formed oxides when react with oxygen. Explain why magnesium oxide has a higher melting point than calcium oxide.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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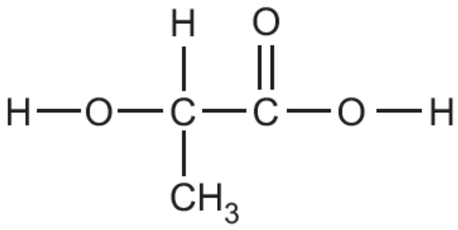
…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Total: 10]

OR

B10 **(a)** Lactic acid has a pH of 3.5. It can be used to make poly(lactic acid), a biodegradable polymer. The structure of lactic acid is shown.



(a) **(i)** Suggest what is meant by the term *biodegradable*.

………………………………………………………………………………………….

………………………………………………………………………………………… [1]

(ii) Draw the partial structure of poly(lactic acid).
Show at least two repeat units.

[2]

(iii) A factory uses 500 tonnes of lactic acid to make poly(lactic acid). The percentage yield is 100% but the mass of poly(lactic acid) made is less than 500 tonnes.
Explain why the mass of poly(lactic acid) made is less than 500 tonnes.

…………………………………………………………………………………………

…………………………………………………………………………………………. [1]

(iv) Calculate the mass of poly(lactic acid) produced from 500 tonnes of lactic acid.

[2]

(b) Lactic acid reacts with ethanol to form an ester.

(i) State the conditions needed to form an ester.

…………………………………………………………………………………………. [1]

(ii) Draw the full structure of the ester produced by the reaction of lactic acid with ethanol.

[1]

(c) When equal mass of potassium carbonate is added to same concentration and volume of lactic acid and hydrochloric acid, the rate of reaction differs. State which reaction is faster and explain in terms of collisions between reacting particles why.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[Total:10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			proton (atomic) number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is $24\,dm^3$ at room temperature and pressure (r.t.p.).

Name: ………………………………………… Index No: ……… Class: ……..…

Bukit Batok Secondary School

PRELIMINARY EXAMINATIONS 2022

SECONDARY 4 EXPRESS

CHEMISTRY **6092/02**

Paper 2

24 August 2022

0820-1005h

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class in the spaces provided at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions in the spaces provided.
The last question is in the form either/or.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 27.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	/ 50
B10	/ 10
B11	/ 10
B12	/ 10
Total	/ 80

This document consists of **27** printed pages.

Section A

Answer **all** questions in the spaces provided.
The total mark for this section is 50.

A1 10 cm^3 of 1 mol/dm^3 sulfuric acid is added to five different test tubes containing substances **A** to **E**. The results are recorded in Table 1.1 below.

substance	gas produced	colour change of solution	precipitate formed
A	✗	✗	✗
B	✗	✓	✗
C	✗	✗	✓
D	✓	✗	✗
E	✗	✗	✗

Table 1.1

(a) Which of the substances is magnesium?

.... [1]

(b) Which of the substances is lead(II) nitrate?

.... [1]

(c) Which of the substances most likely contains a transition metal?

.... [1]

(d) It is later known that potassium hydroxide and silver nitrate are part of the substances used.

(i) Which of the substances could be potassium hydroxide?

.... [1]

(ii) Describe a test that can be used to distinguish between potassium hydroxide and silver nitrate. Include observations you would expect.

....

....

.... [2]

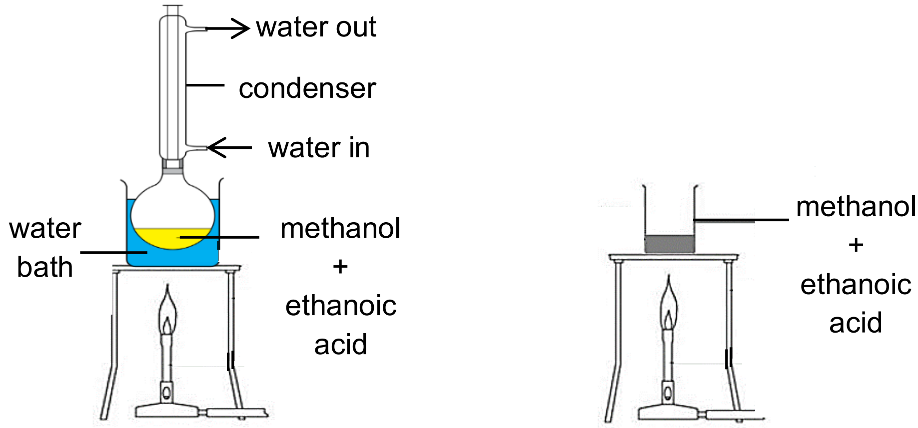
[Total: 6]

A2 To produce ester, methanol and ethanoic acid have to be heated over a period of time in the presence of a catalyst. The properties of the reactants and ester are in Table 2.1 as follows.

compound	boiling point / °C	density / g/cm^3	solubility in water
methanol	67	0.79	yes
ethanoic acid	118	1.05	yes
ester	60	0.93	no

Table 2.1

Students **A** and **B** attempt to prepare ester using different setups shown in Fig. 2.1 below.



Student A **Student B**

Fig. 2.1

(a) Name the catalyst used in both setups and the name of the ester formed.

.... [1]

(b) The yield of ester obtained by Student **B** is low and it is due to the experimental setup. Explain why the setup produces a low yield of ester.

....

.... [1]

(c) How can Student **A** separate the ester from the reaction mixture at the end of the reaction?

.... [1]

(d) Describe a method to determine if the ester obtained is pure.

....

.... [1]

[Total: 4]

A3 Fig 3.1 shows a graph of the density of water at different temperatures.

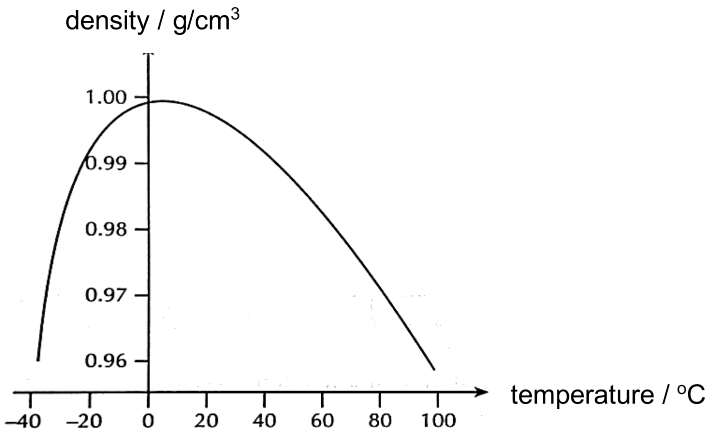


Fig. 3.1

(a) Based on kinetic particle theory, account for the trend in the density change as seen from 20 °C to 100 °C.

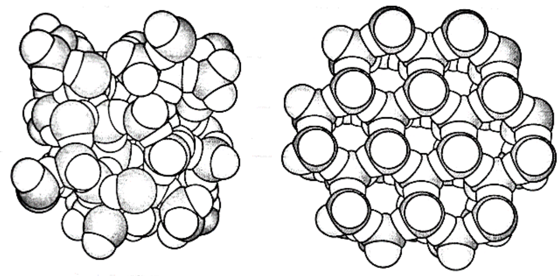
……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

.... [2]

(b) Water is one of the several substances that expands upon freezing.
Fig. 3.2 below shows the arrangement of water molecules at 4 °C and 0 °C.



4 °C **0 °C**

Fig. 3.2

Using the diagram and information provided, explain why ice floats on water.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

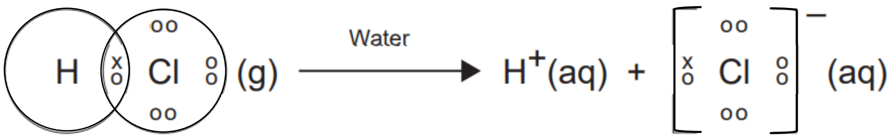
……………………………………………………………………………………………...

.... [2]

[Total: 4]

A4 In 1884 Svante Arrhenius put forward ideas to explain acid-base behaviour. It was many years before his ideas were accepted. In 1903 he was awarded the Nobel Prize for Chemistry.

(a) Hydrogen chloride solution is called hydrochloric acid. It is made by dissolving hydrogen chloride gas in water. An equation which represents this reaction is:



Explain why a solution of hydrogen chloride in water is acidic whereas dry hydrogen chloride gas is not acidic.

....

....

....

.... [2]

(b) The equation below represents the reaction between potassium hydroxide solution and dilute hydrochloric acid:

$$KOH\ (aq) + HCl\ (aq) \rightarrow KCl\ (aq) + H_2O(l)$$

(i) Explain why potassium hydroxide solution is a strong alkali.

....

....

.... [1]

(ii) Explain why potassium chloride solution is neutral.

....

.... [1]

(c) Potassium chloride can be made from chlorine. When a student read that chlorine gas is poisonous, the student concluded that potassium chloride must also be poisonous.

(i) Use your knowledge of chlorine and potassium chloride to explain why this conclusion is **not** correct.

....

....

....

.... [2]

(ii) Potassium chloride can also be prepared using the equation in **(b)**. Describe how a solution of potassium chloride can be prepared using the equation in **(b)**.

....

....

....

.... [2]

[Total: 8]

A5 Metals are extracted from their oxides by reduction.
Table 5.1 shows the minimum temperature that is needed for the reduction of some metal oxides by reaction with carbon.

The metals are represented buy the alphabets **Q**, **R**, **X**, **Y** and **Z**.

formula of metal oxide	minimum temperature needed for reduction / °C
QO	2100
RO	400
XO	900
YO	100
ZO	1600

Table 5.1

(a) Arrange the five metals in ascending order of reactivity.

most reactive ………………..

………………..

………………..

………………..

least reactive ………………. [1]

(b) Using the data in Table 5.1, explain your answer in **(a)** in terms of bonding.

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

………………………………………………………………………………………… [2]

(c) Metal oxides also react with some metals.
In the Thermit reaction, aluminium reacts vigorously with iron(III) oxide to release a lot of heat.

(i) Write a balanced chemical equation for the Thermit reaction.

………………………………………………………………………………… [1]

(ii) Suggest another metal that can react even more vigorously with iron(III) oxide.

………………………………………………………………………………… [1]

[Total: 5]

A6 Carbon monoxide gas, $CO(g)$, and nitrogen gas, $N_2(g)$, are both diatomic molecules.

(a) Fig. 6.1 shows the arrangement of outer electrons in a molecule of $CO(g)$.

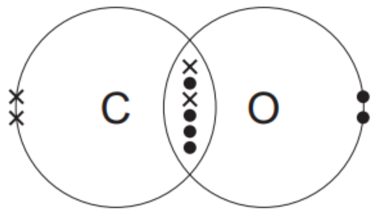


Fig. 6.1

State **one** similarity and **one** difference in the way the atoms in a carbon monoxide molecule are bonded together compared to the atoms in a nitrogen molecule.

similarity ....

....

difference ....

.... [2]

(b) Electronegativity is defined as the tendency of an atom to attract a bonding pair of electrons. In a covalent compound, the atom with higher electronegativity attracts the bonding pair of electrons, causing an unequal distribution of electrons that results in the formation of a polar molecule as shown in Fig. 6.2. This increases the ionic character of a covalent molecule.

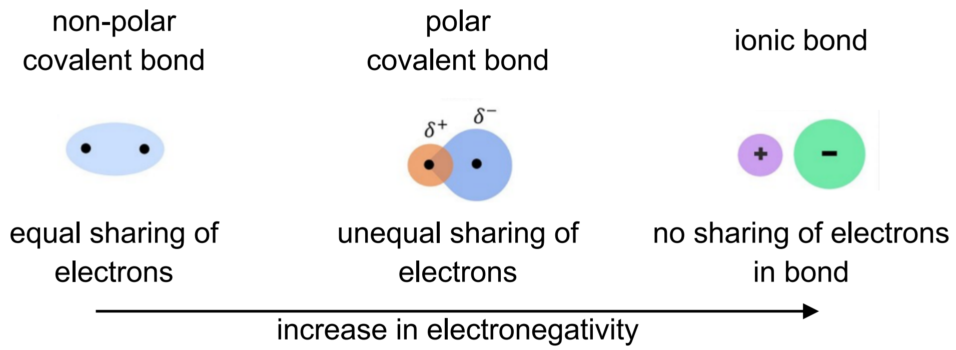


Fig. 6.2

Table 6.1 states the electronegativity values of carbon, nitrogen and oxygen atoms.

	C	N	O
electronegativity	2.5	3.0	3.5

Table 6.1

(i) Species having the same electronic configuration are termed as isoelectronic.

Are the molecules of nitrogen and carbon monoxide isoelectronic? Explain.

……………………………………………………………………………………..

……………………………………………………………………………… [1]

(ii) Using all the information given, suggest why CO(g) has higher boiling point than N_2(g).

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………………… [3]

[Total: 6]

A7 Excess aqueous bromine reacts with methanoic acid to form hydrogen bromide and carbon dioxide gas.

$$Br_2(aq) + HCO_2H(aq) \rightarrow 2HBr(aq) + CO_2(g)$$

This reaction can be followed by measuring the concentration of bromine present in the mixture at regular time intervals. Fig. 7.1 shows the change in concentration of bromine against time in a reaction carried out at 20 °C.

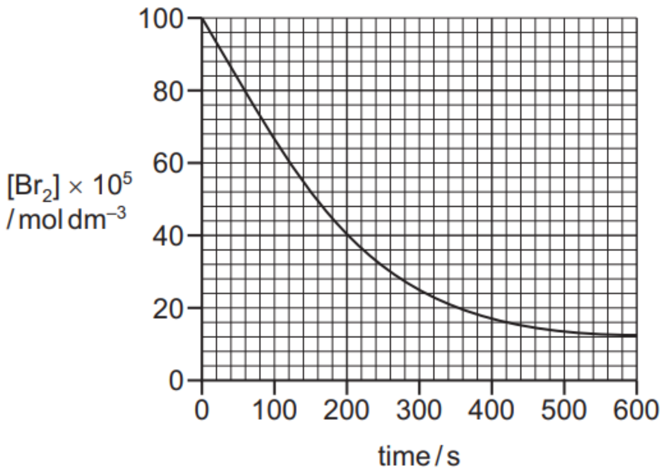


Fig. 7.1

(a) Use the graph to calculate the average rate of reaction at 20 °C during the first 600 s. State the units of this rate of reaction.

[1]

(b) The experiment is repeated at a temperature of 40 °C. This relatively small increase in temperature produces a large increase in reaction rate.

Sketch a graph, on the same axes, to show the expected results when repeating the experiment at 40 °C. [1]

(c) The rate of reaction increases when the frequency of successful collisions between reactant particles increases. Explain why an increase in temperature produces this effect.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Total: 4]

A8 Iron(II) compounds are generally only stable in neutral, non-oxidising conditions.

(a) Most naturally occurring samples of iron(II) oxide are found as the mineral wüstite. Wüstite has formula $Fe_{20}O_x$. It contains both Fe^{2+} and Fe^{3+} ions.
90% of the iron is present as Fe^{2+} and 10% is present as Fe^{3+}.
Deduce the value of x.

[2]

(b) The reaction in which a single reactant is oxidised and reduced is known as *disproportionation* reaction.

Heating of FeO results in the formation of Fe_3O_4, as shown.

$$4FeO \rightarrow Fe + Fe_3O_4$$

Each formula unit of Fe_3O_4 contains one Fe^{2+} and two Fe^{3+} ions.

Show how the reaction is a *disproportionation* reaction in terms of electrons transfer. Include the ionic equations.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(c) Another iron compound, $LiFePO_4$, can be used in lithium-ion rechargeable batteries.

When the cell is charging, lithium reacts with a graphite electrode to form LiC_6.

When the cell is discharging, the half-equations for the two processes that occur are as follows:
anode $LiC_6 \rightarrow 6C + Li^+ + e^-$
cathode $Li^+ + FePO_4 + e^- \rightarrow LiFePO_4$

(i) Use the cathode half-equation to determine the change, if any, in oxidation states of lithium and iron at the cathode during discharging.

metal	change in oxidation state during discharging	
	from	to
lithium		
iron		

[1]

(ii) Write the equation for the overall reaction that occurs when this cell is discharging.

……………………………………………………………………………………… [1]

[Total: 6]

A9 Molten copper(II) chloride can be electrolysed using inert electrodes to form copper.

(a) Write the half-equation for the reaction that occurs at the anode during the electrolysis of molten copper(II) chloride.

.... [1]

(b) During the electrolysis, 2.4 dm^3 of chlorine gas is produced.
Calculate the maximum mass of copper metal formed when molten copper(II) chloride is electrolysed.

[2]

(c) Fig. 9.1 shows the setup of how impure copper can be purified by electrolysis.

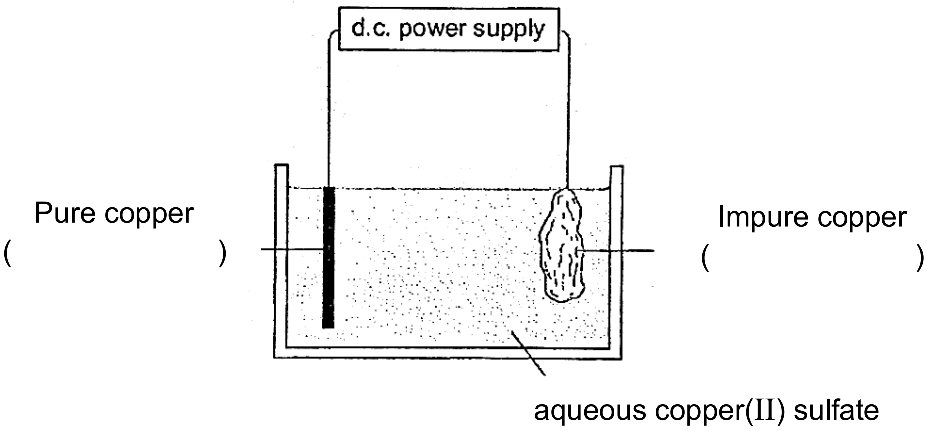


Fig. 9.1

(i) Indicate the cathode and anode in the brackets on Fig. 9.1. [1]

(ii) In an experiment, the electrodes are weighed before and after the electrolysis. The results are given in Table 9.1 below.

	mass of impure copper / kg	mass of pure copper / kg
before electrolysis	10.30	1.55
after electrolysis	0.855	9.80

Table 9.1

Using the information given, calculate the percentage purity of the impure copper.

[2]

(iii) State **one** factor that may affect the accuracy of these results.

………………………………………………………………………………………..

………………………..…………………………………………………………… [1]

[Total: 7]

Section B

Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted

B10 When fuels are combusted in the presence of oxygen, the atoms rearrange to form products, along with a large amount of energy. In combustion reactions, some substances will release more energy than others. Enthalpies of combustion can be used to compare which fuels or substances release the most energy when they are burned.

The enthalpy of combustion of a substance is defined as the heat energy given out when one mole of a substance burns completely in oxygen.

Fig. 10.1 is a graph that shows the bond energy between some common atoms.

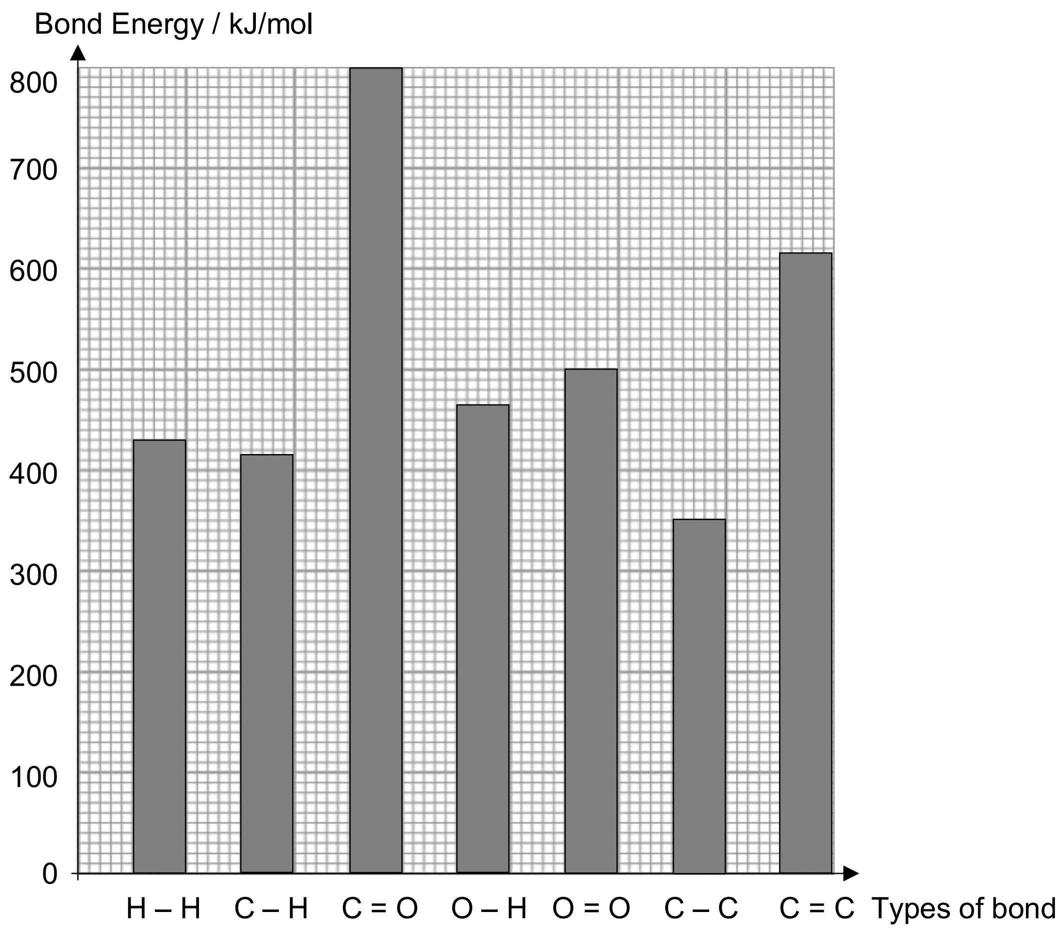


Fig. 10.1

When hydrogen is used as a fuel, it burns to produce water as follows :

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l) \qquad \Delta H = -500\text{ kJ/mol}$$

(a) **(i)** Using Fig. 10.1, show that the combustion of methane is an exothermic process.

[2]

(ii) Using calculations, show that hydrogen gas is a more efficient fuel than methane per gram.

[2]

(b) According to Hess's law, the overall enthalpy change of a reaction is the sum of all enthalpy changes. Fig. 10.2 shows the enthalpy changes involved in a reaction between sodium and chlorine gas. (Note that all the values shown do not indicate if the enthalpy change is positive or negative.)

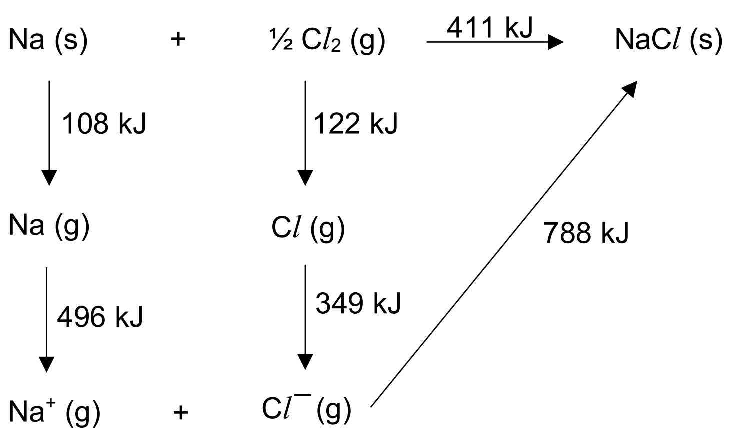


Fig. 10.2

Energy is taken in by an atom to release the first electron from its orbital whereas energy released when an electron is added to a valence shell of an atom.

State if the following processes are exothermic or endothermic.
Explain your answer.

(i) Na (s) → Na (g)

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(ii) C*l* (g) → Cl^- (g)

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(c) Calculate the activation energy required for the reaction between sodium and chlorine gas. Explain how you arrive at your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(d) Using your answers in **(b)** and **(c)**, show calculations to prove that the overall enthalpy change is -411 kJ.

[1]

(e) Sketch a labelled energy profile diagram for the reaction, including all the relevant values in your diagram.

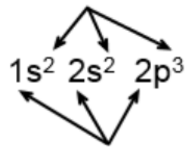
[3]

[Total: 12]

B11 All electrons are found spinning around the nucleus of an atom at specific distances in what we call shells. Each of these shells have sub-shells, which have different energy levels represented by the letters s, p, d and f.

The simplified electronic configuration of nitrogen is typically written as 2.5, but if sub-shells are included, it will then be written as $1s^2\ 2s^2\ 2p^3$. 1s, 2s and 2p represent the shells and sub-shells, while the superscripts represent the number of electrons in each sub-shell.

number of electrons



shells
with s and p being the sub-shells

Table 11.1 shows a list of elements and the electronic configuration of the atoms written with the sub-shells included.

element	electronic configuration
hydrogen	$1s^1$
helium	$1s^2$
lithium	$1s^22s^1$
beryllium	$1s^22s^2$
boron	$1s^22s^22p^1$
carbon	$1s^22s^22p^2$
nitrogen	$1s^22s^22p^3$
oxygen	$1s^22s^22p^4$
fluorine	$1s^22s^22p^5$
neon	$1s^22s^22p^6$
sodium	$1s^22s^22p^63s^1$

Table 11.1

Shells and sub-shells can also be represented using boxes with the electrons in them shown as arrows. Fig. 11.1 shows the electronic configuration of some of the elements in Table 11.1 represented in boxes.

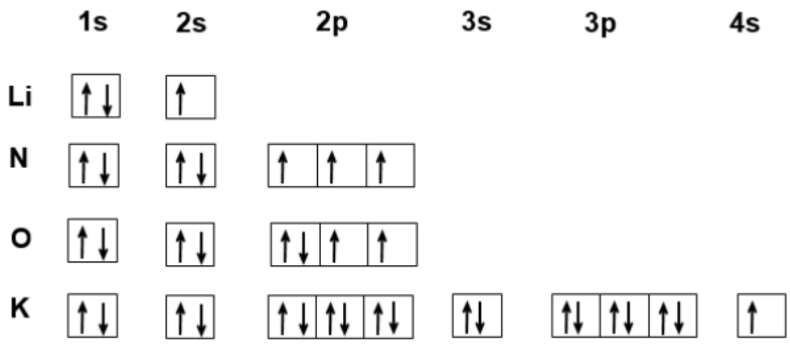


Fig. 11.1

Table 11.2 shows the ionisation energies of the same elements in Table 10.1. The ionisation energy of an atom is the amount of energy required to remove an outermost electron from the atom in gaseous state.

element	**ionisation energy kJ/mol**
lithium	520
oxygen	1402
fluorine	1314
potassium	419

Table 11.2

(a) With reference to Table 11.1, write the electronic configuration, with sub-shells included, for aluminium atom and oxide ion.

aluminium atom …………………………

oxide ion ………………………… [1]

(b) Electrons are filled in the sub-shells according to a fixed pattern.

With reference to Fig. 11.1, suggest the pattern with which electrons are filled in the sub-shells.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(c) Refer to the electronic structure of nitrogen shown below in Fig 11.2 and compare it with the electronic configuration of nitrogen represented as boxes in Fig. 11.1.

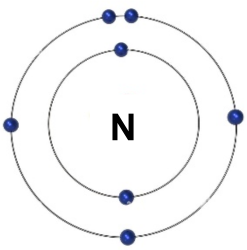


Fig. 11.2

State **one** similarity and **one** difference in the electronic structures represented in Fig. 11.2 compared to Fig. 11.1.

similarity ……………………………………………………………………………………

…………………………………………………………………………………………… [1]

difference ……………………………………………………………………………………

…………………………………………………………………………………………… [1]

(d) Using Fig. 11.1 and Table 11.2, explain why the ionisation energy decreases down the group from lithium to potassium.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………… [2]

(e) Fig. 11.3 shows a plot of the first ionisation energy against atomic number for the first 18 elements in the Periodic Table.

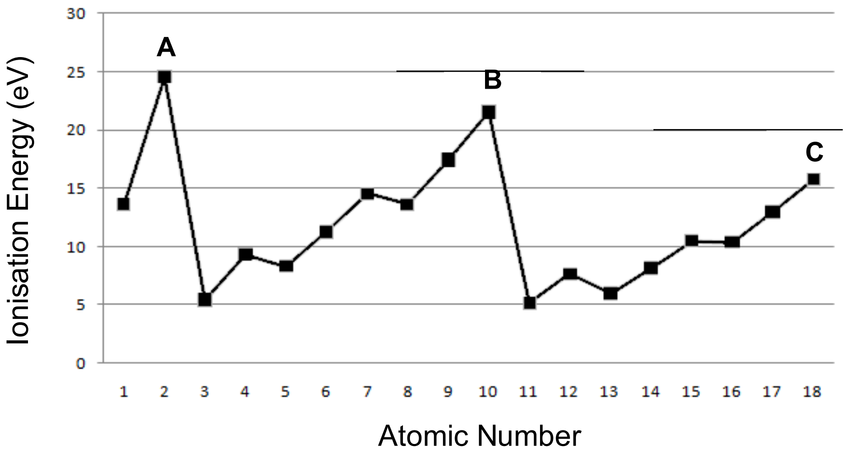
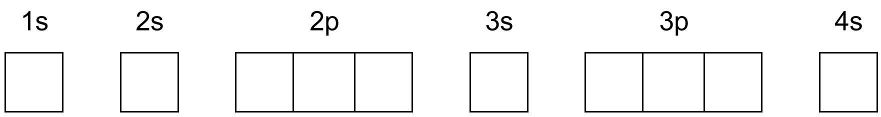


Fig. 11.3

(i) Name the group in which the elements are labelled **A**, **B** and **C** on Fig. 11.3.

………………………………………………………………………………… [1]

(ii) Draw the arrows in the boxes below to represent the electrons configuration of element **B** on Fig. 11.3.



[1]

[Total: 8]

B12 Either

(a) Naphtha is a mixture which contains only hydrocarbon molecules.

(i) What is meant by the term *hydrocarbon*?

………………………………………………………………………………….. [1]

(ii) Name the raw material that is used to produce a sample of naphtha.

…………………………………………………………………………………… [1]

(b) Compound **V** is found in naphtha. It has a molecular formula $C_{10}H_{22}$. When **V** is heated at high pressure in the absence of air, an equal number of moles of ethene, propene and **W** are made. **W** is a compound made of straight chain, saturated molecules.

(i) Name the process that describes this reaction.

…………………………………………………………………………………… [1]

(ii) Deduce and draw the full structural formula of **W**.

[1]

(c) Propene is separated from the mixture and heated in air in the presence of a catalyst. Propene is oxidised to **X**, which contains two functional groups.

(i) Effervescence is seen when Na_2CO_3 (aq) is added to **X**. Identify the functional group present in **X** which is responsible for this observation.

…………………………………………………………………………………… [1]

(ii) Identify a reagent which could be used to show if **X** contains a C=C bond. Include relevant observations.

………………………………………………………………………………………

…………………………………………………………………………………… [2]

(d) **X** reacts with another reagent to form **Y**. Molecules of **Y** react together to form addition polymer **Z**. Fig. 12.1 shows the repeat unit of polymer **Z**.

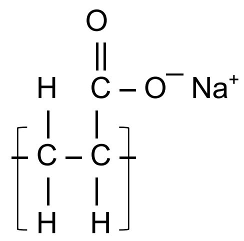


Fig. 12.1

Draw the structural formula of the monomer of **Z**.

[1]

(e) Polymer **Z** is useful because it absorbs large amounts of water. However, there are problems associated with the disposal of products containing polymer **Z**. Combustion is not an appropriate method to dispose of polymer **Z** because the process releases harmful gases. Some of these gases contribute to the enhanced greenhouse effect.

(i) Identify the greenhouse gas released during the combustion of **Z**.

.... [1]

(ii) Identify another gas which could be produced during the combustion of polymer **Z**. Describe a consequence, other than the enhanced greenhouse effect, of its release into the atmosphere.

gas ....

consequence ....

.... [1]

[Total: 10]

B12 Or

Table 12.1 below shows a group of organic compounds known as AHA or alpha hydroxy acids. These compounds are widely used in the cosmetics industries and medically as chemical peels to treat skin.

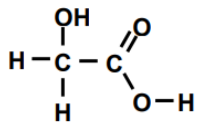
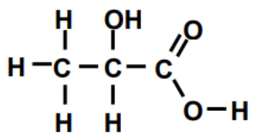
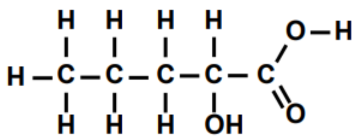
name	molecular formula	structural formula	pH of 1 mol/dm^3 acid
hydroxyethanoic acid	$C_2H_4O_3$		1.91
hydroxypropanoic acid	$C_3H_6O_3$		1.93
	$C_4H_8O_3$		1.99
hydroxypentanoic acid	$C_5H_{10}O_3$		2.07

Table 12.1

(a) Complete the table by filling in the missing name and structural formula of the 3rd member of this homologous series. [2]

(b) An isomer of hydroxypropanoic acid has a pH of 2.43.
Draw a possible structure of this isomer belonging to the same homologous series.

[1]

(c) What is the trend in the acid strength shown by the data in the table?

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(d) PLA, or poly(lactic acid), is a biodegradable plastic that is used in medical implants and decomposable packaging materials. Part of the structure of PLA is shown in Fig. 12.2 below.

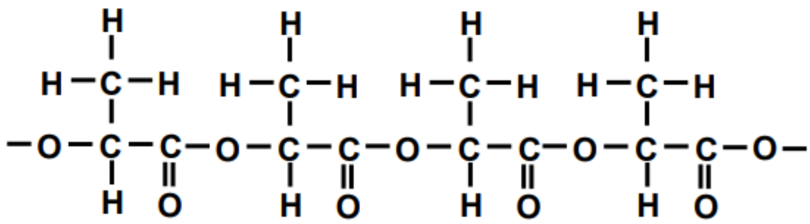


Fig. 12.2

(i) State the reaction that produces this plastic from the alpha hydroxy acid.

…………………………………………………………………………………… [1]

(ii) Draw the structure of the monomer that forms this plastic.

[1]

(iii) Name the type of plastic PLA belongs to.

…………………………………………………………………………………… [1]

(e) Synthetic materials are often put through tensile testing where the stress and strain of the material is measured and plotted on a graph. Stress refers to the amount of force applied to the material and strain refers to the degree at which the material stretches under a given force. Fig. 12.3 shows the relationship between the stress and strain of two grades of PLA.

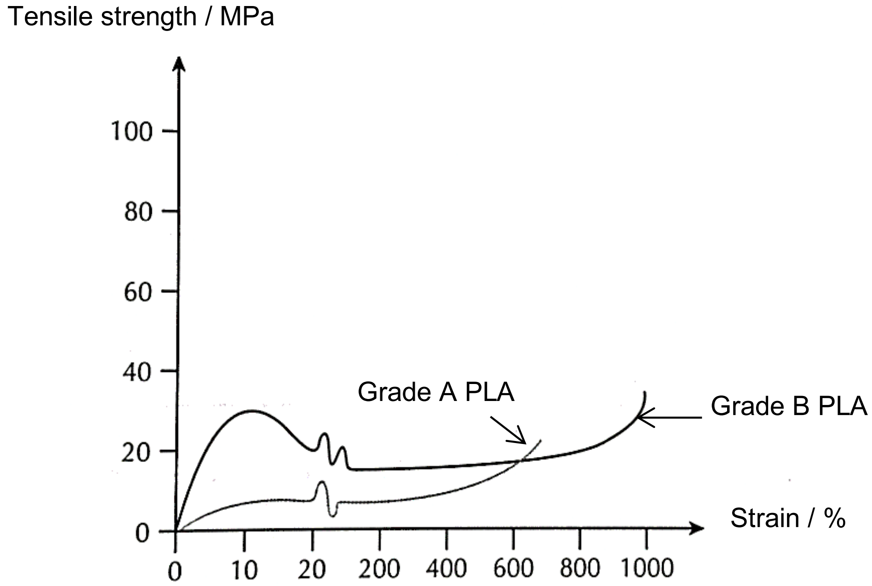


Fig. 12.3

(i) Using the information from Fig. 12.3, state with reason, which of the materials is stronger.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Suggest, using the information from Fig. 12.3, if Grade A or B PLA is a more flexible material. Explain your answer.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

[Total: 10]

End of paper

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group

I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Aℓ aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cℓ chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tℓ thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fℓ flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

BEDOK SOUTH SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022

4EXP

CANDIDATE NAME	
CLASS	
REGISTER NUMBER	

CHEMISTRY 6092/02

23rd August 2022

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, register number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue, or correction fluid.

SECTION A (50 marks)
Answer **all** questions in the spaces provided.
Write your answers in the spaces provided on the question paper.

SECTION B (30 marks)
Answer all **three** questions in the spaces provided. The last question is in the form either/or.
Write your answers in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show working or if you do not use appropriate units.
You are reminded of the need for ***clear presentation*** in your answers.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page **19**.

For Examiner's Use	
Section A (31.25%)	50
Section B (18.75%)	30
Total	80

Setter: DL

This paper consists of **19** printed pages including this cover page

Section A

Answer **all** questions in this question in the spaces provided.

The total mark for this section is 50.

A1 Select elements from the list to answer the following questions.

You may use each element once, more than once or not at all.

sodium	copper	magnesium
bromine	zinc	hydrogen
rubidium	chlorine	silver

(a) Which **two** elements react together most vigorously?

.... **[1]**

(b) Which element forms an ion that can change damp blue litmus paper red?

.... **[1]**

(c) Which solid, when attached to iron, will cause it to rust most effectively?

.... **[1]**

(d) Which element forms an amphoteric oxide?

.... **[1]**

(e) Which substance is responsible for the depletion of the ozone layer?

.... **[1]**

(f) Which **two** elements combine to form a compound with the lowest boiling point?

.... **[1]**

[Total: 6]

A2 The following are statements about groups and periods in the Periodic Table.

For each statement, state whether it is true or false.

If a statement is false, write a new statement to correct the false statement.

(a) The most stable group contains of only non-metals.

....

....

(b) The strongest reducing agent is at the bottom of a group.

....

....

(c) The colour of transition metals gets darker down the groups.

....

....

(d) The number of valence electrons involved in bonding increases across the period.

....

.... **[6]**

[Total: 6]

A3 A new system for treating the exhaust emissions of diesel cars has been developed.

The system injects a fluid called DEF (Diesel Exhaust Fluid) into the hot exhaust gases.

DEF contains an aqueous solution of urea, $(NH_2)_2CO$.

(a) Draw a 'dot-and-cross' diagram for urea, $(NH_2)_2CO$.

Show outer electrons only.

[3]

(b) When the DEF is injected into the hot exhaust gases, the high temperature causes the reaction shown in equation 1.

equation 1 $(NH_2)_2CO + H_2O \rightarrow 2NH_3 + CO_2$

The ammonia formed reacts with nitrogen oxides in the exhaust gases.

equation 2 $4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$

equation 3 $8NH_3 + 6NO_2 \rightarrow 7N_2 + 12H_2O$

(i) The DEF is stored in a tank in the car away from the hot engine.
If this tank becomes too hot, it could cause an explosion.
Use equation 1 to explain why.

....

....

.... **[1]**

(ii) State a source of nitrogen oxides in the exhaust gases.

....

.... **[1]**

(iii) State, with a reason, one benefit to the environment of using DEF to treat exhaust gases.

....

.... **[1]**

(iv) Suggest and explain **one** reason why using DEF does **not** solve all environmental problems caused by the exhaust gases.

....

....

.... **[2]**

(v) Write an overall equation for the reaction of urea with NO_2.

[2]

(c) A motorist buys a 250 cm^3 bottle of DEF.

The label says that the bottle contains 100 g of urea.

Calculate the concentration of urea in mol/dm^3.

concentration of urea = ……………………………. mol/dm^3 **[2]**

[Total: 12]

A4 **Table 4** shows information about some electrolysis experiments.

experiment	anode	cathode	electrolyte	substance formed at anode	substance formed at cathode
1	carbon	carbon	dilute aqueous sodium chloride		
2	carbon	carbon	concentrated aqueous sodium chloride		
3	carbon	copper	dilute aqueous copper(II) sulfate	oxygen gas	copper metal
4	copper	carbon	dilute aqueous copper(II) sulfate	Cu^{2+} ions	copper metal
5	brass	brass	dilute aqueous copper(II) sulfate		

Table 4

(a) Complete **Table 4** by filling in the missing information. **[5]**

(b) Describe **three** differences that can be **seen** between experiment 3 and 4.

....

....

....

....

....

[3]

(c) Write an ionic equation for the reaction at the anode in experiment 3.

[1]

(d) After the experiments have completed, the final electrolyte solutions from all the five experiments are collected separately in 5 different labelled beakers. However, during transportation, the labels for experiment 3, 4 and 5 have dropped off.

Student A claimed that the electrolyte solution from experiment **1** can be used to identify the 3 solutions.
Another student B claimed that the electrolyte solution from experiment **2** can be used to identify the 3 solutions.

Which one of the two claims is correct? Explain your choice.

....

....

....

....

....

[3]

[Total: 12]

A5 Aluminium is the most abundant metal and the third most abundant element after oxygen and silicon in the Earth's crust. Aluminium is a highly reactive metal and is rarely found as a pure element.

(a) Write the formula of one compound that contains the elements aluminium, silicon and oxygen.

.... **[1]**

(b) Thermit reaction is used to join lengths of railway track. It is a highly exothermic reaction between aluminium and iron(III) oxide. The molten iron produced is used to fill the gaps.

$$2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(l)$$

(i) What is the name given to this type of reaction?

.... **[1]**

(ii) Iron that is produced can be used as a catalyst in the Haber Process to produce ammonia. Explain, in terms of bonding and structure, why iron and ammonia have different boiling points.

....

....

....

....

.... **[3]**

(iii) Al_2O_3 can be purified to get back the pure metal. Name the method used to extract the metal from its oxide.

.... **[1]**

(c) Rocks such as quartz are made of covalently bonded compounds of silicon and oxygen. Typically, quartz contains 46.7% silicon and 53.3% oxygen by mass. Determine the empirical formula of the compound in quartz.

[2]

[Total: 8]

A6 Carbon-12 and Carbon-13 are two isotopes of the element carbon. These isotopes exist naturally as different allotropes like diamond and graphite. Carbon can form compounds of hydrocarbon that are isomers like butene.

(a) Draw the full structural formula of butene and another of its isomer.

[2]

(b) Explain why carbon-12 and carbon-13 are isotopes in terms of their atomic structure. Which isotope will form an isomer of butene with the highest boiling point?

....

....

....

.... **[2]**

(c) State two differences in the structure of allotrope diamond and graphite.

....

....

....

.... **[2]**

[Total: 6]

SECTION B (30 marks)

Answer all **three** questions in the section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 The air pollutants emitted by a car come from undesirable chemical reactions that occur during fuel combustion inside the engine. In the most common type of combustion reaction, petrol or diesel reacts with oxygen to form water and carbon dioxide to release energy to run the engine.

$$C_xH_y + (x + \frac{y}{4})\, O_2 \rightarrow x\, CO_2 + \frac{y}{2}\, H_2O$$

Petrol and diesel are both obtained by fractional distillation of crude oil at different temperature range.

Car manufacturers must ensure in petrol engines, oxygen and fuel are designed to be almost exactly stoichiometrically balanced, so that, ideally, there is no excess of either reactant at the end of the reaction to minimise pollution caused by their cars. For instance, too little oxygen can result in the production of carbon monoxide and unburnt hydrocarbon, both of which are considered pollutants when present in the air at ground level. On the other hand, if oxygen is present in more than the stoichiometric amount at high temperatures, the extra oxygen can react with the nitrogen gas to produce other pollutants, called oxides of nitrogen.

To reduce the potentially harmful pollutants that are created as by-products of combustion, the exhaust passes through a catalytic converter, which converts carbon monoxide, unburnt hydrocarbons, and various oxides of nitrogen into less-harmful chemical compounds before they are released into the air.

There are two kinds of catalytic converter: 2-way catalytic converter and 3-way catalytic converter.

A 2-way catalytic converter has two simultaneous reactions:

a) Oxidation of carbon monoxide to carbon dioxide:

$$2CO + O_2 \rightarrow 2CO_2$$

b) Oxidation of unburnt hydrocarbons to carbon dioxide and water:

$$C_xH_y + (x + \frac{y}{4})\, O_2 \rightarrow x\, CO_2 + \frac{y}{2}\, H_2O$$

A 3-way catalytic converter has three simultaneous reactions:

a) Reduction of oxides of nitrogen to nitrogen and oxygen:

$$2NO_x \rightarrow xO_2 + N_2$$

b) Oxidation of carbon monoxide to carbon dioxide:

$$2CO + O_2 \rightarrow 2CO_2$$

c) Oxidation of unburnt hydrocarbons to carbon dioxide and water:

$$C_xH_y + (x + \frac{y}{4})\ O_2 \rightarrow x\ CO_2 + \frac{y}{2}\ H_2O$$

The table below shows the amount of pollutants produced by a petrol-fuelled car installed with different Catalytic Converters (CC) in grams per kilometer of distance travelled.

	Amount of NO_x / gkm^{-1}	Amount of CO / gkm^{-1}	Amount of C_xH_y / gkm^{-1}
No CC	1.9	15	1.5
2-way CC	1.3	7	0.5
3-way CC	0.63	2.1	0.25

(a) Octane, C_8H_{18}, is a common hydrocarbon found in petrol.
Using appropriate equation, calculate the minimum volume of oxygen required to completely react with 2 moles of octane at room temperature and pressure.

[3]

(b) Petrol and diesel are both obtained by fractional distillation of crude oil at different temperature range.

Which fraction, petrol or diesel, can be obtained at a lower temperature range? Explain why this fraction can be obtained at a lower temperature range than the other.

....

....

....

....

.... **[3]**

(c) What additional environmental problem can a 2-way catalytic converter cause as compared to a 3-way catalytic converter?

....

....

....

.... **[2]**

(d) Name one key element (besides iron) used in the manufacture of a 2-way catalytic converter. Based on the data given, suggest why the amount of NO_x produced for every kilometer of travelled is reduced from 1.9 g to 1.3 g after the installation of a 2-way catalytic converter.

....

....

....

....

....

.... **[2]**

[Total: 10]

B8 The table below shows the reaction of salt **X** with some common laboratory chemicals.

Test	Reagent used	Results		
		Colour change (solution)	Gas produced	Precipitate formed
1	HCl	×	✓	×
2	H_2SO_4	×	✓	×
3	$NaOH$	×	×	×
4	NH_4OH	×	×	×
5	$Ba(NO_3)_2$	×	×	✓
6	$CuSO_4$	×	×	✓

(a) Name the anion that is most likely found in **X**. Explain your answer.

....

....

.... **[2]**

(b) Describe an additional test that will confirm the identity of the anion.
Write a balanced chemical equation for this positive test.

....

.... **[2]**

(c) Write an ionic equation for the formation of the precipitate when $CuSO_4$ reacts with **X**.

[2]

(d) Suggest a possible identity for the cation of **X**. Explain your answer.

....

....

.... **[2]**

(e) Describe an additional test that will confirm the identity of the cation.

....

....

.... **[2]**

[Total: 10]

EITHER

B9 This is a question about the reaction of amine with bromine to produce HBr.

$$C_6H_5NH_2 + 3Br_2 \rightarrow C_6H_2NH_2Br_3 + 3HBr$$

The initial rate of this reaction was determined using different concentrations of the reactants as shown in the following experiments.

Table B9a

experiment	Concentration of $C_6H_5NH_2$ (mol/dm^3)	Concentration of Br_2 (mol/dm^3)	Initial rate of reaction (mol/dm^{3}s)
1	0.001	0.001	0.007
2	0.001	0.002	0.014
3	0.001	0.003	0.021
4	0.002	0.003	0.084
5	0.003	0.003	0.189

From the data in **Table B9a**, changes in the concentration of each reactant affect the rate of reaction differently. Knowing how the rate is affected by the concentration of each reactant will allow us to predict the rate of reaction.

Depending on how the rate is affected by concentration of each reactant, we can classify reactions into the following two types as shown in **Table B9b**.

Table B9b

type of reaction	characteristic	example
First order reaction with respect to reactant A	The rate of reaction is proportional to the concentration of A	If you tripled (x3) the concentration of A, the rate of reaction would increase 3 times (x3).
Second order reaction with respect to reactant A	The rate of reaction is proportional to the square of the concentration of A	If you tripled (x3) the concentration of A, the rate of reaction would increase 9 times (x3^2).

(a) Using information from **Table B9a**, show why the order of reaction with respect to Br_2 is First order.

....

....

....

....

.... **[3]**

(b) **(i)** Using information from **Table B9a**, describe how the rate of reaction changes as the concentration of $C_6H_5NH_2$ changes.

....

....

.... **[2]**

(ii) Hence, determine the order of reaction with respect to $C_6H_5NH_2$.

....

.... **[1]**

(iii) Determine the rate of reaction when concentration of $C_6H_5NH_2$ is 0.002 mol/dm^3 and concentration of Br_2 is 0.001 mol/dm^3.

.... **[1]**

(iv) Use ideas about collisions between particles to explain the effect of increasing the concentration of $C_6H_5NH_2$ on the speed of reaction.

....

....

....

....

.... **[3]**

[Total: 10]

OR

B9 Most living things on Earth obtain energy through the oxidation of glucose in their cells. However, it has been found that some bacteria utilise different reaction pathways to obtain energy for survival. The table below shows some examples of such bacteria.

Bacterium	Reaction pathway
X	$2H_2S + O_2 \rightarrow 2S + 2H_2O$ + energy
Y	$4FeCO_3 + 6H_2O + O_2 \rightarrow 4Fe(OH)_3 + 4CO_2$ + energy
Z	$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4HSO_4^-$

(a) State which substance has been oxidised in the reaction pathway of bacteria **X**. Explain your answer in terms of the change in the oxidation state.

....

....

.... **[2]**

(b) Using suitable half-equation, state if iron is an oxidising agent or reducing agent in the reaction pathway occurring in bacteria **Y**. Explain your answer.

....

....

.... **[3]**

(c) After the initial reaction of iron(**II**) sulfide in bacteria **Z**, the ferrous cation (Fe^{2+}) further reacts with the water and oxygen as shown below:

I. $4Fe^{2+} + O_2 + 2H_2O \rightarrow 4Fe^{3+} + 4OH^-$

II. $Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$

(i) Write an overall equation for the reaction of FeS_2 to form $Fe(OH)_3$ in bacteria **Z**. Show your workings.

[2]

(ii) State if the overall equation in **(c)(i)** represents a redox reaction. Explain your answer.

....

....

....

....

....

.... **[3]**

[Total: 10]

70

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
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87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

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actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name:	Register Number:	Class:

BEDOK GREEN SECONDARY SCHOOL

4E **Preliminary Examination 2022** **4E**

Chemistry 6092/2

Paper 2

22 August 2022

1 h 45 min

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

Section B
Answer **all** three questions, the last question is in the form either/or.
Answer all questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is given on page 19.

The use of an approved scientific calculator is expected, where appropriate

For Examiner's Use	
Section A	
B9	
B10	
B11	
Total [80 marks]	

This document consists of **19** printed pages including the cover page.

[Turn Over

Section A [50 marks]

Answer all the questions in this section in the spaces provided

A1 The table shows some oxides formed by the elements in Period 3 of the Periodic Table.

compound	melting point / °C	type of bonding	type of structure
Na_2O	1132		
SiO_2	1710		
Cl_2O	-121		

(a) Complete the table on the type of bonding and structure that each oxide has. [3]

(b) Explain, in terms of the bonding within the structure, the difference in the melting point between oxides of sodium and chlorine.

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………….. [3]

(c) Describe the **change** in the nature of the oxides of the elements across Period 3.

…………………………………………………………………………………..

………………………………………………………………………………….. [1]

A2 Calcium ethanoate is administered to patient with kidney disease to prevent high blood phosphate which may lead to heart disease and stroke. It is prepared by excess calcium with ethanoic acid.

(a) Suggest why excess calcium is used.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(b) Suggest how the excess calcium could be removed from the reaction mixture.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(c) Describe how you can obtain pure dry crystals of calcium ethanoate from a solution of calcium ethanoate.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

(d) Describe one other reaction that can be used to prepare calcium ethanoate.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(e) Describe a method to show that the calcium ethanoate crystals are pure.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(f) Explain why the chemical used in medicines need to be as pure as possible.

……………………………………………………………………………………..

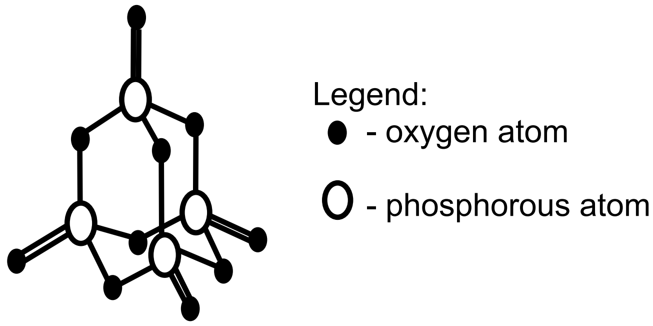
…………………………………………………………………………………….. [1]

A3 One of the largest uses of phosphorus is in the making of safety matches. A safety match ignites when it is rubbed against the striking surface of a match box.

The match head contains the following substances.

- phosphorus, P_4
- potassium chlorate(V), $KClO_3$
- sulfur, S
- a hydrocarbon wax

(a) Phosphorus burns to form phosphorus(V) oxide. This oxide is covalently bonded with a simple molecular structure.
The structure of phosphorus(V) oxide is shown below.



State the molecular formula of phosphorus(V) oxide.

.... [1]

(b) The heat from the combustion of phosphorus provides enough energy for the decomposition of potassium chlorate(V) to oxygen and potassium chloride.
Construct the equation for the decomposition of potassium chlorate(V).

.... [1]

(c) The sulfur on the match head ignites to form sulfur dioxide.
Explain why sulfur dioxide is an atmospheric pollutant.

....

....

....

.... [2]

(d) Finally the wax on the match head begins to combust.
One compound in the wax has the chemical formula $C_{18}H_{38}$.
Which homologous series of hydrocarbons does this compound belong? Explain your answer.

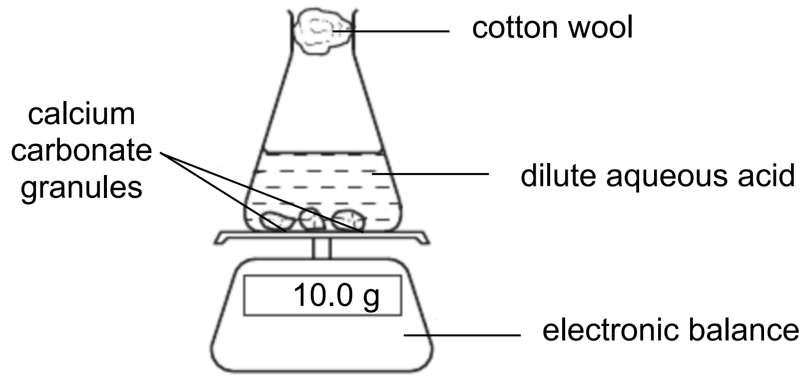
....

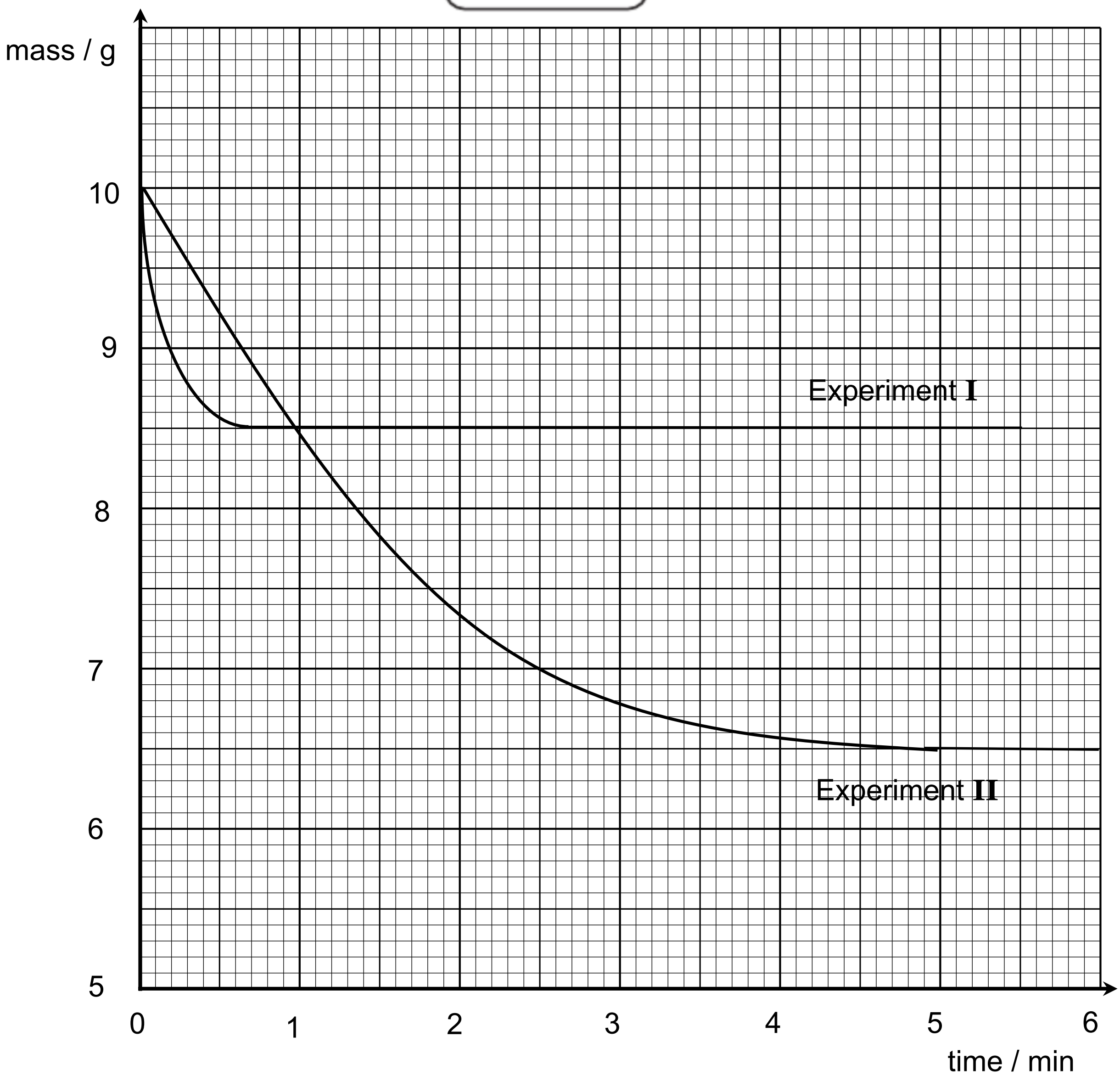
.... [1]

A4 A student used the apparatus shown below to investigate the speed of reaction between 10.0 g of calcium carbonate with **excess** dilute hydrochloric acid and dilute sulfuric acid at room temperature and pressure (r.t.p).

In experiment I, the student used 2.00 mol/dm^3 dilute sulfuric acid.
In experiment II, the student used 2.00 mol/dm^3 dilute hydrochloric acid.

The mass of the set up was measured at regular time intervals.
The data of mass/g against time/min is shown in the graphs below.





(a) Suggest why the mass of carbonates in both experiments decreases over time.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(b) Explain why the reaction between calcium carbonate and dilute sulfuric acid did not proceed to completion.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(c) **(i)** Calculate the theoretical loss of mass for experiment **II**.

theoretical loss of mass = ………………… [1]

(ii) Hence, calculate the % yield of the carbon dioxide produced.

% yield of carbon dioxide produced = ………….. [1]

(d) State the time experiment **II** was half completed.

…………………………………………………………………………………….. [1]

(e) Sketch on the grid shown on the graphs if experiment **II** is conducted

(i) at 10.0 ^{o}C. Label this graph S. [1]

(ii) using 10.0 g of the impure powdered calcium carbonate. Label this graph T. [1]

(f) Describe and explain how using a more concentrated hydrochloric acid will affect the speed of the reaction.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

A5 The industrial preparation of ethanol involves the reaction between ethene and steam.

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

(a) **(i)** State a source for ethene.

………………………………………………………………………………… [1]

(ii) Describe the conditions for this reaction.

………………………………………………………………………………… [1]

(iii) This reaction must be conducted in an oxygen-free environment. Explain why this is necessary.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

………………………………………………………………………………… [2]

(b) Ethanol and methane are two common fuels. The heat of combustion of the two fuels are given below.

fuel	heat of combustion (kJ/mol)
methane	889
ethanol	1300

Show, by calculation, which fuel produces a larger amount of heat energy when 1 kg of the fuel is burnt.

fuel which produces a larger amount of heat = …………….. [2]

A6 The equation for the reaction between acidified potassium dichromate(VI), $K_2Cr_2O_7$ and hydrogen peroxide, H_2O_2 is shown below.

$$K_2Cr_2O_7 + 3H_2O_2 + 4H_2SO_4 \rightarrow Cr_2(SO_4)_3 + K_2SO_4 + 3O_2 + 7H_2O$$

$\Delta H = -295$ kJ/mol

(a) Describe two observations in this experiment.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

(b) Describe a chemical test for oxygen.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(c) Which chemical, hydrogen peroxide or potassium dichromate(VI), is the oxidising agent? Explain your answer.

……………………………………………………………………………………..

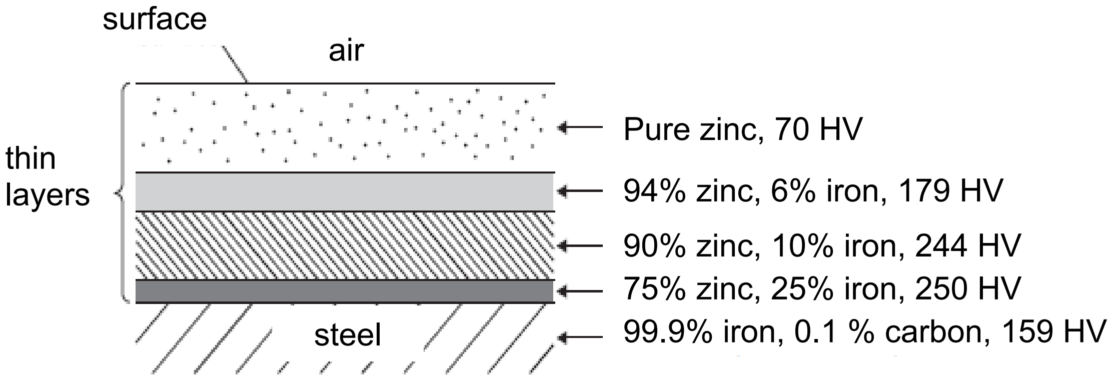
……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

A7 Steel is dipped into molten zinc to prevent it from rusting.
The zinc combines with the iron in the steel to form layers of zinc-iron alloys.

The diagram shows a cross-section through the layers.
HV is a unit of hardness. The higher the HV number, the harder the metal.



(a) Use information from the diagram to deduce a relationship between the hardness of the alloy and the composition of iron in the alloy.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(b) Steel car bodies are coated with zinc before painting. Explain why the car bodies do not rust, even if the paint is damaged.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(c) Explain why steel is harder than pure iron.

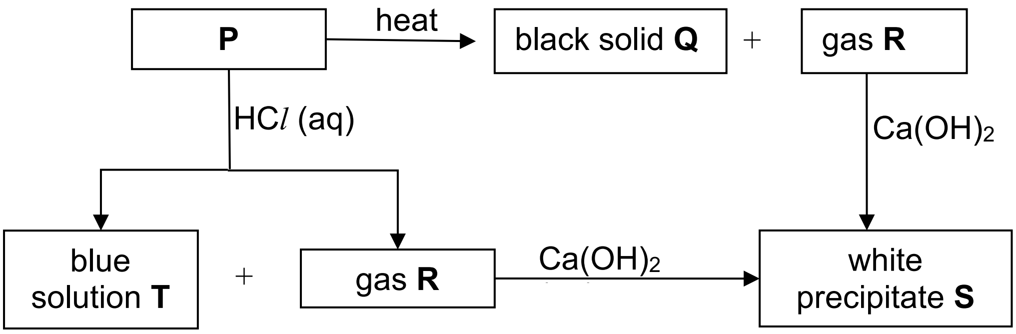
……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

A8 Compound **P** is a pale green powder. The scheme below shows some reactions of a compound **P**.



(a) Identify **P**, **Q**, **T** and **S**.

P ....

Q ....

T ....

S .... [4]

(b) Write the ionic equation, including state symbols, for the reaction of **P** with HC*l*(aq).

.... [1]

Section B (30 marks)

Answer all three questions from this section.
The last question is in the form **either/or** and only **one** of the alternatives should be attempted.
Write your answers in the spaces provided.

B9 Reactive Oxygen Species (ROS) is a phrase used to describe a number of reactive molecules and free radicals derived from molecular oxygen. A free radical can be defined as atoms that contain an unpaired electron in the valence shell.

Atomic oxygen has two unpaired electrons in its outer electron shell. This electron structure makes oxygen susceptible to radical formation.

The sequential reduction of oxygen through the addition of electrons leads to the formation of a number of ROS as shown in Table 9.

name of ROS	formula
oxygen	O_2
superoxide anion	$\bullet O_2^-$
peroxide	O_2^{2-}
hydrogen peroxide	H_2O_2
hydroxyl radical	$\bullet OH$
hydroxyl ion	OH^-

Table 9

A superoxide is an anion which occurs widely in nature. It contains an oxygen-oxygen single bond. With one unpaired electron, the superoxide ion is a highly reactive particle. A peroxide also contains an oxygen-oxygen single bond. The simplest stable peroxide is hydrogen peroxide.

Superoxides and peroxides are formed as a natural by-product of the normal metabolism of oxygen in living things. They are oxidising in nature and high levels will result in cell damage which may eventually lead to many forms of cancer and aging.

As superoxides are toxic, nearly all living things contain the enzyme, superoxide dismutase. The superoxide dismutase will react with superoxide ions and form hydrogen peroxide and oxygen. Catalase, another enzyme found in living things, reacts with the hydrogen peroxide to form water and oxygen. This natural mechanism in living things helps to control the levels of reactive oxygen species at safe levels.

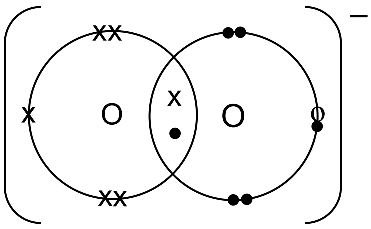
(a) Determine the oxidation state of oxygen in hydrogen peroxide.

[1]

(b) Draw the 'dot-and-cross' diagram to show the bonding in hydrogen peroxide. You need to draw only the valence electrons.

[2]

(c) The structure of the superoxide anion, $\bullet O_2^-$, is as shown below.



<u>Legend:</u>
x – electrons of first oxygen atom
• - electrons of second oxygen atom
o - electron from reduction

(i) With reference to the structure of the superoxide anion, suggest why it is oxidising in nature. [2]

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Deduce the structure of peroxide, O_2^{2-}.

[2]

(d) Write down the equation for the reaction of the enzyme, catalase, with hydrogen peroxide.

.... [1]

(e) Suggest what will happen to an individual if the amount of reactive oxygen species is not controlled.

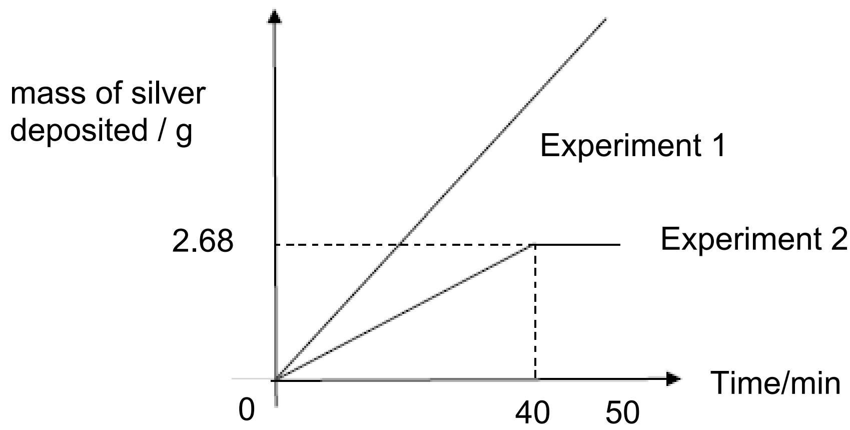
....

.... [2]

B10 A pupil carried out two separate experiments using different electrodes in the laboratory.

In each experiment, he electrolysed 2.00 dm^3 of aqueous silver nitrate containing 2.68 g of silver ions. The same amount of current was passed in both experiments and the increase in mass of the cathode was weighed every 5 minutes for 50 minutes.

The diagram below shows the results of the two experiments.



(a) **(i)** Describe how the mass of silver deposited at the cathode changes with time in experiment 1.

....

.... [1]

(ii) Write the half equation for the formation of silver at the cathode for both experiments.

.... [1]

(iii) One possible reason for the different results obtained in the above experiments is the use of different materials as the anode. Suggest suitable substances that can be used to make the anodes of Experiment 1 and 2.

Experiment 1: ……………………………………………………………

……………………………………………………………………………

Experiment 2: ……………………………………………………………

…………………………………………………………………………… [2]

(iv) Using your answer in **(iii)**, explain the shape of the graph in Experiment 2.

……………………………………………………………………………

……………………………………………………………………………

…………………………………………………………………………… [2]

(v) State the observation at the anode for Experiment 2 and give the half equation for the reaction.

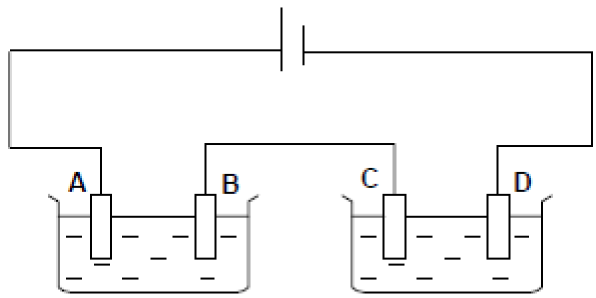
……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

…………………………………………………………………………… [2]

(b) A circuit was connected as shown in the diagram below and a current passed through it for a period of time.

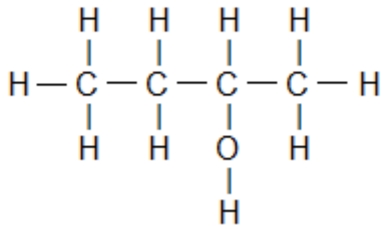


Given that 12.8 g of copper and 14.0 g of cerium were deposited at electrodes **B** and **D** respectively, calculate the charge on a cerium ion.

charge on cerium ion = …………… [2]

Either

B11 2-butanol is a colourless flammable liquid. It has several isomers.



2-butanol

2-butanol is produced when an organic compound **X**, reacts with water under suitable conditions.

(a) Draw the structural formula of organic compound **X**.

[1]

(b) **(i)** Define the term isomer.

………………………………………………………………………………

……………………………………………………………………………… [1]

(ii) Draw the structural formula of 2 isomers of 2-butanol.

[2]

(c) Suggest a chemical test to differentiate between 2-butanol and butanoic acid and state the observations.

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………………… [2]

(d) Describe the observation when aqueous bromine is added to

(i) organic compound **X**,

…………………………………………………………………………………… [1]

(ii) 2-butanol.

…………………………………………………………………………………… [1]

(e) 2-butanol reacts with ethanoic acid to form 2 products.
Draw the structural formula of the products.

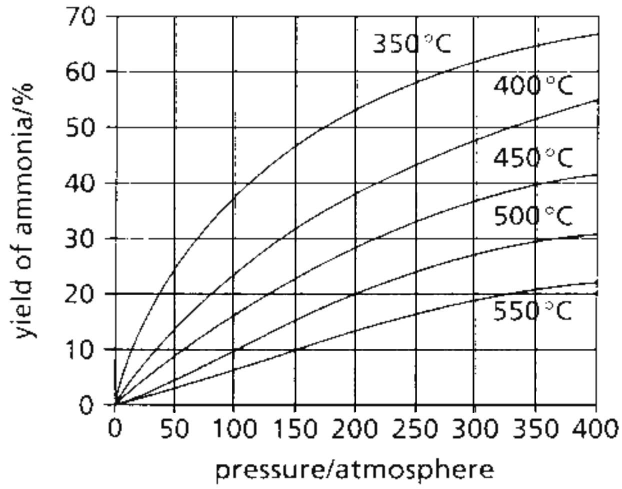
[2]

OR

B11 Ammonia is manufactured by the Haber process

$$N_2 + 3H_2 \rightarrow 2NH_3.$$

The graph below shows the yield of ammonia at different temperature and pressure conditions.



(a) By referring to the graphs, choose the combination of conditions that gives the highest yield of ammonia.

………………………………………………………………………………………… [1]

(b) The conditions for producing ammonia in industries are 450 °C, 250 atm and iron powder. Explain why these conditions are chosen instead of the ones that you have listed in **(a)**.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [3]

(c) The Haber process is an exothermic reaction.

(i) Draw the energy profile diagram of this reaction without a catalyst.

[1]

(ii) On the same axes as **(i)**, draw the energy profile diagram of this reaction with a catalyst. Label the diagram 'with catalyst'. [1]

(d) A student reacted 5 g of ammonium chloride with 100 cm^3 of 0.5 mol/dm^3 calcium hydroxide according to the equation,

$$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3 + 2H_2O.$$

(i) Write the ionic equation for this reaction.

……………………………………………………………………………… [1]

(ii) Calculate the expected volume of ammonia gas produced.

[2]

(iii) Explain why the volume of ammonia gas is less than expected.

………………………………………………………………………………

……………………………………………………………………………… [1]

End of Paper

Name	Class				Index Number		

BROADRICK SECONDARY SCHOOL
SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2022

CHEMISTRY **6092/02**

Paper 2

Aug 2022

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on top of this page.
Write in dark blue or black pen.
You may use a **soft pencil** for any diagrams or graphs.

Section A (50 Marks)
Answer **all** questions in the spaces provided.

Section B (30 Marks)
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page **20**.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
P1	/ 40
P2 Section A	/ 50
P2 Section B	/ 30
P3	/40

This document consists of **20** printed pages including this cover page.

Setter : MR. LIANG ZW

Section A [50 marks]

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

For Examiner's Use

A1 Iron is extracted from iron ore in the Blast Furnace.

The equations A, B, C, D and E show some reactions that happen in the Blast Furnace.

A $CaCO_3 \rightarrow CaO + CO_2$

B $SiO_2 + CaO \rightarrow CaSiO_3$

C $C + O_2 \rightarrow CO_2$

D $CO_2 + C \rightarrow 2CO$

E $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Use the letters, A, B, C, D and E to answer the following questions.

(a) Which equation shows thermal decomposition?

.... [1]

(b) Which equation shows combustion?

.... [1]

(c) Which equation shows a reaction between an acidic compound and a base?

.... [1]

(d) Which equation shows the formation of a toxic gas?

.... [1]

(e) Two equations show different elements in compounds being reduced.

Give the letters for these **two** equations.

.... and .... [1]

(f) Iron from the Blast Furnace is further processed to make steel. Some types of steel contain more carbon than others.

How are the properties of high carbon steel different from those of low carbon steel?

....

.... [2]

[Total: 7]

A2 Fluorine forms numerous compounds of varied properties.

For Examiner's Use

The chemical formulae and melting points of two of the compounds formed are shown below.

compound	chemical formula	melting point / °C
aluminium fluoride	AlF_3	1291
phosphorus trifluoride	PF_3	-151

(a) Draw a 'dot and cross' diagram to show the bonding formed in aluminium fluoride and phosphorus trifluoride.

Show only the outer shell electrons.

aluminium fluoride

phosphorus trifluoride

[4]

(b) Explain in term of bonding and structure, why aluminium fluoride has a high melting point while phosphorus trifluoride has a low melting point.

…………………………………………………………………………………………

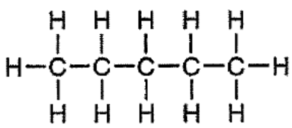
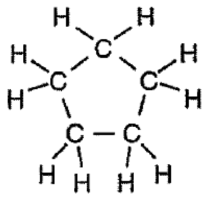
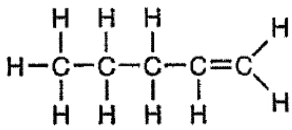
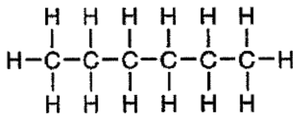
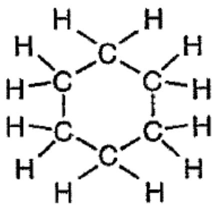
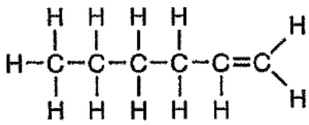
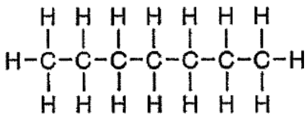
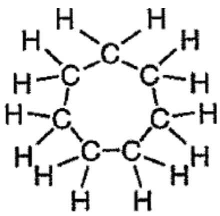
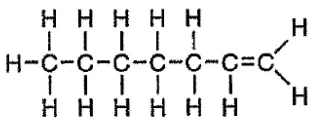
…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [3]

[Total: 7]

A3 The table shows the names and structures of some hydrocarbons.

number of carbon atoms	**alkanes**	**cycloalkane**	**alkene**
5	pentane 	cyclopentane 	pentene 
6	hexane 	cyclohexane 	hexene 
7	heptane 	cycloheptane 	heptene 

(a) Cycloalkanes are an example of a homologous series.

(i) Explain how the formulae of cycloalkanes in the table show this.

………………………………………………………………………………………... [1]

(ii) Suggest **two** differences in physical properties between cyclopentane and cycloheptane.

………………………………………………………………………………………...

………………………………………………………………………………………... [2]

(iii) The molecular formula of hexadecane is $C_{16}H_{34}$.

Give the molecular formula for cyclohexadecane

………………………………………………………………………………………... [1]

For Examiner's Use

(b) **(i)** Are cycloalkanes isomers of alkanes? Explain your reasoning.

…………………………………………………………………………………………...

…………………………………………………………………………………………... [1]

(ii) Draw the structure of a branched chain isomer of hexane which is a straight chain alkane with the formula C_6H_{14}.

[1]

(c) The percentage of carbon and hydrogen in some molecules are shown in the table.

name of molecule	percentage of carbon by mass	percentage of hydrogen by mass
hexane	84	16
hexene	86	14
cycloheptane	86	14

Explain why the percentages of carbon and hydrogen are the same for hexene and cycloheptane, but different for hexane.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

……………………………………………………………………………………………. [2]

(d) Bromine water can be used in a test to distinguish between cycloalkanes and alkenes.

Describe the results that would be obtained if this test is carried out on separate samples of cyclooctane and octene.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

……………………………………………………………………………………………. [2]

[Total: 10]

For Examiner's Use

A4 Aqueous thiosulfate, $S_2O_3^{2-}(aq)$, reacts with aqueous iodine according to the equation.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In a titration, 40.0 cm^3 of 0.1 mol/dm^3 aqueous thiosulfate was added to 30 cm^3 of 0.1 mol/dm^3 aqueous iodine.

(a) Determine the limiting reagent. Show your working.

[3]

(b) If only 0.001 mol of I^- was produced, calculate the percentage yield.

percentage yield …………………% [2]

(c) Explain why aqueous thiosulfate acts as a reducing agent in this reaction in terms of changes in oxidation states.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

(d) Name another suitable reagent that can be used to confirm that aqueous thiosulfate is a reducing agent. Include the observation in your answer, if any.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

[Total: 9]

For Examiner's Use

A5 Iron(II) sulfate crystals decompose when heated to give three gases U, V and W and an orange-brown solid T.

- Gas U was tested with filter paper soaked with acidified potassium manganate(VII). The filter paper changed colour from purple to colourless.
- Analysis of gas V showed it contained 40.0% sulfur and 60.0% oxygen by mass.
- When gas W was condensed it formed a colourless liquid that turned anhydrous copper(II) sulfate from white to blue.
- Solid T was dissolved in dilute nitric acid. Aqueous ammonia was added drop by drop and a red-brown precipitate was obtained.

(a) **(i)** What is the formula for gas U?

……………………………………………………………………………………... [1]

(ii) Determine the empirical formula of gas V.

empirical formula of gas V …………………… [2]

(iii) Name gas W.

……………………………………………………………………………………... [1]

(iv) Give the name or the formula of the metal ion present in solid T.

……………………………………………………………………………………... [1]

(b) Iron(II) sulfate dissolves in water to give a green solution X. Aqueous sodium hydroxide was added drop by drop to solution X.

A green precipitate, Y, was formed.

(i) Name precipitate Y.

……………………………………………………………………………………... [1]

(ii) Construct the ionic equation, with state symbols, to show the formation of the precipitate Y.

……………………………………………………………………………………... [1]

For Examiner's Use

(c) Use the following information to suggest the steps needed to prepare by precipitation pure barium sulfate, using aqueous iron(II) sulfate and powdered barium carbonate in a laboratory.

- barium sulfate is insoluble in water
- barium carbonate is insoluble in water
- barium nitrate is soluble in water

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [3]

[Total: 10]

A6 Group I and Group VII elements show different trends in their properties.

Group I
Li
Na
K
Rb

Group VII
F
C*l*
Br
I

(a) Explain why the reactivity of metals in Group I increases on going down the group.

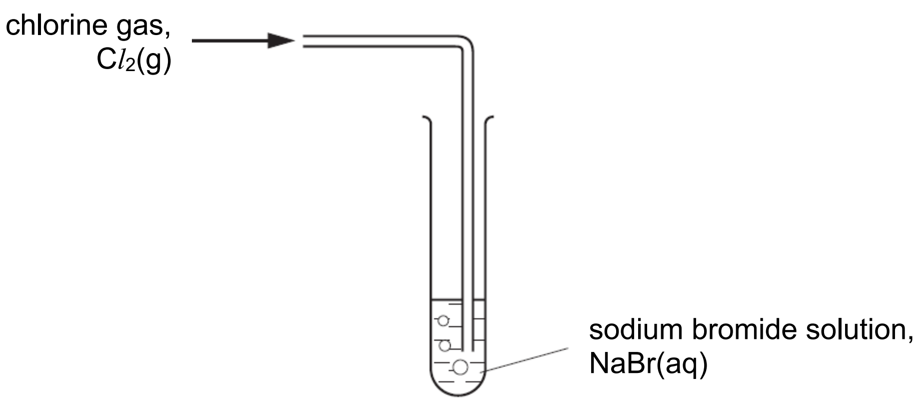
……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(b) When chlorine gas is bubbled into sodium bromide solution, a reaction occurs.



This reaction is commonly known as a 'displacement reaction'.

(i) Write an ionic equation for the displacement reaction.

…………………………………………………………………………………………… [2]

(ii) Explain your observations in **(i)**.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

For Examiner's Use

For Examiner's Use

(c) The radii of atoms and ions can be measured.

The table below shows some information about the atomic and ionic radii of Group I and Group VII elements.

element	number of shells of electrons in atom	atomic radius / *pm*	number of shells of electrons in ion	ionic radius / *pm*
Group I				
lithium (Li)	2	152	1	68
sodium (Na)	3	185	2	98
Group VII				
fluorine (F)	2	71	2	133
chlorine (C*l*)	3	99	3	181

[1 pm = 10^{-12} m]

(i) Suggest a reason for the difference in radius of a fluorine atom when it forms a fluorine ion.

……………………………………………………………………………………………...

……………………………………………………………………………………………... [1]

(ii) Lithium and fluorine are found in the same period.

Suggest why the atomic radius decreases across a period.

……………………………………………………………………………………………...

……………………………………………………………………………………………... [1]

[Total: 7]

Section B [30 marks]
Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

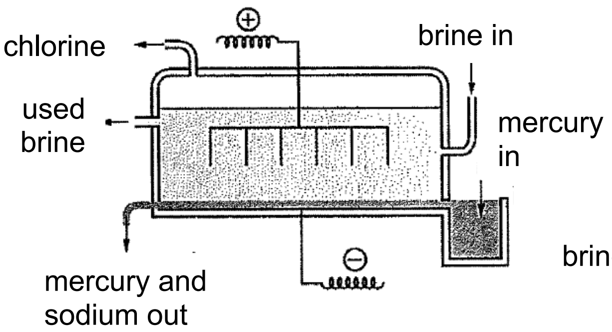
For Examiner's Use

B7 Read the information about the industrial electrolysis of brine.

Industrial Electrolysis of Brine
Brine is a concentrated solution of sodium chloride, containing about 25% by mass of sodium chloride. Electrolysis of brine produces chlorine, hydrogen and sodium hydroxide.

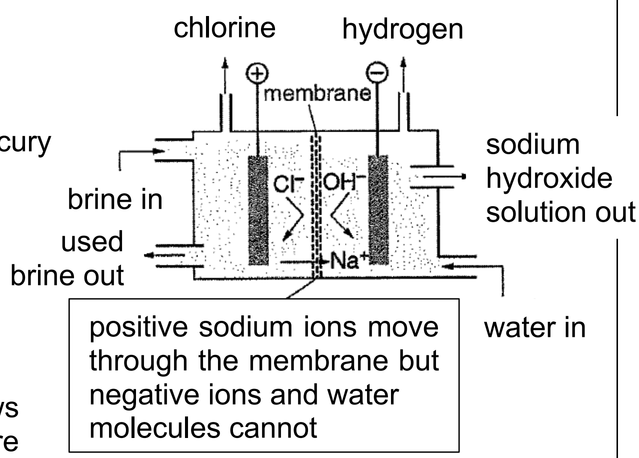
Industrial electrolysis of brine used to be carried out in mercury cells but is now mostly carried out in membrane cells. The diagrams below show how these cells work.

mercury cell



The sodium and mercury mixture flows into another tank (not shown) where sodium reacts with water to make sodium hydroxide and hydrogen.

membrane cell



The membrane cell allows sodium hydroxide and chlorine to be produced in the same cell. Without the membrane, the sodium hydroxide would not be pure because it would contain chloride ions.

One other problem that the membrane cell solves is that it keeps the chlorine gas and hydroxide ions separate. Chlorine and hydroxide ions react together which would reduce the amount of chlorine gas made and create more impurities in the sodium hydroxide.

The table below shows some information of the two types of cell.

	mercury	membrane
overall energy consumption (kWh per tonne of chlorine) 1 tonne = 1,000,000 g	3360	2650
purity of sodium hydroxide produced	high purity	high purity
concentration of sodium hydroxide produced	50% concentration	30% concentration
other points	mercury is toxic and must be removed from used brine	low maintenance costs

For Examiner's Use

(a) **(i)** In the membrane cell, it is important that negative ions do not pass through the membrane.

Explain why.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [3]

(ii) It is an advantage that negative ions do not pass through the membrane. Describe other advantages of using membrane cell instead of mercury cell.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(iii) Give a disadvantage of using membrane cell over mercury cell.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(b) Calculate the energy consumption of the membrane cell per mole of chlorine gas produced.

Give your answer to 3 significant figures.

[2]

For Examiner's Use

(c) **(i)** Write the overall equation for the reaction in the membrane cell.

……………………………………………………………………………….………..………… [1]

(ii) Calculate the maximum mass of sodium hydroxide that can be produced from 1 tonne of concentrated brine.

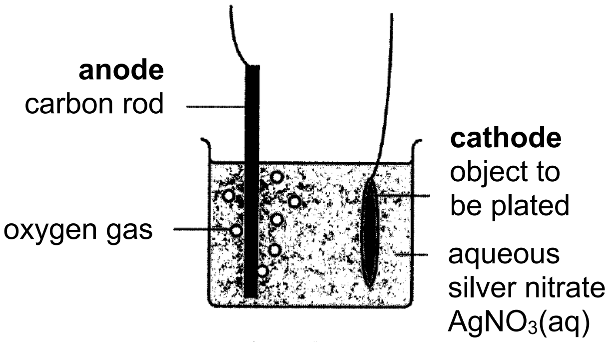
Give your answer to 3 significant figures.

[3]

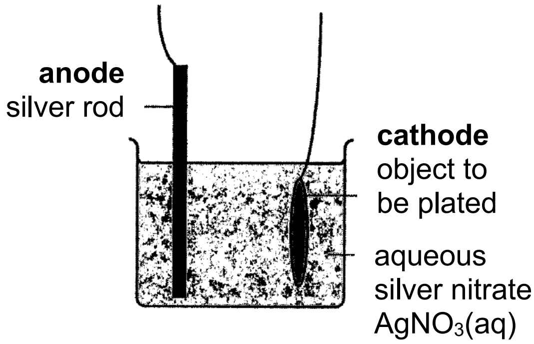
[Total: 12]

B8 A student sets up two different experiments for electroplating an object with silver.

For Examiner's Use



Experiment 1



Experiment 2

(a) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

experiment 1

anode: ....

cathode: ....

experiment 2

anode: ....

cathode: .... [3]

(b) At the beginning of each experiment the student removes a sample of the electrolyte, aqueous silver nitrate, and puts it in a test-tube.

The student then adds a few drops of aqueous sodium chloride to the sample.

(i) Describe and explain what the student sees.

Include an ionic equation in your answer.

....

.... [2]

(ii) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is still being deposited on the object in experiment 2.

Suggest a reason for this observation and describe how he could use aqueous sodium chloride to find out if his reasoning is correct.

....

.... [2]

For Examiner's Use

(c) If an iron object is placed in a beaker of aqueous silver nitrate, a silver coating forms on the iron.

If a gold object is placed in aqueous silver nitrate, no reaction happens.

Explain why.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

[Total: 8]

For Examiner's Use

EITHER

B9 Poly(propene) and nylon are both used to make strong, waterproof ropes.

Poly(propene) is an addition polymer. Nylon is a condensation polymer.

(a) Describe the differences between addition polymers and condensation polymers.

....

....

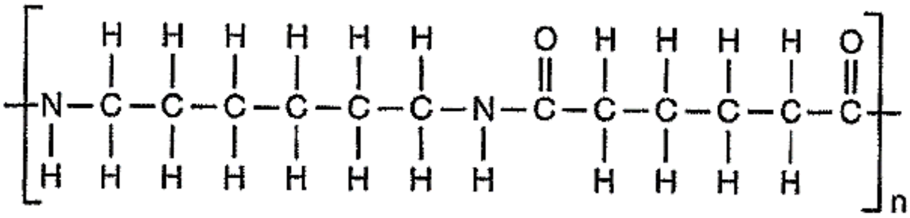
....

....

.... [3]

(b) There are several different types of nylon. One type of nylon is nylon-6,6.

This is the repeating unit of nylon-6,6.



(i) Draw the structures of the two monomers that react to form nylon-6,6.

monomer 1

monomer 2

[2]

For Examiner's Use

(ii) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range of 14 000 to 22 000.

What is the range of the average number of repeating units in the nylon-6,6 molecules?

Show your working.

[2]

(c) Nylon-5,10 is made by reacting these two monomers together.

$$H_2N{-}(CH_2)_5{-}NH_2 \quad + \quad HO{-}\overset{\overset{\Large O}{\|}}{C}{-}(CH_2)_8{-}\overset{\overset{\Large O}{\|}}{C}{-}OH$$

(i) Draw the repeating unit of nylon-5,10.

[1]

(ii) Give one similarity and one difference between the structures of the repeating units of nylon-6,6 and nylon-5,10.

similarity ....

....

difference ....

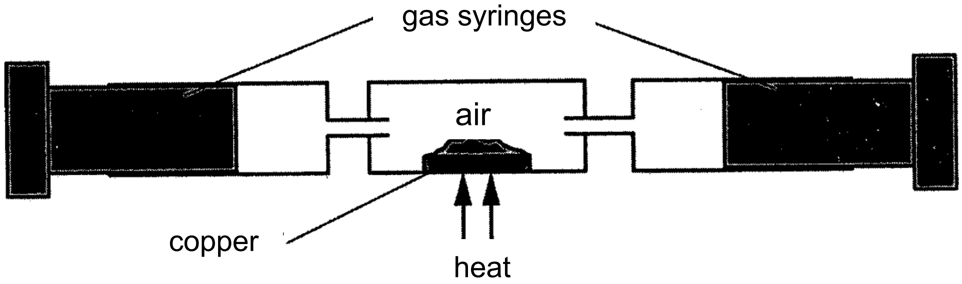
.... [2]

[Total: 10]

For Examiner's Use

OR

B10 An experiment (Experiment 1) was set up to heat copper in air.



At the start of Experiment 1, the apparatus contained a total of 200 cm^3 of air.

During heating, the copper reacted with oxygen in the air to form black copper(II) oxide.

The copper was heated until the volume of gas, measured at room temperature and pressure, remained constant.

(a) **(i)** Explain why it was important to continue heating until the volume remained constant.

....

.... [1]

(ii) The table shows some data about the mass change during the experiment.

mass of copper at the start of the experiment	**mass of solid left at the end of the experiment**
1.00 g	1.07 g

Use the data in the table to show that the solid left at the end of the experiment contains unreacted copper.

Show your working.

....

.... [3]

For Examiner's Use

(b) **(i)** Name the gas that is left in the gas syringes at the end of the experiment.

………………………………………………………………………………………….. [1]

(ii) Estimate the total volume of gas left in the gas syringes at the end of the experiment.

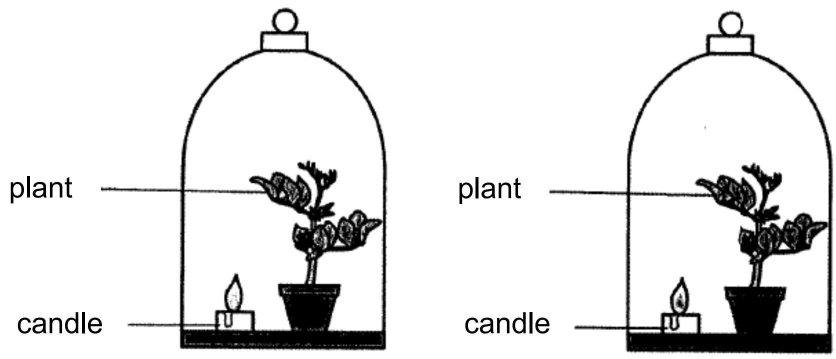
Explain your reasoning.

…………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(c) A burning candle and a plant were placed in two jars of air.

Both jars were left in sunlight.



Jar A **Jar B**

A 200 cm^3 sample of air from Jar A was tested immediately after the candle burned out using the same procedure as in Experiment 1.

A 200 cm^3 sample of air from Jar B was tested a few days after the candle burned out using the same procedure as in Experiment 1.

Describe and explain how the results of the tests would differ for each jar.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….. [3]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			proton (atomic) number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is $24\,dm^3$ at room temperature and pressure (r.t.p.).

BEATTY SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
SECONDARY FOUR EXPRESS

CANDIDATE NAME	
CLASS	
REGISTER NUMBER	

CHEMISTRY

6092/02

Paper 2

19 August 2022

Setter: Mr Yeo Chee Keong

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
A	50
B7	12
B8	8
B9…	10
Total	80

This document consists of **20** printed pages and **0** blank page.

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Use the list of substances to answer the questions.

You may use each substance once, more than once or not at all.

iodine

ozone

dichloroethane

magnesium

potassium manganate(VII)

copper(II) sulfate

calcium chloride

diamond

(a) Which substance is a good reducing agent?

.... [1]

(b) Which substance can be formed under ultraviolet radiation conditions?

.... [1]

(c) Which substance exists as three different colours when the physical state is changed?

.... [1]

(d) Which **two** substances can react to undergo a redox reaction?

.... [1]

(e) Which substances are elements?

.... [1]

[Total: 5]

A2 Lithium is a metal with low melting point and low density. It can react with cold water to form lithium hydroxide and hydrogen gas.

(a) Write a chemical equation for the reaction of lithium with cold water.

.... [1]

(b) Given that 0.2 g of lithium metal was used in the reaction with an excess of cold water, determine the volume of hydrogen gas produced.

[2]

(c) Describe how you can determine that the reaction has reached completion.

....

.... [1]

[Total: 4]

A3 Hydrochloric acid reacts with methanol to form chloromethane and water in the equation as shown.

$$HCl(aq) + CH_3OH(aq) \rightarrow CH_3Cl(g) + H_2O(l)$$

(a) Briefly describe a practical method by which the concentration of hydrochloric acid can be determined in a sample.

....

....

....

....

....

....

....

....

....

.... [3]

(b) Fig. 3.1 shows how the concentration of hydrochloric acid changes as the reaction proceeds.

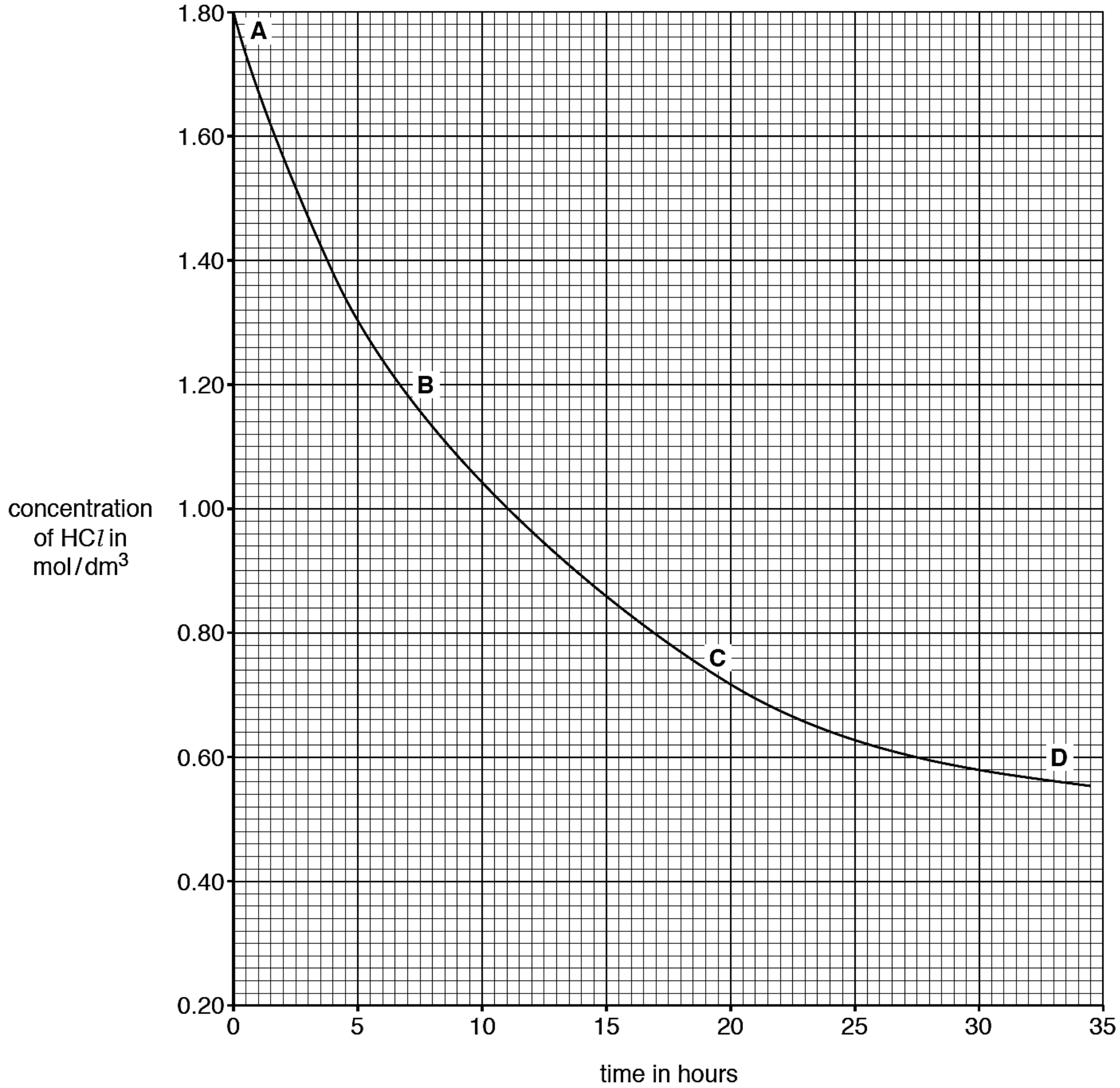


Fig. 3.1

(i) Deduce the concentration of hydrochloric acid 4 hours from the start of the experiment.

concentration = ... mol/dm^3 [1]

(ii) With reference to the graph in Fig. 3.1, explain clearly whether hydrochloric acid or methanol is the limiting reactant.

....

....

.... [2]

(iii) Explain why point **A** in Fig. 3.1 has the fastest rate of reaction.

.... [1]

(iv) Enriq thinks that the average rate of the reaction can be determined by the formula as shown:

$$\left(\frac{\text{rate at point }\mathbf{A}+\text{rate at point }\mathbf{B}+\text{rate at point }\mathbf{C}+\text{rate at point }\mathbf{D}}{4}\right)$$

Do you agree with Enriq? Explain your answer.

....

....

.... [2]

(c) The rate of formation of chloromethane and water can be changed by altering some conditions.

(i) Draw on Fig. 3.1, the curve that you would expect if the experiment was repeated with hydrochloric acid at a higher temperature.

[1]

(ii) Use ideas about collisions between particles to describe and explain how the rate of a reaction changes when the concentration of hydrochloric acid is increased.

....

....

....

.... [2]

(iii) Use kinetic particle theory to explain why increasing the pressure of the reaction chamber has little or no effect on the rate of reaction.

....

....

.... [2]

[Total: 14]

A4 Hydrogen is an important source of fuel as it burns cleanly and has a high energy content per unit mass. Hydrogen can be produced from the steam-methane reforming reaction shown in Step 1.

Step 1: $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +206$ kJ/mol

The carbon monoxide produced can undergo water-gas shift reaction to produce more hydrogen shown in Step 2.

Step 2: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ $\Delta H = -41.0$ kJ/mol

(a) Based on **Step 1** and **Step 2**, write the overall equation for the production of hydrogen gas. Include the overall enthalpy change.

.... [2]

(b) Give **two** reasons why it is better to produce hydrogen using both steps of the reaction in **(a)** than using **Step 1** alone. Explain your answer clearly.

....

....

....

....

.... [4]

(c) Another method of hydrogen production is through the electrolysis of pure water as shown.

$$2H_2O(l) \rightarrow O_2(g) + 2H_2(g) \quad \Delta H = +484 \text{ kJ/mol}$$

However, this electrolytic process takes place very slowly. Explain why the reaction takes place very slowly and suggest a modification to make the reaction proceed faster.

explanation ....

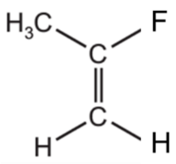
....

modification ....

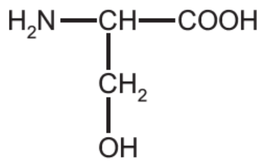
.... [2]

[Total: 8]

A5 The diagram shows two organic molecules, **A** and **B** which can undergo polymerisation.



A



B

(a) State the type(s) of polymerisation that both molecules can undergo.

molecule **A** ……………………………………………………………………………..

molecule **B** ……………………………………………………………………….. [2]

(b) Draw the structure of **two** repeating units when molecule **A** undergoes polymerisation.

[1]

(c) Suggest why polymers made from molecule **B** show a wider range of properties than polymers made from molecule **A**.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

…………………………………………………………………………………………… [2]

[Total: 5]

A6 Ethanol can be manufactured by the hydration of steam with ethene and the fermentation of glucose solution. Table 6.1 shows a comparison of both methods producing ethanol.

Table 6.1

method	fermentation	hydration
raw material	glucose	ethene
reaction	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	$C_2H_4 + H_2O \rightleftharpoons C_2H_5OH$
operating pressure	1 atm	60 to 70 atm
type of process	batch (stop-start)	continuous (runs all the time)

(a) State the source of the raw materials used for both methods.

source of glucose …………………………………………………………………………...

source of ethene …………………………………………………………………… [1]

(b) With reference to Table 6.1, suggest one reason why hydration is preferred over fermentation to produce ethanol.

....

.... [1]

(c) Table 6.2 shows the amount of ethanol formed when one mole of ethene reacts with one mole of steam under different conditions.

Table 6.2

temperature / °C	pressure / atm	amount of ethanol / mol
250	50	0.420
300	50	0.400
300	60	0.460
300	70	0.550
350	50	0.380

(i) Describe the effect of temperature changes on the amount of ethanol formed.

....

.... [1]

(ii) Hence, explain why the optimum temperature of 300 °C was used.

....

.... [1]

(iii) High pressures of up to 200 atm were **not** used in the reaction as an unwanted product may be formed.

Name this unwanted product.

.... [1]

(iv) Given that 40 g of ethene was used, calculate the actual **number of moles** of ethanol formed and the **percentage yield** for the reaction conditions occurring at 300 °C and 70 atm.

[2]

(d) Peihao claims that the hydration of ethene with steam is an exothermic reaction.

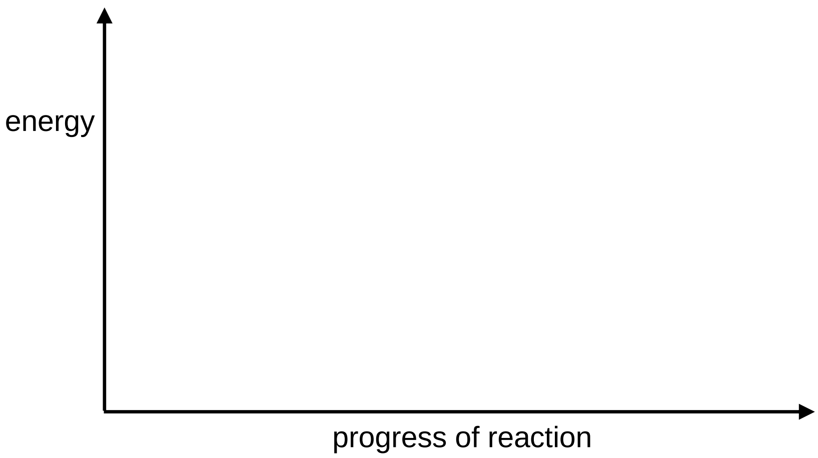
Do you agree with him? Use the bond energies in Table 6.3 to justify your answer.

Table 6.3

bond	bond energy, in kJ/mol	bond	bond energy, in kJ/mol
H − H	436	C − O	358
O − H	463	C − H	412
C = C	612	C − C	348

.... [3]

(e) Draw the energy profile diagram for the reaction in **(d)**. Label on the diagram the activation energy and the enthalpy change.



[3]

(f) Draw a structural isomer of ethanol.

[1]

[Total: 14]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or question and only one of the alternatives should be attempted.

B7 Properties of Transition Metals

Transition metals have similar properties like main group (Group I and II) metals. In addition, transition metals exhibit variable oxidation states, form coloured compounds and their compounds can be used as catalysts.

<u>Variable Oxidation States</u>

As d-block elements in Period 3, transition metals can hold up to 18 electrons in the third electron shell. Beyond argon (2,8,8), the electronic configuration of Period 4 elements require the knowledge of the orbital theory. Specifically, Period 4 elements' electronic configuration would be represented by d-orbitals (3d) and s-orbitals (4s).

4s orbitals are lower in energy than 3d orbitals, hence electrons occupy the 4s orbitals before the 3d orbitals. The s-orbitals can hold a maximum of two electrons while the d-orbitals can hold a maximum of ten electrons.
An illustration of the electronic configuration of scandium is shown below.

number of electrons in the orbital

$$[Ar]4s^{2}3d^{1}$$

electron shells

Electronic configuration of argon (2,8,8) is simplified as [Ar], where [Ar] represent 18 electrons.

The electronic configuration of some elements in Period 4 are shown in Table 7.1.

Table 7.1

proton number	element	electronic configuration
19	potassium	$[Ar]4s^1$
20	calcium	$[Ar]4s^2$
21	scandium	$[Ar]4s^2 3d^1$
22	titanium	$[Ar]4s^2 3d^2$
23	vanadium	$[Ar]4s^2 3d^3$
24	chromium	
25	manganese	$[Ar]4s^2 3d^5$
26	iron	
27	cobalt	
30	zinc	$[Ar]4s^2 3d^{10}$

Transition metals can have variable oxidation states due to the loss of electrons in the 4s and 3d orbitals. For example, titanium can have variable oxidation states of +1, +2, +3 and +4 from the loss of electrons from the 4s and 3d orbitals.

Coloured Compounds

Transition metals form coloured compounds. This is due to several reasons. First, the five d-orbitals split into two different energy levels when a compound is formed as shown in Fig. 7.1.

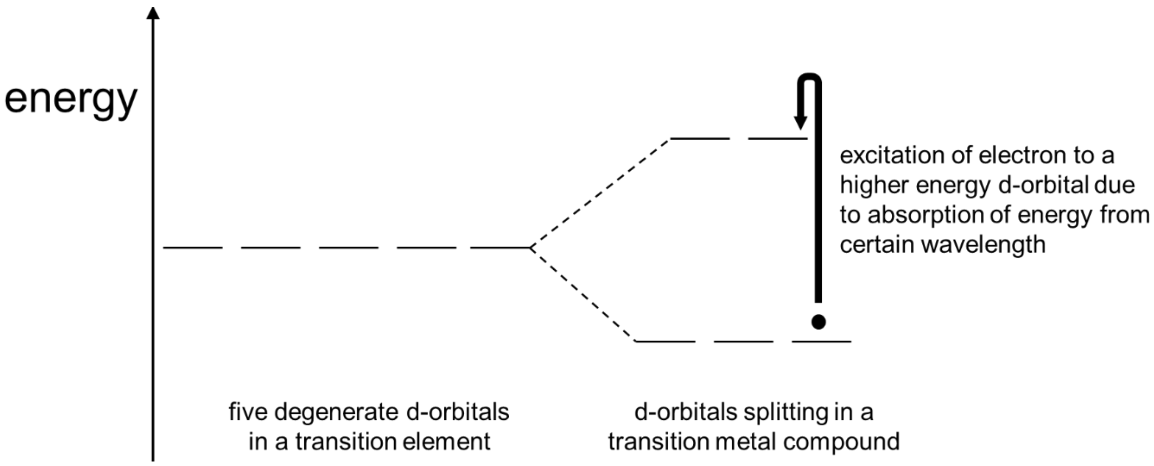
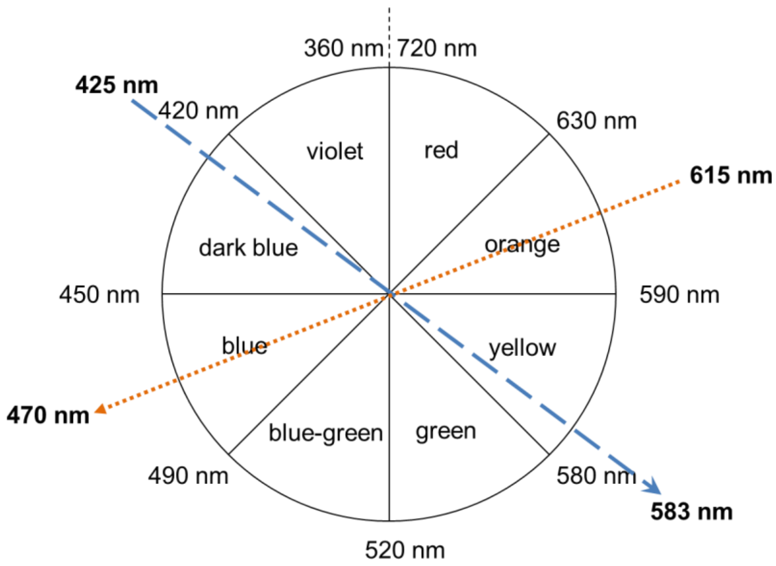


Fig. 7.1

Second, the electron in the lower energy d-orbitals absorbs a certain wavelength of light within the visible region of the electromagnetic spectrum and is excited (moved) to a higher energy level of the **empty or partially filled d-orbital** as shown in Fig. 7.1.

Third, the **colour observed** by our eyes is the **complement of the colour absorbed.** Fig. 7.2 shows the wavelengths absorbed by the different compounds of iron and copper and the colour observed.



solutions	wavelength absorbed (colour)	wavelength observed (colour)
copper(II) compound	615 nm (orange)	470 nm (blue)
iron(III) compound	425 nm (dark blue)	583 nm (yellow)

Fig. 7.2

One example illustrated in Fig. 7.2 would be that some solutions of copper(II) compound absorbed wavelengths at around 615 nm (orange colour) and the wavelengths observed are at around 470 nm (blue colour), which is observed by us as blue solutions.

Catalytic properties

Transition metals and their compounds are good catalysts as they provide a binding site for the reactants to react. This helps to increase the rate of reaction.
The catalysed conversion of sulfur dioxide to sulfur trioxide using vanadium(V) oxide in the two-step reaction is shown.

Step 1: $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$
Step 2: $2V_2O_4 + O_2 \rightarrow 2V_2O_5$

(a) With reference to Table 7.1, write the electronic configuration of iron and cobalt.

electronic configuration of Fe ....

electronic configuration of Co .... [2]

(b) **(i)** State all the possible oxidation states that vanadium can have.

.... [1]

(ii) Is it possible for manganese to have an oxidation state of +8? Explain your answer.

....

.... [1]

(c) **(i)** A sample solution **Z** absorbs a wavelength of around 680 nm.

With reference to Fig. 7.2, state the **colour** of wavelength **absorbed** by solution **Z**.

.... [1]

(ii) Nickel(II) chloride solutions absorb a wavelength of around 395 nm.

With reference to Fig. 7.2, state the **colour** of wavelength **observed** from a solution of nickel(II) chloride.

.... [1]

(iii) With reference to Fig. 7.1 and Fig. 7.2, explain why nickel is able to form coloured compounds when reacted with chlorine.

....

....

....

....

....

.... [3]

(d) Zinc is a Period 3 transition metal with the electronic configuration $[Ar]4s^2 3d^{10}$. However, solutions of zinc compounds are colourless.

With reference to the data given, explain why solutions of zinc compounds appear colourless.

....

.... [1]

(e) **(i)** Explain how the conversion of sulfur dioxide to sulfur trioxide shows that vanadium(V) oxide acts a catalyst.

....

.... [1]

(ii) Briefly explain how a catalyst increases the rate of reaction.

....

.... [1]

[Total: 12]

B8 Fig. 8.1 shows the carbon dioxide concentration in the atmosphere in the Northern Hemisphere between 1965 and 2014.

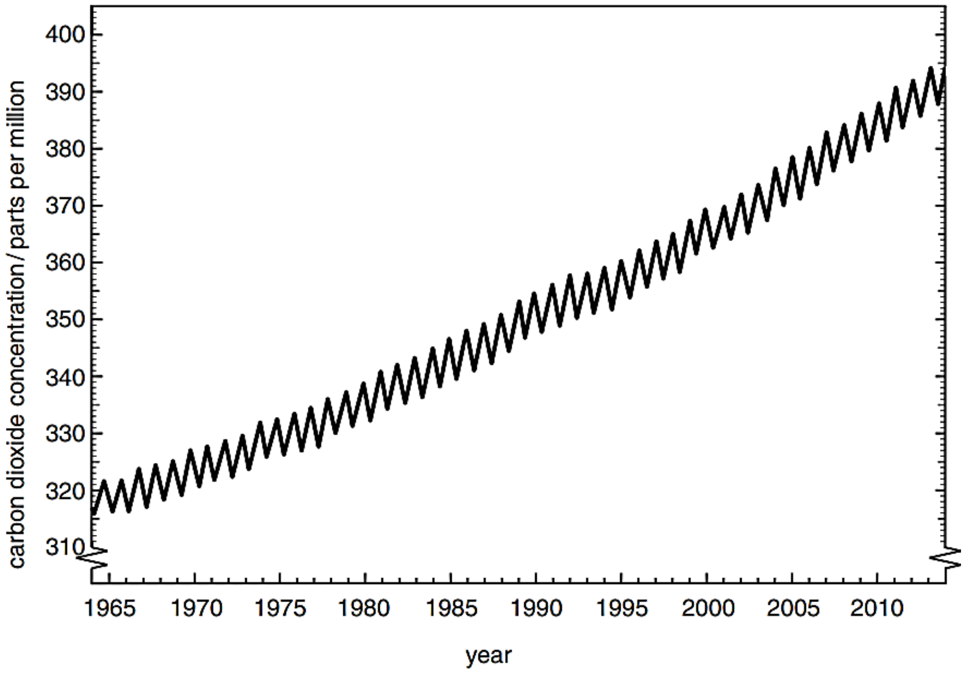


Fig. 8.1

(a) **(i)** Describe the general trend observed in Fig. 8.1.

.... [1]

(ii) Explain the changes in the carbon dioxide concentration over the 50-year period observed in **(a)(i)**.

....

....

.... [2]

(iii) The concentration of carbon dioxide **varies within the year**, where the lowest concentration of carbon dioxide was observed during summer times in June, and the highest concentration of carbon dioxide observed during winter times in December.

Describe and explain the trend observed **within each year**.

....

....

....

....

....

.... [3]

(b) **(i)** Explain why it is important to regulate the concentration of carbon dioxide in the atmosphere.

....

....

.... [1]

(ii) State one effect brought about by the high concentrations of carbon dioxide.

....

.... [1]

[Total: 8]

EITHER

B9 Wayne sets up a simple electric cell experiment shown in Fig. 9.1.

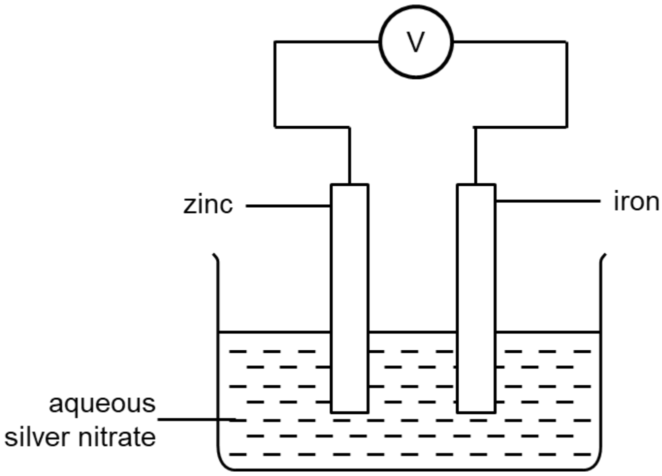


Fig. 9.1

(a) Use your knowledge of energy conversion to explain why the simple electric cell in Fig. 9.1 is also known as a potable battery.

....

.... [1]

(b) Write ionic equations for reaction at each electrode.

positive electrode ....

negative electrode .... [2]

(c) A small amount of grey deposit was observed at the bottom of the beaker.

Explain this phenomenon observed.

....

....

.... [2]

(d) Skyler thinks that replacing the same number of moles of zinc metal with magnesium metal will increase only the rate but **not** yield of the product.

Do you agree? Explain your answer.

....

....

.... [2]

(e) Other than the small amount of grey deposit obtained, Wayne claims that his experiment setup is the best way to coat silver onto the iron object.

Suggest one reason this method of coating is **not** cost-effective.

……………………………………………………………………………………………….

……………………………………………………………………………………… [1]

(f) Draw another experiment setup that can efficiently coat the iron object with silver.

[2]

[Total: 10]

OR

B9 Table 9.1 shows the melting points of some compounds formed with Period 3 elements.

Table 9.1

compound	melting point / °C	compound	melting point / °C	compound	melting point / °C
sodium fluoride	990	sodium oxide	1130	sodium chloride	808
magnesium fluoride	1260	magnesium oxide	2850	magnesium chloride	715
aluminium fluoride	1290	aluminium oxide	2070	aluminium chloride	190
silicon tetrafluoride	−90	silicon dioxide	1710	silicon tetrachloride	−68

(a) Jie Xi thinks that the type of anion affects the melting point of the **metallic compounds** formed.

Do you agree with her? Use the information in Table 9.1 to describe any trends observed and the attractive forces between particles to explain your answer.

....

....

....

....

....

....

....

.... [3]

(b) **(i)** Theoretically, a more reactive metal forms stronger ionic bonds in its compounds. Explain why this statement is true.

....

.... [1]

(ii) Is the theory in **(b)(i)** applicable to the compounds listed in Table 9.1? Use the information in Table 9.1 to support your answer.

....

.... [1]

(c) **(i)** Draw a 'dot-and-cross' diagram for silicon tetrachloride.

Show outer electrons only.

[2]

(ii) With reference to the structure and bonding, explain the difference in the melting points of silicon dioxide and silicon tetrachloride.

....

....

....

....

.... [3]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			proton (atomic) number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

CHRIST CHURCH SECONDARY SCHOOL
2022 PRELIMINARY EXAMINATION
FOUR EXPRESS

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S	INDEX NUMBER	

CHEMISTRY 6092/02

Paper 2

08 July 2022

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number, name and class on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	
Section B	
8	
9	
10 Either	
10 Or	
Total	

This document consists of **24** printed pages.

Section A

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Fig. 1.1 shows part of the Periodic Table. Only some of the elements are shown.

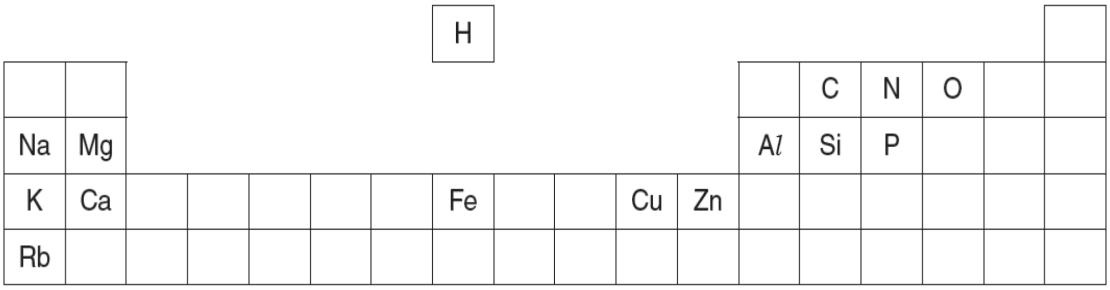


Fig. 1.1

(a) Each element may be used once, more than once or not at all.
Use the symbols used in the diagram.

Give **one** element which

(i) has a giant molecular structure,

………………………………………………………………………………………….. [1]

(ii) combines with oxygen to form a gas which contributes to acid rain,

………………………………………………………………………………………….. [1]

(iii) forms an ion of type X^+ which has only three completely filled shells of electrons,

………………………………………………………………………………………….. [1]

(iv) forms a chloride with the formula XCl_2 and forms white precipitate insoluble in excess sodium hydroxide solution.

………………………………………………………………………………………….. [1]

(b) Arsenic reacts with oxygen to form arsenic(III) oxide, As_2O_3.
Construct a balanced chemical equation for this reaction.

………………………………………………………………………………………….. [1]

(c) Arsenic(III) oxide is slightly soluble in water. Arsenous acid, $\mathbf{H_3AsO_3}$, a weak acid is formed.

100 cm^3 of 0.05 mol/dm^3 of both arsenous acid and hydrochloric acid are added separately to excess magnesium.

(i) Suggest whether arsenous acid will produce more, less or the same volume of hydrogen compared to hydrochloric acid?

……………………………………………………………………………………….. [1]

(ii) Will the **pH** of arsenous acid solution be higher, lower or the same as hydrochloric acid?

……………………………………………………………………………………….. [1]

[Total: 7]

A2 Niobium, Nb, is a transition element. Sodium is an element in Group I of the Periodic Table.

(a) Describe two properties of niobium which are different from sodium.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

………………………………………………………………………..…………………….[2]

(b) Niobium chloride is a covalent molecule. Fig. 2.1 shows the structure of niobium chloride.

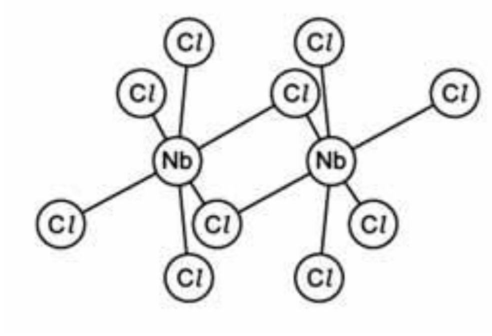


Fig. 2.1

(i) What is unusual about the structure of niobium chloride?

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………..……..[1]

(ii) State the molecular formula of niobium chloride.

……………………………………………………………………………….…..………..[1]

(c) Sodium chloride has a much higher melting point than niobium chloride.

(i) Draw a 'dot-and-cross' diagram to show the electronic structure of sodium chloride. You only need to show the outer shell electrons.

[2]

(ii) Use your knowledge of bonding in sodium chloride and niobium chloride to explain the difference in their melting points.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[3]

(d) Describe a simple experiment which you could carry out to determine whether an aqueous solution contained an ionic or covalent compound.

Your answer should clearly state all the equipment required and how the observations made would lead to the conclusion.

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………[3]

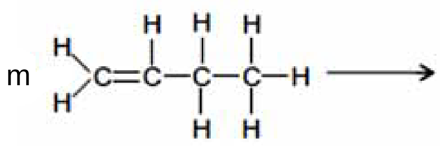
[Total: 12]

A3 **(a)** Polybutadiene is a synthetic rubber which is used in the manufacture of car tyres. It is non-biodegradable. More than 2 million tonnes of polybutadiene are produced annually as shown by the reaction in Fig. 3.1.

Fig. 3.1

Polybut-1-ene is a non-toxic, colourless and odourless material which is used in the manufacture of plastics, cosmetics and adhesives. It is made by polymerising but-1-ene.

(i) Complete the equation in Fig. 3.2 by drawing in the box provided the structure of the polybut-1-ene formed.



but-1-ene polybut-1-ene

[1]

Fig. 3.2

(ii) Describe one difference in the structure between polybutadiene and polybut-1-ene.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(iii) Give one chemical test and observations that can be used to distinguish between polybutadiene and polybut-1-ene.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(iv) Suggest one property of polybutadiene which makes it a suitable material to make car tyres.

…………………………………………………………………………………………

……………………………………………………………………………...……….[1]

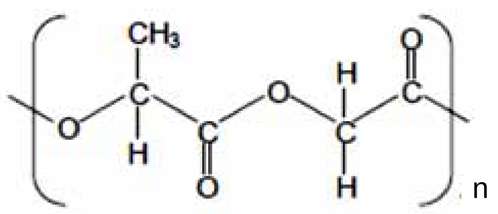
(v) Equal masses of polybutadiene and polybut-1-ene are burnt in air.

Which substance is more likely to burn with a more smoky flame?
Explain your answer.

…………………………………………………………………………………………

………………………………………………………………………………………[1]

(b) Some biopolymer stitches are made of materials that the human body produces naturally. These stitches need not be removed as the body can absorb them when the wound is healed. The structure for one of these biopolymers is shown below.



This biopolymer is made from the polymerisation of two different monomers.

Draw the structural formulae of the two monomers in the boxes below.

monomer 1	monomer 2

[2]

[Total: 8]

A4 Hydrazine, N_2H_4, is used as a rocket fuel. The equation for the combustion of hydrazine given below.

$$N_2H_4(g) + O_2(g) \longrightarrow 2H_2O(g) + N_2(g) \qquad \Delta H = -622 \text{ kJ/mol}$$

(a) Explain, in terms of bond breaking and bond forming, why the above reaction is an exothermic reaction.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………..[2]

(b) Draw the energy profile diagram for the reaction between hydrazine and oxygen. On your diagram, label clearly the following.

- axes
- ΔH of reaction,
- activation energy, E_a,
- reactants and products

[3]

(c) Hydrazine also undergoes another reaction with fluorine

$$N_2H_4(g) + 2F_2(g) \longrightarrow 4HF(g) + N_2(g)$$

Table 4.1 gives information about the bond energy of some bonds.

Table 4.1

Bond	bond energy (Kj/mol)
N – N	163
N – H	390
F – F	158
H – F	565
N ≡ N	945

Calculate the ΔH for the reaction between hydrazine and fluorine.

[2]

[Total: 7]

A5 Ammonia gas can be decomposed to nitrogen gas and hydrogen gas.

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$$

(a) Other than the reaction above, name one **other** source of hydrogen gas for the aerospace industry.

……………………………………………………………………………………………[1]

(b) One of the uses of ammonia is in the manufacture of nitric acid. This is done by a two-stage process.

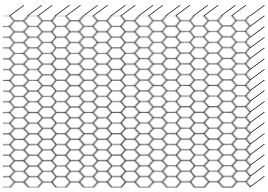
Stage 1: ammonia is converted to nitrogen(II) oxide.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

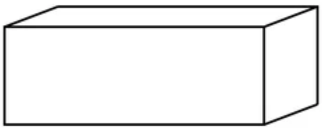
Stage 2: nitrogen(II) oxide is converted to nitric acid.

$$4NO(g) + 2H_2O(l) + 3O_2(g) \rightarrow 4HNO_3(aq)$$

(i) In **stage 1**, ammonia and oxygen are passed through a porous honeycomb-shaped catalyst A and a non-porous block-shaped catalyst B, of the same mass.



catalyst A



catalyst B

Explain, in terms of collision theory, which catalyst, A or B, is more efficient.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) Explain, in terms of oxidation states, why **stage 2** is a redox reaction.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(iii) Calculate the maximum mass of nitric acid which can be produced from 720 dm^3 of ammonia measured at room temperature and pressure.

[2]

(iv) Use the two equations from **stage 1** and **stage 2** to construct an overall equation for the conversion of ammonia to nitric acid.

…………………………………………………..………………………………..[1]

[Total: 8]

A6 Fig. 6.1 gives the set-up used to investigate the relative reactivity of various metals, A, B, C and D. The metal strips and copper were first cleaned with sandpaper. Various metal strips were connected in turn with the copper sheet and the voltage recorded.

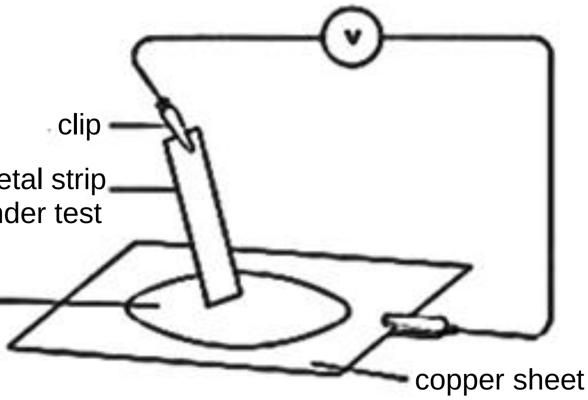


Fig. 6.1

Table 6.1 gives the results of the investigation.

Table 6.1

metal under test	direction of electron flow in the external circuit	voltage recorded (volts)
A	A to Cu	+ 1.40
B	Cu to B	- 2.22
C	A to C	+ 0.77
D	A to D	+ 0.28

(a) Explain why the metal strips and copper sheet were first cleaned with sandpaper.

……………………………………………………………………………………………...

……………………………………………………………………………………………..[1]

(b) Which of these metal(s) is/are less reactive than copper?
Explain your answer in terms of electron flow and the results shown in Table 6.1

……………………………………………………………………………………………...

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..[2]

(c) Using the results in Table 6.1, arrange the four metals A, B, C and D in decreasing order of reactivity.

……………………………………………………………………………………..………[1]

[Total: 4]

A7 **(a)** Table 7.1 shows data about the melting point and boiling point of three halogens, chlorine, bromine and iodine.

Complete Table 7.1 by filling in the names of the halogens.

Table 7.1

name of halogen	melting point / ^{o}C	boiling point / ^{o}C
	- 7.2	58.8
	-100.9	-34.7
	113.8	184.5

[1]

(b) Sea water contains potassium bromide.

Bromine can be produced from sea water by displacement.

Name an element that can displace bromine from sea water. Give a reason for your choice.

…..……………………………………………………………………………………….…

………………………………………………………..……………….……………......[1]

(c) Table 7.2 shows the colours of some silver halide precipitates and the observations made when the precipitates are left to stand.

Table 7.2

silver halide	colour of precipitate	observations on standing
silver chloride	white	rapid formation of grey solid
silver bromide	cream	slow formation of grey solid
silver iodide		no visible change after several minutes

[1]

(i) Complete Table 7.2 to show the colour of silver iodide precipitate.

(ii) What conclusion can you make about the relationship between the reactivity of halogen and the rate of breakdown of silver halide.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

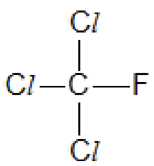
[Total:4]

Section B

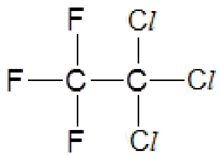
Answer all **three** questions from this section.
The last question is in the form **EITHER / OR** and only **one** of the alternatives should be attempted.

B8 Chlorofluorocarbons (CFCs) are inert on the Earth's surface. However in the stratosphere, they are very reactive. CFCs are part of a group of compounds which can be classfied as ozone depleting compounds. Other than CFCs, there are also hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs) and perfluorocarbons (PFCs).

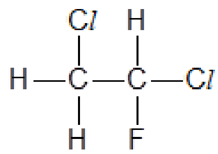
Some common examples of CFC and HCFC molecules are shown in Fig. 8.1 below with their names.



CFC - 11



CFC - 113A



HCFC - 141

Fig. 8.1

A naming system for these substances was devised several decades ago. The prefixes to the name tell us the elements present in the compound as shown in Table 8.1 below.

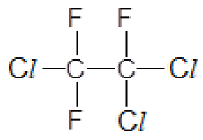
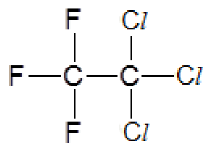
Table 8.1

prefix	elements present
PFC	carbon, fluorine
CFC	carbon, fluorine, chlorine
HFC	hydrogen, carbon, fluorine
HCFC	hydrogen, carbon, fluorine, chlorine

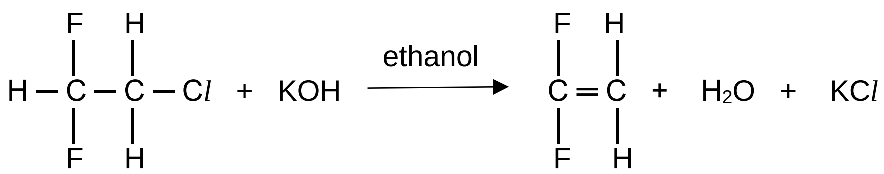
The numbers suffixed to the names of the compounds give us the number of each type of atom present in one molecule of the compound. The key to decoding the number is simply to add 90 to the number suffixed to the name.

For example, to decode the number of atoms in CFC - 113A, we add 113 to 90 to obtain 203. The first number, 2, tells us the number of carbon atoms, the second number, 0, tells us the number of hydrogen atoms and the third number, 3, tells us the number of fluorine atoms. Chlorine atoms make up the remaining bonds since all these compounds are saturated.

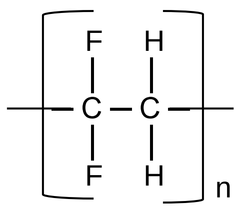
The letter ‘a’ in CFC - 113a tells us about the structural formula of the compound. The arrangement of the type of atoms in the compound that most evenly distributes atomic masses has no letter. The second most even distribution is given the letter ‘a’, the third most even distribution is given the letter ‘b’, so on and so forth.

molecule	atomic mass of left carbon	atomic mass of right carbon
 CFC - 113	73.5	90
 CFC - 113a	57	106.5

Although most of these substances are harmful to the ozone layer, they can also be used to make polymers by first converting them to alkenes. For example, HCFCs react with potassium hydroxide which is dissolved in ethanol (solvent) to give an alkene, potassium chloride and water. An example of the reaction is shown below.



The alkene produced from the above reaction can be used to make useful polymers such as the one shown below.



(a) Draw the structure of a PFC molecule with two carbon atoms.

[1]

(b) In the table given below, draw the **other** two isomers of HCFC -141 in the correct respective boxes.

HCFC -141a	HCFC - 141b

[2]

(c) A student comments that HFCs are safer alternatives to CFCs as HFCs do not harm the environment like CFCs do.

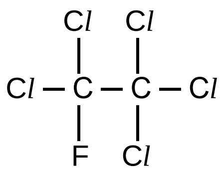
Explain why the student is correct.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

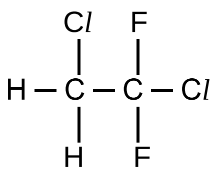
(d) Use the naming system discussed in the passage, write down the names of the following molecules.

(i)



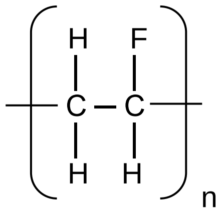
………………………………………………………………………………………[1]

(ii)



………………………………………………………………………………………[2]

(e) **(i)** A scientist wants to produce the polymer, polyvinyl fluoride, using HCFCs.



Using a suitable HCFC, write down **two** equations showing the reactions he has to carry out to produce polyvinyl fluoride.

Show the structures of all the organic compounds in your equations.

[3]

(ii) Samples of the polyvinyl fluoride polymer produced were analysed and found to have a maximum relative molecular mass of 12000.

Calculate the maximum number of repeating units for this polymer?

[2]

[Total: 12]

B9 **(a)** Six samples of carbonates are heated strongly until there is no further change in mass.

Table 9.1 shows the mass of solid remaining at the end of the heating.

Table 9.1

carbonate	mass before heating / g	mass after heating / g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
iron(II) carbonate	2.00	1.24
magnesium carbonate	2.00	0.95
sodium carbonate	2.00	2.00
zinc carbonate	2.00	1.30

(i) Explain why there is a decrease in mass for most carbonates except sodium carbonate.

....

....

....

....[2]

(ii) Which of the above carbonates is the **least** thermally stable? Explain your answer.

....

....

....

....[2]

(iii) For each carbonate, a 2.00 g sample was heated.

Explain why the mass of solid obtained after heating is different for each carbonate.

....

....

....

....[2]

(b) A student carried out an experiment to investigate the rusting of iron nails. He joined small pieces of different metals to identical iron nails and placed the nails in open test-tubes which contained a little water.

The observations that he made some days later are as shown in Fig. 9.1.

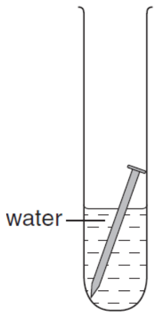
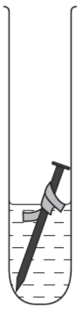
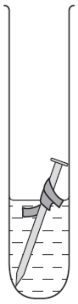
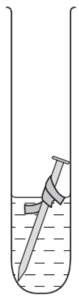
metal joined to nail	none (control)	tin	magnesium	zinc	copper
diagram of set-up					
observation	slight rusting	heavy rusting	no rusting	no rusting	heavy rusting

Fig. 9.1

What conclusions could the student draw from these observations?

....

....

....

....[2]

[Total: 8]

Either

B10 The speed of reaction between three compounds, hydrogen peroxide, hydrochloric acid and potassium iodide, was studied in a series of experiments.

$$H_2O_2(aq) + 2KI(aq) + 2HCl(aq) \longrightarrow 2H_2O(l) + I_2(aq) + 2KCl(aq)$$

The speed of reaction was measured using the rate of production of iodine as shown below.

$$\text{rate of production of iodine} = \frac{\text{change in concentration of iodine}}{\text{change in time}}$$

Table 10.1 shows the results obtained.

Table 10.1

experiment	concentration of H_2O_2 (mol/dm^3)	concentration of HCl (mol/dm^3)	concentration of KI (mol/dm^3)	rate of production of I_2 (mol/dm^3/s)
1	0.1	0.1	0.1	0.0001
2	0.2	0.1	0.1	0.0002
3	0.4	0.1	0.1	0.0004
4	0.1	0.2	0.1	0.0001
5	0.2	0.1	0.2	0.0004

(a) **(i)** Using the information given in Table 10.1, state how the concentration of potassium iodide affects the speed of reaction.

....

....

....[2]

(ii) Besides potassium iodide, identify another reactant whose concentration affects the speed of reaction and suggest how the speed is affected.

Explain your answer using the data provided in Table 10.1.

....

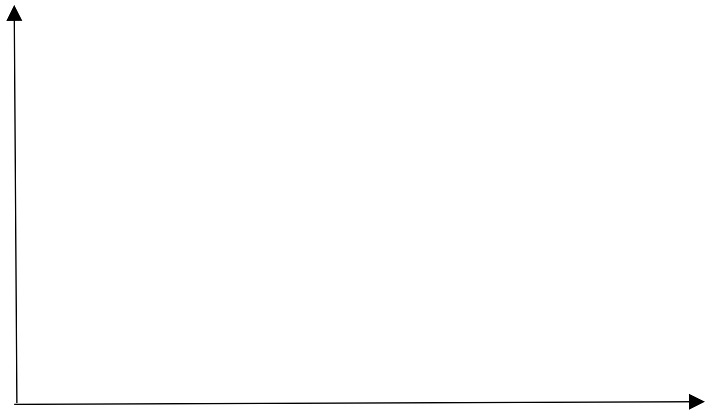
....

....

....

....[2]

(b) Sketch the graph of the concentration of hydrogen peroxide against the speed of reaction using the axes provided below.



[2]

(c) Besides concentration, state and explain using collision theory one **other** factor that increases the speed of reaction.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………..……[2]

(d) From experiment 1, assuming that hydrogen peroxide is the limiting reagent, calculate the mass of iodine formed in the reaction when the volume of hydrogen peroxide used is 100 cm^3.

[2]

[Total: 10]

Or
B10 A student electrolysed 2 dm^3 aqueous copper(II) sulfate using platinum electrodes. A current of 1 ampere was passed. The graph of gain in mass of the cathode against time is given in Fig 10.1.

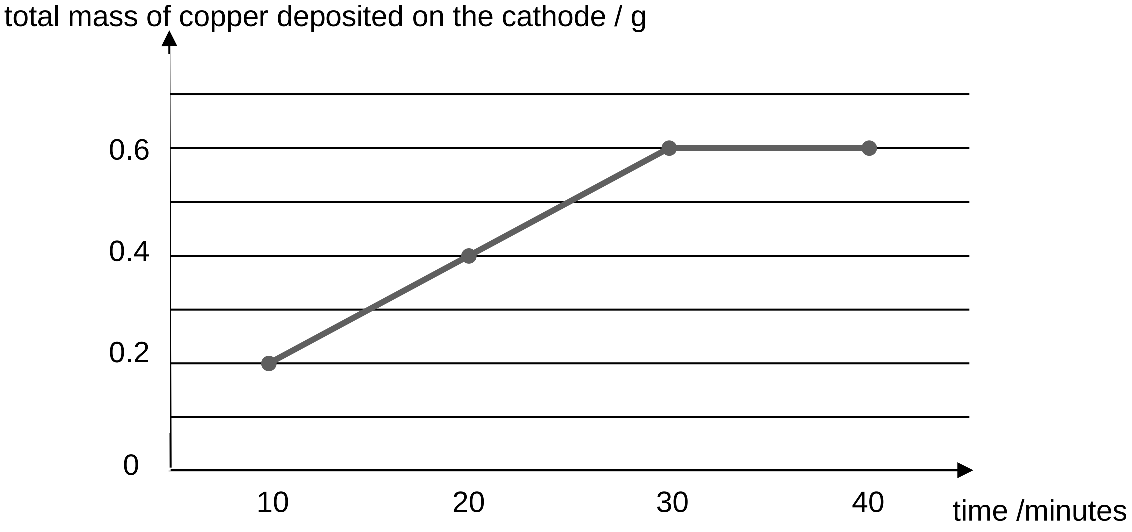


Fig 10.1

(a) Write ionic equations, including state symbols, to represent the formation of

(i) copper at the cathode,

…………………………………………………………………………………………[1]

(ii) oxygen at the anode.

…………………………………………………………………………………………[1]

(b) The solution initially contained 2.50 g of copper(II) sulfate crystals ($CuSO_4 . 5H_2O$).

(i) Calculate the initial concentration of the copper(II) sulfate solution in mol/dm^3.

[1]

(ii) From the graph, what mass of copper was deposited after 10 minutes? How many moles of copper is this?

[1]

(iii) What is the concentration of the copper(II) sulfate, in mol/dm^3, after 10 minutes?

[2]

(c) Describe and explain the change in the appearance of aqueous copper(II) sulfate over time.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………[2]

(d) Why does the mass of copper deposited at the cathode not increase after 30 minutes, although the volume of oxygen given off at the anode continues to increase after this time?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………[2]

[Total 10]

End of Paper

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name: ______________________________ (   )   Class: _____

CHIJ KATONG CONVENT
PRELIMINARY EXAMINATIONS 2022
Secondary Four Express

CHEMISTRY   6092/02

Duration: 1 hour 45 minutes

Class: 405, 406

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, registration number and class on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/ tape.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/ or.
Answer **all** questions in the spaces provided.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.

At the end of the examination fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
Paper 1	/ **40**
Section A	/ **50**
Section B	/ **30**
TOTAL	/ **120**

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Choose from the following oxides to answer the questions.

calcium oxide
iron(III) oxide
lithium oxide
magnesium oxide
nitrogen dioxide
silicon dioxide

Each oxide may be used once, more than once or not at all.

State which oxide

(a) has a simple molecular structure,

…………………………………………………………………………………… [1]

(b) is a coloured solid,

…………………………………………………………………………………… [1]

(c) contains ions with a +1 charge,

…………………………………………………………………………………… [1]

(d) is a product of the thermal decomposition of limestone,

…………………………………………………………………………………… [1]

(e) is used in the cracking of long-chain hydrocarbons.

…………………………………………………………………………………… [1]

[Total: 5]

A2 Table 2.1 shows a list of elements and their atomic and mass numbers.

Table 2.1

element	A	B	C	D	E	F	G	H
atomic number	8	11	15	17	18	28	30	35
mass number	16	23	31	37	40	59	65	80

A to H are not the atomic symbols of the elements.
Using the letters, A to H, choose an element which

(a) forms coloured compounds,

…………………………………………………………………………………………………… [1]

(b) forms an anion with a charge of -2 most readily,

…………………………………………………………………………………………………… [1]

(c) has lower density than potassium and reacts vigorously with water,

…………………………………………………………………………………………………… [1]

(d) forms a diatomic molecule which displaces bromine from sodium bromide solution.

…………………………………………………………………………………………………… [1]

[Total: 4]

A3 Fig. 3.1 shows a part of the metal reactivity series.

magnesium
aluminium
zinc
chromium
iron

more reactive
↓
less reactive

Fig. 3.1

(a) When chromium reacts with dilute hydrochloric acid, its oxidation state increases from 0 to +2.

Give the chemical formulae of the products formed when chromium reacts with dilute hydrochloric acid.

…………………………………………………………………………………………………… [1]

A3 **(b)** Aluminium is a reactive metal. However, when an aluminium wire is immersed in dilute hydrochloric acid, no visible reaction was observed.

Explain why this is so.

…..…………………………………………………………………………………………..…………..…

…..…………………………………………………………………………………………..…………..…

…..…………………………………………………………………………………………..…………..… [2]

(c) Pure zinc metal is soft and has limited uses as it corrodes easily.

A brass alloy consists of 11% copper and 89% zinc.

However it is widely used to make musical instruments and statues because of its corrosion resistance and aesthetic appearance.

Draw a labelled diagram to show the arrangement of the atoms in this brass alloy in the box provided.

[2]

[Total: 5]

A4 This question is about the reactions of aqueous potassium hydroxide.

(a) Aqueous potassium hydroxide reacts with dilute sulfuric acid as shown.

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

In an experiment, 0.78 g of aqueous potassium hydroxide was added to 45 cm^3 of 0.20 mol / dm^3 sulfuric acid.

Show by calculation that sulfuric acid is in excess.

[3]

(b) Aqueous potassium hydroxide is warmed with aqueous ammonium carbonate.

State the name of the gaseous product formed in this reaction.

.... [1]

[Total: 4]

A5 Hydrogen reacts with chlorine to produce hydrogen chloride. The reaction is represented by the equation.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \qquad \Delta H = -184 \text{ kJ / mol}$$

(a) Apart from temperature, state and explain, in terms of collisions between reacting particles, another factor that increases the rate of this chemical reaction.

....

....

....

.... [2]

A5 **(b)** **(i)** Calculate the energy released when excess hydrogen reacts with 2 moles of chlorine. You may assume that no other side reaction occurs.

energy released = ……………. kJ [1]

(ii) Explain why the reaction is exothermic, in terms of the energy changes that take place during bond breaking and bond making.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Total: 5]

A6 **(a)** Ammonia is manufactured by the Haber Process as shown in the equation.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta H = -92.4 \text{ kJ / mol}$$

Table 6.1 shows how the percentage yield of ammonia at equilibrium varies with both temperature and pressure.

Table 6.1

pressure / atm	percentage yield of ammonia at equilibrium			
	200 °C	300 °C	400 °C	500 °C
40	72	34	13	5
100	81	51	25	10
200	86	63	36	18
300	88	69	40	24

(i) Describe how the percentage yield of ammonia at equilibrium changes with temperature.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

A6 **(a)** **(ii)** Describe how the percentage yield of ammonia at equilibrium changes with pressure.

……………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(iii) Finely divided iron acts as a catalyst in the Haber Process.

Explain how using a catalyst has an economic advantage.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) The ammonia produced in the Haber Process is used to manufacture nitric acid by a two-stage process.

Stage 1 Ammonia is converted to nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

Stage 2 Nitrogen monoxide is converted to nitric acid.

$$4NO(g) + 2H_2O(g) + 3O_2(g) \rightarrow 4HNO_3(aq)$$

Use the equations in the two stages to construct an overall chemical equation for the conversion of ammonia to nitric acid.

…………………………………………………………………………………………… [1]

[Total: 5]

A7 This question is about alkanes and alkenes.

(a) The boiling point, melting point and density of alkanes increase as the number of carbon atoms increases.

State another physical property of alkanes which increases as the number of carbon atoms increases.

…………………………………………………………………………………………… [1]

(b) Two typical reactions of alkanes are combustion and cracking.

(i) State the name of another typical chemical reaction of alkanes.

…………………………………………………………………………………………… [1]

(ii) State the chemical name of the reactant for the reaction in **(b)(i).**

…………………………………………………………………………………………… [1]

A7 **(c)** Alkenes are produced by cracking alkanes. Tridecane, $C_{13}H_{28}$, can be cracked to produce an alkene with four carbon atoms and one other hydrocarbon only.

Construct a chemical equation for this reaction.

…………………………………………………………………………………………………… [1]

(d) A hydrocarbon contains 88.9% carbon by mass.

Calculate the empirical formula of this compound.

[2]

[Total: 6]

A8 The structure of an organic compound, T, is shown in Fig. 8.1.

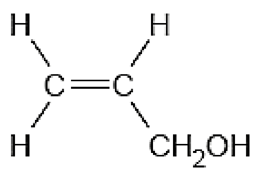


Fig. 8.1

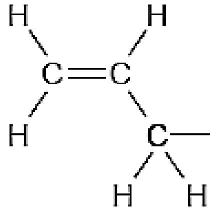
(a) Compound T can be oxidised to a carboxylic acid.

Suggest a suitable oxidising agent for this reaction.

…………………………………………………………………………………………………… [1]

(b) Compound T reacts with methanoic acid, HCOOH, to form an ester.

Complete the structure of this ester to show all the atoms and all the covalent bonds.



[1]

A8 **(c)** Dilute methanoic acid is a weak acid. Dilute nitric acid is a strong acid.

Give the formula of the ion that is present in both acids.

……………………………………………………………………………………………………… [1]

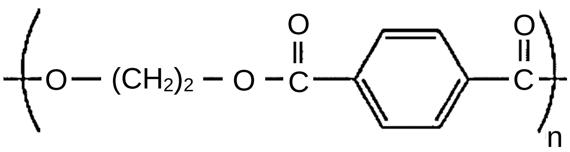
(d) Write a chemical equation for the reaction of methanoic acid with zinc.

……………………………………………………………………………………………………… [2]

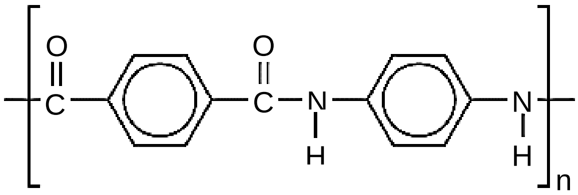
[Total: 5]

A9 Fig 9.1 shows the structure of some polymers A, B, C and D.

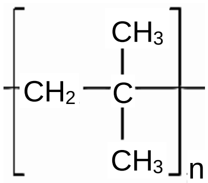
A



B



C



D

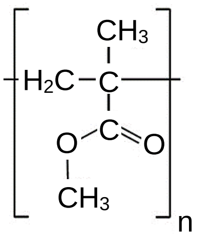


Fig. 9.1

(a) A sample of polymer C contains molecules with a relative molecular mass of 14 000.

Determine the number of carbon atoms present in a molecule of the polymer.

[2]

A9 **(b)** Predict if each statement is true or false.

Put a tick (√) in one box in each row.

	true	false
Polymer D is a polyester.		
Water is formed as a by-product when monomers react to form polymers A and B.		
The empirical formula of polymer C is the same as its monomer.		
One of the monomers that reacts to form polymer B is an alcohol.		

[2]

(c) Draw the structural formulae of the two monomers that react to form polymer A.

[2]

(d) **(i)** Draw the structural formula of the monomer that reacts to form polymer D.

[1]

A9 **(d)** **(ii)** The monomer in **(d)(i)** can be formed by reacting an acid and an alcohol under suitable conditions.

Draw the structural formulae of the acid and alcohol.

[2]

(e) Polymers A, B, C and D are non-biodegradable.

State why being non-biodegradable is both an advantage and a disadvantage.

………

………

………

……… [2]

[Total: 11]

Name: ______________________________ (   ) Class: _________

Section B

Answer all **three** questions in this section.
The last question is in the form of an either/ or and only one of the alternatives should be attempted.

B10 This question is about copper and its compounds.

(a) Anhydrous copper(II) sulfate is used to test for the presence of water. When this test is positive, hydrated copper(II) sulfate is formed.

(i) State the colour change observed during this test.

………………………………………………………………………………………………… [1]

(ii) State how hydrated copper(II) sulfate can be changed back into anhydrous copper(II) sulfate.

………………………………………………………………………………………………… [1]

(iii) Describe a test to determine if a sample of water is pure.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) When 4.7 g of copper(II) nitrate is heated strongly, it decomposes to produce copper(II) oxide, nitrogen dioxide and oxygen as shown by the chemical equation.

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

Calculate

(i) the volume of nitrogen dioxide formed at room temperature and pressure,

[2]

B10 (b) (ii) the mass of oxygen formed.

[2]

(c) Copper(II) oxide powder can be reduced to copper by reacting with hydrogen gas.

Write the chemical equation for this reaction with state symbols included.

………………………………………………………………………………………………….....[2]

[Total: 10]

B11 Figure 11.1 shows an experimental set-up of two cells, Cell 1 and Cell 2 connected together. Both electrodes X and Y are made of graphite.

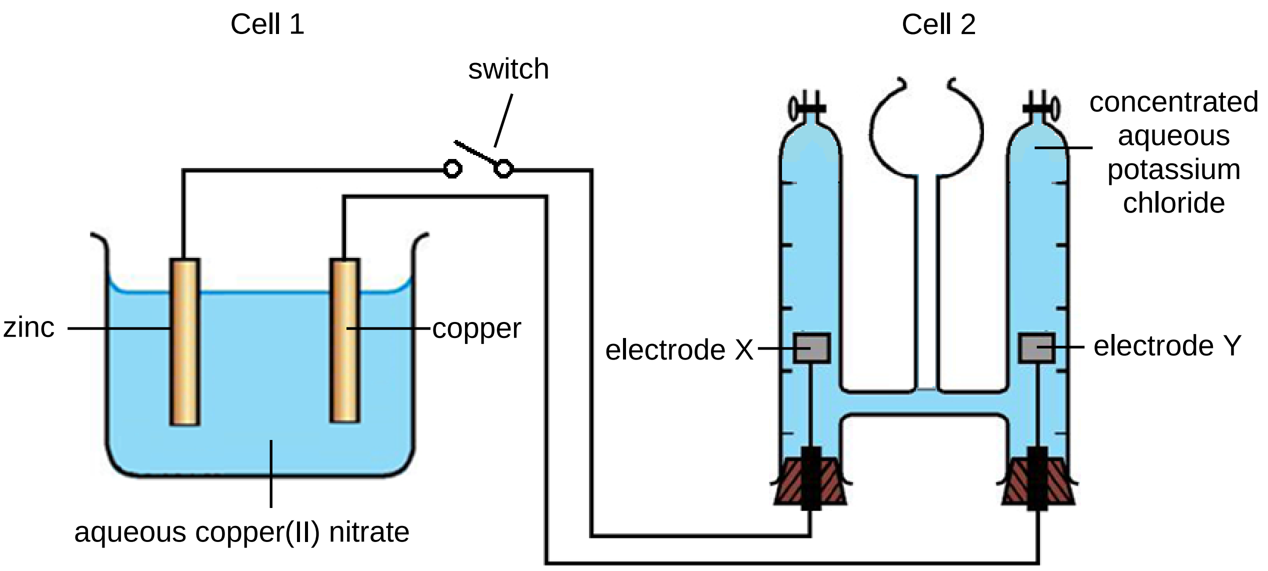


Fig. 11.1

When the switch is closed, reactions occur in both cells.

(a) Deduce which cell is a simple cell.

State a reason for your answer.

……...

……………………………………………………………………………………………………….[2]

B11 **(b)** Name all the ions present in aqueous copper(II) nitrate in Cell 1.

…… [1]

(c) Write ionic equations for the reactions at the electrodes in Cell 1.

zinc electrode: ……………………………………………………………………………………

copper electrode: ………………………………………………………………………………… [2]

(d) A gas is produced at each of the electrodes in Cell 2.

(i) Identify the gas produced at electrode Y.

Explain your answer using ideas of selective discharge.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) A student draws Fig. 11.2 for Cell 2 after the switch is closed for a period of time to show the volume of the gas collected at each electrode.

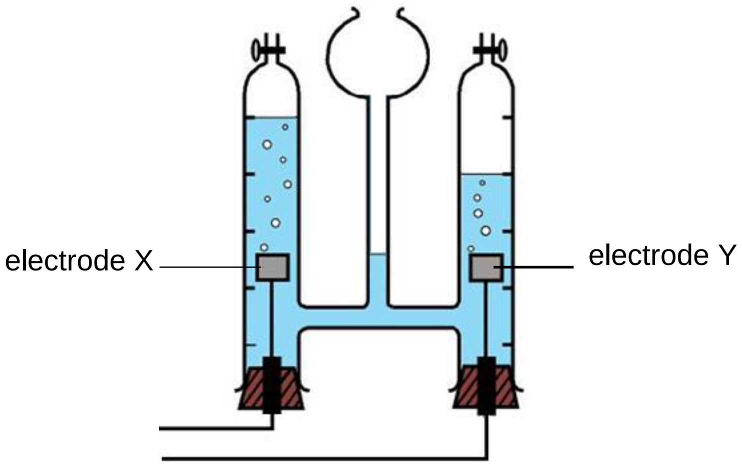


Fig. 11.2

Do you agree with the student's drawing?

Give a reason for your answer.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

B11 (d) (iii) After the electrolysis has been running for some time in Cell 2, a new product is formed at electrode Y.

Explain the reason for this observation.

………

……… [2]

[Total: 10]

EITHER

B12 Table 12.1 shows some data about the composition of the mixtures of exhaust gases from a car.

Table 12.1

substances in exhaust gases	percentage by volume	
	without catalytic converter	with catalytic converter
nitrogen	67.60	67.75
carbon dioxide	12.00	12.60
water vapour	11.00	11.45
oxygen	9.00	8.20
carbon monoxide	0.20	0
nitrogen oxides	0.15	0
unburnt hydrocarbons (C_8H_{18})	0.05	0

(a) Explain why the exhaust gases from the car contain a large amount of nitrogen.

………

……… [1]

(b) One of the exhaust gases may contribute to global warming.

State the name of this gas and describe a possible consequence of global warming.

………

………

……… [2]

B12 (c) (i) Fig. 12.1 shows the structure of a catalytic converter.

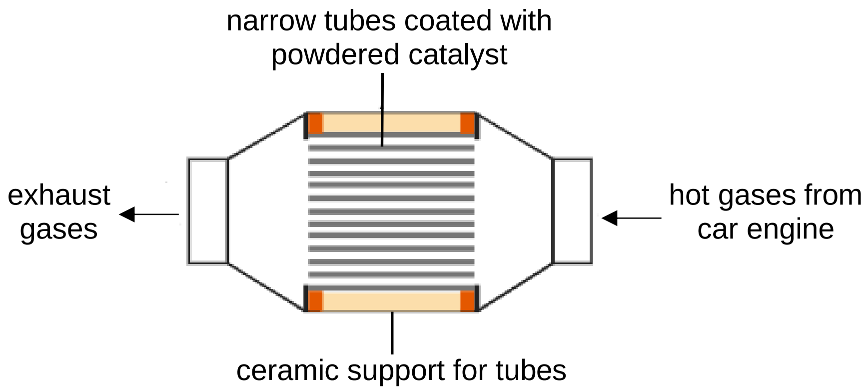


Fig. 12.1

Using the information from Fig. 12.1, state and explain two factors other than a catalyst, why the reactions in the catalytic converters are fast.

……

……

……

………………………………………………………………………………………………… [2]

(ii) Using the information in the Table 12.1, suggest with explanations, two substances in the exhaust gases that are removed by the catalytic converter.

Write a balanced chemical equation to support your answer.

……

……

……

………………………………………………………………………………………………… [3]

(iii) Using the information in the Table 12.1, explain why the percentage of nitrogen increases while the percentage of oxygen decreases when using a catalytic converter.

……

……

………………………………………………………………………………………………… [2]

[Total: 10]

OR

B12 Alcohols can be partially oxidised to form aldehydes.

Aldehydes are a homologous series of organic compounds.

Partial oxidation is achieved by reacting an alcohol with the oxidising agent in a distillation apparatus as shown in Fig. 12.1.

In an experiment carried out in the laboratory, ethanol was partially oxidised to form ethanal which is an aldehyde.

The boiling points of ethanol and ethanal are given in the Table 12.1.

Table 12.1

	ethanol	ethanal
boiling point / °C	78.0	20.0

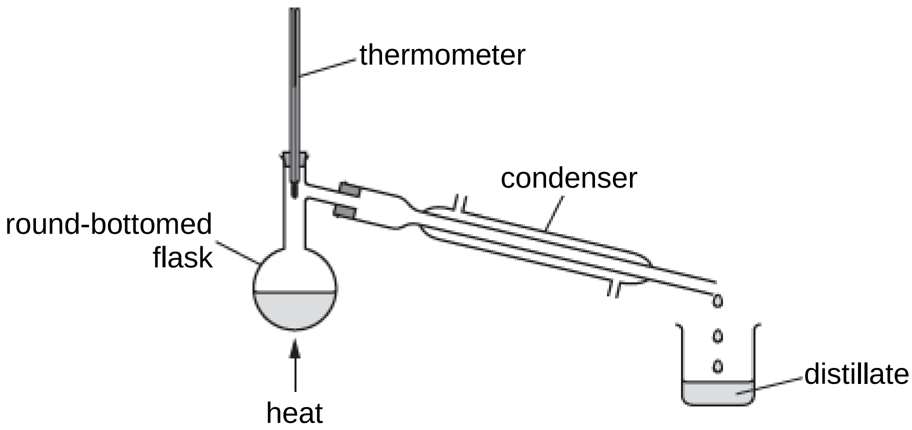


Fig. 12.1

(a) Suggest why only a small amount of distillate was collected using this set-up.

…………………………………………………………………………………………………… [1]

(b) Table 12.2 shows some information about aldehydes.

Table 12.2

name	………………	ethanal	propanal	butanal
molecular formula	CH_2O	C_2H_4O	C_3H_6O	………………

(i) Complete the missing information in Table 12.2. [1]

B12 (b) (ii) Deduce the general formula of aldehydes.

…………………………………………………………………………………………………… [1]

(c) The full structural formula of ethanal is shown in Fig. 12.2.

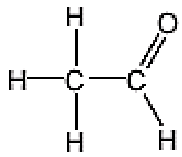


Fig. 12.2

The C=O group in aldehydes is located at the end of the carbon chain.

The C=O group is responsible for the characteristic reactions of aldehydes.

(i) State the name given to the C=O group in aldehydes.

…………………………………………………………………………………………………… [1]

(ii) With reference to Fig. 12.2, draw the dot-and-cross diagram to show the electron arrangement in a molecule of ethanal. Only the valence shells need to be drawn.

[3]

(d) Propanone belongs to another homologous series called ketones.

Ketones have the same C=O group as aldehydes but the C=O group is not at the end of the carbon chain.

Propanone has the same molecular formula as propanal, C_3H_6O.

(i) State the term used to describe molecules with different structural formula but with the same molecular formula.

…………………………………………………………………………………………………… [1]

B12 (d) (ii) Draw the full structural formula of propanone, C_3H_6O.

[2]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is $24\,dm^3$ at room temperature and pressure (r.t.p.).

O

CONVENT OF THE HOLY INFANT JESUS SECONDARY
Preliminary Examination in preparation for
the General Certificate of Education Ordinary Level 2022

CANDIDATE NAME	
CLASS	
REGISTER NUMBER	

CHEMISTRY **6092/02**

Paper 2

31 August 2022

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 22.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **21** printed pages and **1** blank pages.

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The table shows some reactions.

	reaction	**decrease, increase or unchanged** in oxidation state
A	$Ca\underline{C}O_3 \rightarrow \underline{C}O_2$	
B	$\underline{H}NO_3 \rightarrow \underline{H}_2$	
C	$K\underline{Mn}O_4 \rightarrow \underline{Mn}O$	
D	$\underline{Na}OH \rightarrow \underline{Na}Cl$	

(a) Complete the table by stating if the oxidation state of the element underlined has decreased, increased or is unchanged after the reaction. [2]

(b) Use the letters **A**, **B**, **C**, and **D** to answer the following questions.

(i) Which reaction shows part of a neutralisation reaction?

.... [1]

(ii) In which two reactions do the products formed have particles that are very far apart and have high kinetic energy?

.... [1]

(iii) In which reaction would a colour change be observed?

.... [1]

[Total: 5]

A2 Amino acids may be separated by using two-dimensional paper chromatography. This involves putting a spot of the mixture on the corner of a piece of chromatography paper and allowing a solvent to soak up the paper. The paper is then dried, turned through 90° and placed in a second solvent. This method gives better separation than a one solvent method.

(a) Define the term 'Retention Factor' or the R_f value in chromatography.

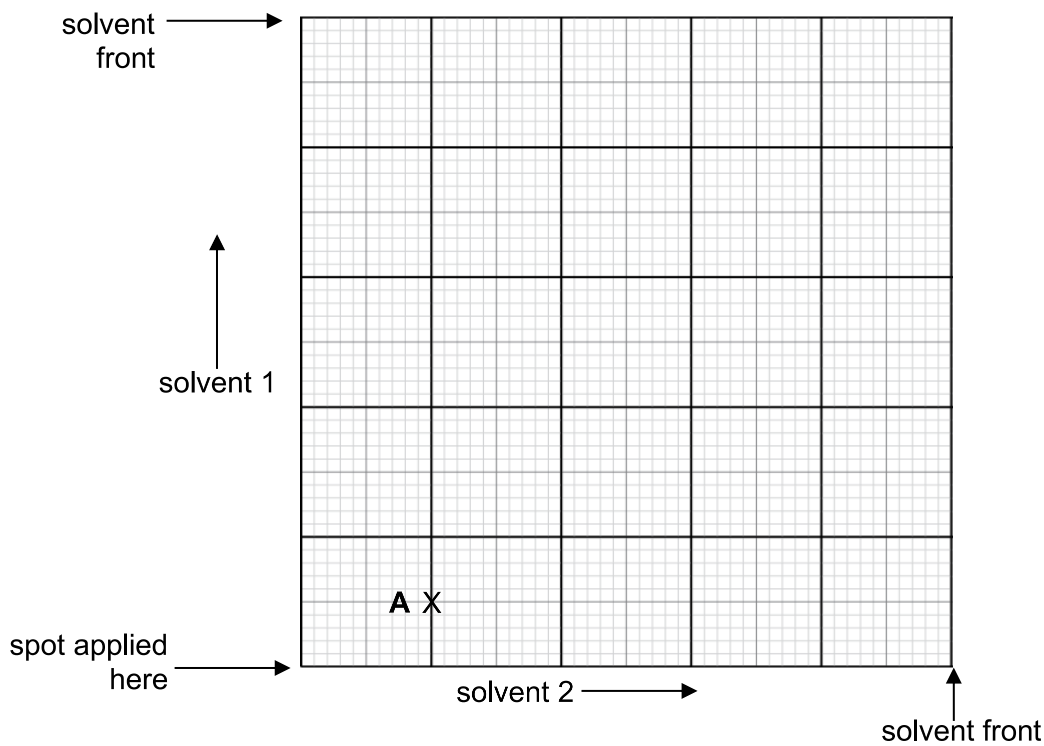
....

.... [1]

(b) The table below shows the R_f values for some amino acids in two different solvents.

amino acid	R_f (solvent 1)	R_f (solvent 2)
A	0.1	0.2
B	0.0	0.4
C	0.3	0.0
D	0.8	0.9
E	0.6	0.5

Use the grid below to plot the positions of the amino acids **B**, **C**, **D** and **E** after the two-dimensional paper chromatography using solvent 1 followed by solvent 2. Label each point clearly. The amino acid **A** has been done for you.



[2]

(c) Which amino acid travelled fastest in both solvents? .... [1]

(d) Which amino acid did **not** move at all in solvent 2? .... [1]

[Total: 5]

A3 Ammonia is a compound of nitrogen and hydrogen.

(a) The table gives information about nitrogen and hydrogen atom.

	nitrogen atom	hydrogen atom
number of protons	7	
number of electrons	7	1
electronic structure		1

Complete the table for the number of protons in a hydrogen atom and the electronic structure in a nitrogen atom. [1]

(b) Use the electronic structure of nitrogen, explain why the formula of ammonia is NH_3 and not NH_4.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(c) What are the optimal conditions for making ammonia from nitrogen and hydrogen in the Haber process?

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(d) Ammonia is used to make fertiliser such as ammonium phosphate, $(NH_4)_3PO_4$ and ammonium nitrate, NH_4NO_3. The fertiliser contains ammonium ions, NH_4^+.

(i) Draw a 'dot-and-cross' diagram to show the bonding in an ammonium ion. Show outer electrons only.

[2]

(ii) Fertilisers that contains higher percentage of nitrogen by mass are more effective in promoting plant growth.

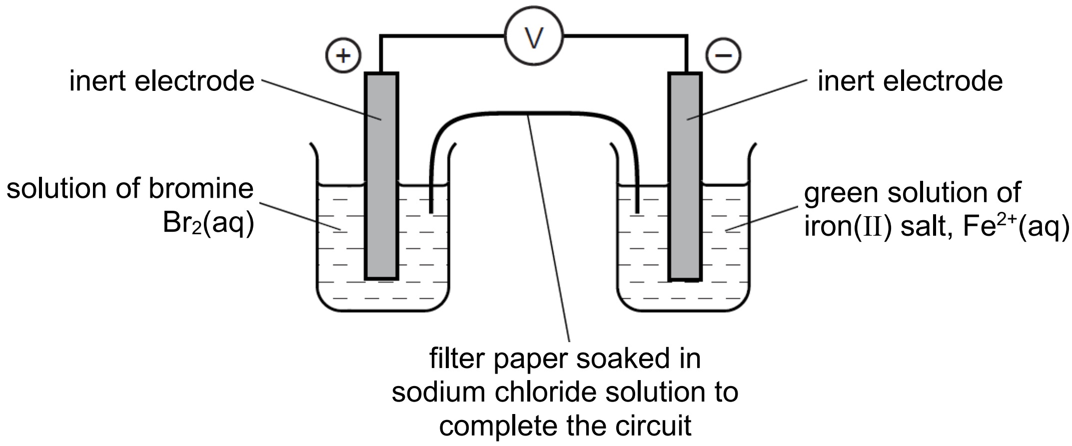
Use calculations to decide which fertiliser, ammonium phosphate, $(NH_4)_3PO_4$ and ammonium nitrate, NH_4NO_3 is more effective.

Show your working.

.... [3]

[Total: 10]

A4 The diagram shows a simple cell.



(a) In the left beaker, the colour changes from brown to colourless.

Write a half-equation, with state symbols, for the reaction that occurs in the left beaker.

…………………………………………………………………………………………………… [2]

(b) Is the change in **(a)** oxidation or reduction? Explain your reasoning in terms of oxidation state.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(c) Describe and explain what would be observed in the right beaker.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(d) When the solution of bromine is replaced by a solution of chlorine, the voltage increases. When the solution of bromine is replaced by a solution of iodine, the voltage decreases.

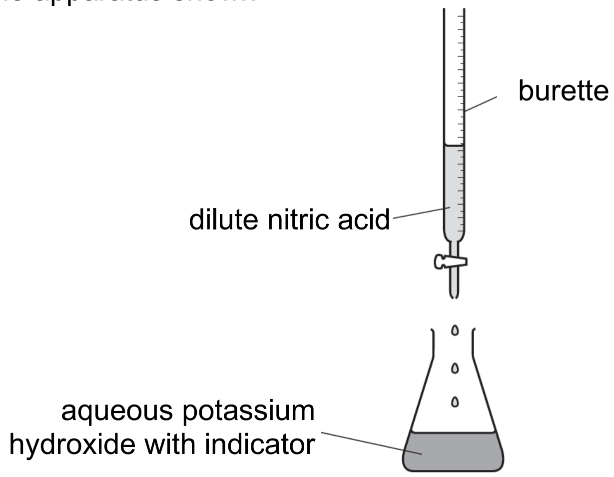
Suggest an explanation for this difference.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

[Total: 6]

A5 A student investigated the concentration of potassium hydroxide and dilute nitric acid by titration using the apparatus shown.



He used 25.0 cm^3 of aqueous potassium hydroxide. He did the titration three times and recorded the following results.

titration number	volume of dilute nitric acid / cm^3
1	18.10
2	18.90
3	18.20

(a) Which one of the results is anomalous?

Suggest what mistake the student made in washing of the apparatus to cause the anomalous result.

…………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(b) The equation for the reaction taking place in the titration is shown.

$$HNO_3 + KOH \rightarrow KNO_3 + H_2O$$

The student concluded that the aqueous potassium hydroxide was more concentrated than the dilute nitric acid.

Do the measurements obtained in the experiment support this conclusion?

Explain your reasoning.

…………………………………………………………………………………………………

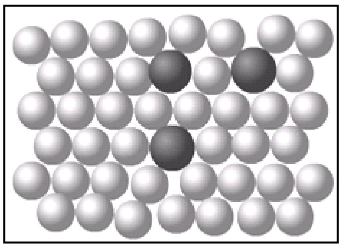
…………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

[Total: 4]

A6 Nickel and nickel alloys are used in electronic components.

(a) The diagram below shows the arrangement of atoms in nickel alloy.



Nickel alloys are much harder than pure nickel.
Use ideas about the arrangement of atoms in nickel alloy to explain why.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) Nickel can be extracted in a three-step process.

The last step involves nickel carbonyl, $Ni(CO)_4$. The equation for the last step is

$$Ni(CO)_4(g) \rightarrow Ni(s) + 4CO(g)$$

Based on the information provided, discuss why the extraction of nickel is a concern to humans.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(c) A student carried out some experiments to investigate the displacement reaction of nickel and three other metals, cobalt, magnesium and tin.

She added the metals into salt solutions. The table shows her observations.

	salt solution			
metal	cobalt(II) nitrate	magnesium nitrate	nickel(II) nitrate	silver nitrate
cobalt		no change, solution remains colourless	grey solid formed in pink solution	grey solid formed in pink solution
magnesium	grey solid formed in colourless solution		grey solid formed in colourless solution	grey solid formed in colourless solution
nickel	no change, solution remains pink	no change, solution remains colourless		
silver	no change, solution remains pink	no change, solution remains colourless	no change, solution remains green	

(i) The student accidentally left the observation for the experiment of nickel with silver nitrate blank.

Describe what the student would observe for the experiment of nickel with silver nitrate.

....

.... [1]

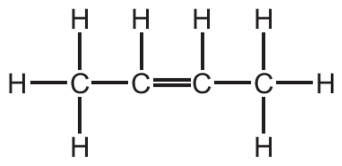
(ii) Write an equation for the reaction that happens between cobalt and silver nitrate.

.... [1]

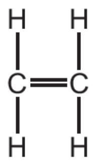
[Total: 5]

A7 The structures of six organic compounds are shown.

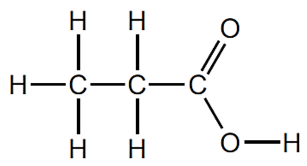
A



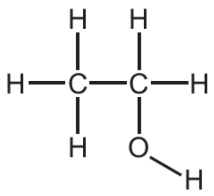
B



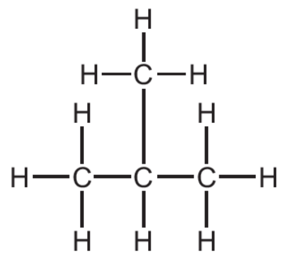
C



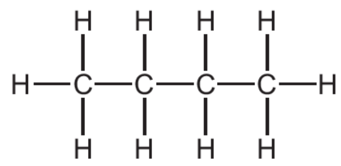
D



E



F



(a) State two compounds which are isomers of each other and explain why.

compounds ……………………………………………………………………………….…

explanation …..……………………………………………………………………….…

…………………………………………………………………………..…………..… [2]

(b) Compound **D** is manufactured using one of the other compounds.

State which is the other compound, and the reagent and conditions required for the reaction. Write a balanced chemical equation for the reaction.

compound ……………………………………………………………………………..…

reagent and conditions ………………………...……………………………………..…

equation ……………………………………………………………..……………..… [3]

(c) Compound **A** forms an addition polymer.

Draw **two** repeat units of the addition polymer formed from **A**.

[1]

(d) Describe a chemical test to distinguish between compound **B** and compound **D**.

test ……………………………………………………………………………………………..…..…

results for compound **B** ..…………………………………………………………………..…

results for compound **D** ……………………………………………….………..…..…. [2]

(e) Name the organic compound formed from the reaction between compound **C** and compound **D**.

……………………………………………………………………………..……………..…. [1]

[Total: 9]

A8 The exhaust gases from the internal combustion engines of motor cars and lorries contain pollutants.

The table shows the masses of pollutants formed when one kilogram of each fuel is burnt.

fuel	mass of pollutant / g				
	carbon monoxide	oxides of nitrogen	sulfur dioxide	volatile organic compounds eg. unburnt hydrocarbons	particulates
petrol	236	29	0.9	25	0.6
diesel	10	59	3.8	17	18.6

(a) Suggest and explain which fuel is a greater contributor to the production of acid rain.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(b) Explain how oxides of nitrogen are formed in the internal combustion engines of motor cars and lorries.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(c) Oxides of nitrogen and carbon monoxide from exhaust gases are removed by catalytic converters. In the catalytic converter, carbon monoxide reacts with nitrogen monoxide.

Construct the chemical equation for this reaction and explain why this reaction does not remove all the environmental problems caused by exhaust gases.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

[Total: 6]

CANDIDATE NAME

CLASS

REGISTER NUMBER

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 Read the following article and answer the questions that follow.

Properties of Alkynes

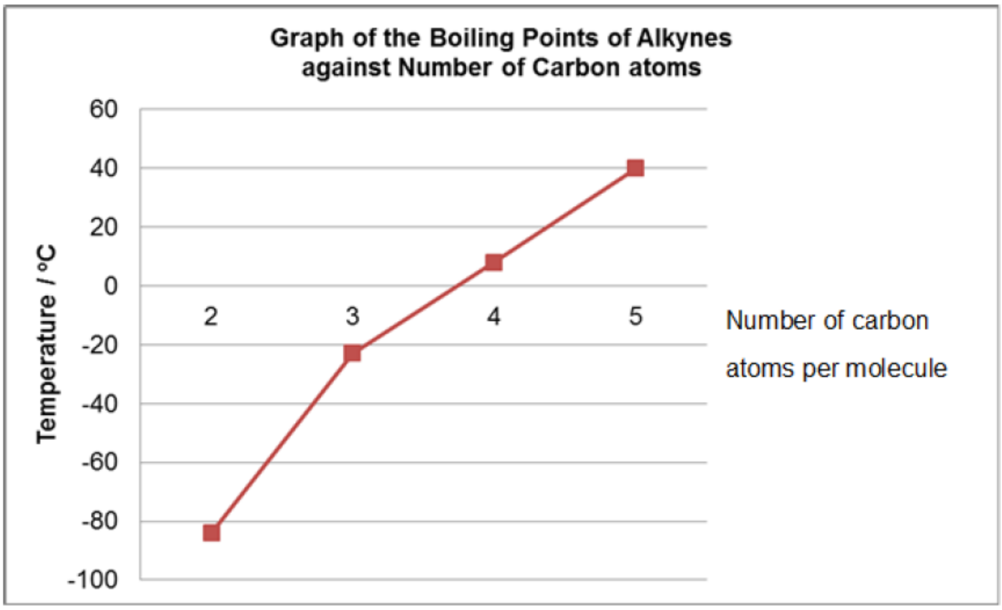
The alkynes are a homologous series of hydrocarbons. All alkynes contain a carbon to carbon triple bond (C ≡ C). **Table 1** below gives the structural formula and boiling points of some alkynes.

Table 1

name of alkyne	structural formula	molecular formula	M_r	boiling point / °C
ethyne	H — C ≡ C — H	C_2H_2	26	−84
propyne	H — C ≡ C — CH_3	C_3H_4	40	−23
butyne	H — C ≡ C — CH_2 — CH_3	C_4H_6	54	8
pent-1-tyne	H — C ≡ C — CH_2 — CH_2 — CH_3	C_5H_8	68	40

Graph 1 shows the boiling points of some alkynes plotted against the number of carbon atoms in each alkyne molecule.

Graph 1



Manufacture of Ethyne

For the past 50 years, ethyne was produced by the reaction of calcium carbide with water according to the equation below.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

A modern method for producing a good yield of ethyne is by heating ethene above 1150 °C. The reaction is represented by the equation shown below.

$$CH_2{=}CH_2(g) \rightarrow H{-}C{\equiv}C{-}H(g) + H_2(g)$$

Reaction of Alkynes

Alkynes are unsaturated compounds that react similarly to alkenes in many chemical reactions such as the addition reactions.

For example, like the alkenes, alkynes also undergo addition reaction with bromine water, However, unlike alkenes, alkynes react more slowly with bromine water.

(a) Describe and explain the trends shown by the data in **Table 1** and **Graph 1**.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) Draw a 'dot-and -cross' diagram to show the bonding found in ethyne.
Show outer electrons only.

[2]

(c) Using the information in the article,

(i) deduce the general formula of the homologous series of alkynes;

………………………………………………………………………………………… [1]

(ii) write the chemical formula of hex-1-yne, a six-carbon alkyne;

………………………………………………………………………………………… [1]

(iii) predict the boiling point of hex-1-yne.

………………………………………………………………………………………… [1]

(d) Chemical suppliers used to sell tins of 500 g calcium carbide.

Calculate the volume of ethyne that will be obtained at room temperature and pressure from 500 g of calcium carbide.

volume of ethyne = …………………………………… [2]

(e) From the article, suggest a test to distinguish an alkyne from an alkene. Include appropriate apparatus and chemicals to use in the test.

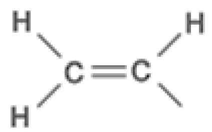
………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(f) When ethyne reacts with carbon monoxide and water, in the presence of a catalyst, propenoic acid is formed.

Complete the structure of the propenoic acid in the equation shown below.

$H-C\equiv C-H \;+\; CO \;+\; H_2O \;\rightarrow$ 

(propenoic acid)

[1]

[Total: 12]

B10 **(a)** A student investigated the strength of sulfuric acid and hexanesulfonic acid.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

$$C_6H_{13}SO_3H \rightarrow H^+ + C_6H_{13}SO_3^-$$

The student is given 0.1 mol/dm^3 of aqueous sulfuric acid and 0.2 mol/dm^3 of aqueous hexanesulfonic acid.

(i) Describe how the student could prove that hexanesulfonic acid is also a strong acid.

....

....

.... [2]

(ii) Deduce why, for a fair comparison, the two acid solutions must have different concentration.

....

.... [1]

(iii) Write the chemical equation for the reaction between aqueous hexanesulfonic acid and magnesium.

.... [1]

(b) Another student investigated the properties of a weak alkali, methylamine, which are similar to those of ammonia.

$$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$$

(i) Explain what is meant by the term weak alkali.

....

.... [1]

(ii) When aqueous methylamine is added to aqueous iron(II) sulfate, a green precipitate is formed.

Write an ionic equation for the formation of the green precipitate.

.... [1]

(iii) What would the student sees if aqueous methylamine is added to aqueous iron(III) nitrate?

.... [1]

(iv) Suggest the name of a reagent that will displace methylamine from one of its salts, methylammonium sulfate, $(CH_3NH_3)_2SO_4$.

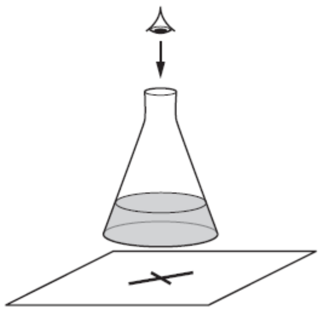
.... [1]

[Total: 8]

EITHER

B11 When aqueous sodium thiosulfate and dilute hydrochloric acid are mixed, a precipitate of insoluble sulfur is produced. This makes the mixture difficult to see through.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow S(s) + 2NaCl(aq) + H_2O(l) + SO_2(g)$$



A student adds the following volumes of aqueous sodium thiosulfate, dilute hydrochloric acid and deionised water to the conical flask. The time taken for the formation of the precipitate of sulfur to make the cross disappear from view is recorded.

experiment number	volume of sodium thiosulfate / cm^3	volume of hydrochloric acid / cm^3	volume of deionised water / cm^3	time taken for cross to disappear from view / s
1	10	10	40	56
2	20	10	30	28
3				

(a) In experiment 3, the student wanted the sodium thiosulfate to be double the concentration used in experiment 2.

(i) Complete the table to show the volumes which should be used and the expected time taken for the cross to disappear from view in experiment 3. [2]

(ii) Explain, in terms of collisions between reacting particles, how increasing the concentration of sodium thiosulfate would change the rate of reaction.

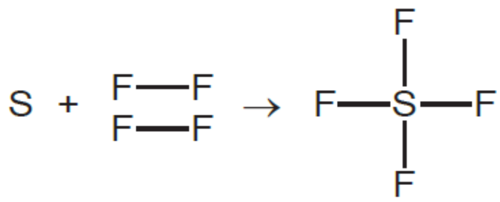
....

....

.... [2]

(b) Sulfur tetrafluoride, SF_4, can be made by combining gaseous sulfur with fluorine. The reaction is exothermic.

During the reaction, the amount of energy given out is 780 kJ/mol.



(i) Draw the energy profile diagram for this reaction. Label the 'activation energy' and 'enthalpy change' in your diagram.

[3]

(ii) The F — F bond energy is 160 kJ/mol.

Use this information to determine the bond energy, in kJ/mol, of one mole of S – F bond in SF_4.

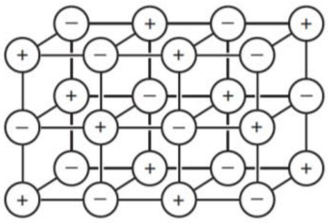
[3]

[Total: 10]

OR

B11 The boxes show the structure of three compounds, sodium chloride, silicon dioxide and cyclohexane.

sodium chloride
⊕ sodium ion
⊖ chloride ion

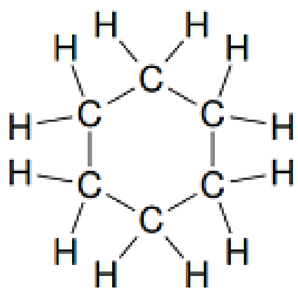


melting point: 801 °C

silicon dioxide
● silicon atom
● oxygen atom

melting point: 1600 °C

cyclohexane



melting point: 81 °C

(a) In the structure of sodium chloride, the ratio of positive ions to negative ions is 1:1. In the structure of a different ionic compound, the ratio of positive ions to negative ions is 1:2.

Suggest why this ratio varies in different ionic compounds.

....

.... [2]

(b) Diamond has a similar structure and consequently similar properties as silicon dioxide.

State **two** physical properties common to both diamond and silicon dioxide.

....

.... [2]

(c) Give the empirical formula of cyclohexane.

.... [1]

(d) Explain why the melting points of the three compounds differ from each other.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

(e) When all three compounds are liquids, one of the compounds conducts electricity.

Name this compound. Explain why it conducts electricity when liquid.

compound ……………………………………………………………………………………

explanation …………………………………………………………………………………

…………………………………………………………………………………………………… [2]

[Total: 10]

End of Paper

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			proton (atomic) number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

康 柏 中 学

COMPASSVALE SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
CHEMISTRY 6092/02

Paper 2 Theory

Secondary Four Express

Name: _______________________	Duration: 1 h 45 min
Index No: ________	Date: 26 August 2022
Class: ___________	Marks: _____/80

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 21.

The use of an approved scientific calculator is expected, where appropriate.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 **(a)** Use the list of oxides to answer the questions.

aluminium oxide

calcium oxide

iron(II) oxide

magnesium oxide

silicon dioxide

sodium oxide

sulfur dioxide

Each oxide may be used once, more than once or not at all.

Which oxide

(i) contains ions with a 3+ charge,

.... [1]

(ii) has a simple molecular structure,

.... [1]

(iii) is a coloured solid at room temperature and pressure,

.... [1]

(iv) is used to reduce acidity of soils,

.... [1]

(v) reacts with both acids and alkalis to form salt and water?

.... [1]

(b) Table 1.1 shows the ease with which different metal oxides can be reduced.

Table 1.1

metal oxide	ease of reduction
calcium oxide	**not** reduced by carbon at 1800 °C
iron(III) oxide	reduced by carbon at 650 °C
silver oxide	reduced by heating without carbon
titanium(IV) oxide	reduced by carbon at 1800 °C but **not** at 650 °C

Use the information in the table to place the metals in order of their reactivity.

least reactive ⟶ most reactive

[1]

[Total: 6]

A2 Table 2.1 shows the composition of a compound **Z** obtained from the planet Mars after an analysis.

Table 2.1

element	percentage by mass
potassium	39.4
iron	28.3
oxygen	32.3

(a) Show that the empirical formula of **Z** is K_2FeO_4.

[3]

(b) K_2FeO_4 can be prepared in the laboratory by the reaction between iron(III) oxide, Fe_2O_3, chlorine, Cl_2, and potassium hydroxide, KOH.

$$Fe_2O_3 + 3Cl_2 + 10KOH \rightarrow 2K_2FeO_4 + 6KCl + 5H_2O$$

A 2.00 g sample of Fe_2O_3 is added to 20.0 cm^3 of 4.00 mol/dm^3 KOH.

(i) Which reagent is in excess?

Show your working.

[2]

(ii) Identify the oxidising agent in this reaction. Explain your answer.

oxidising agent ....

explanation ....

....

.... [2]

[Total: 7]

A3 Both dilute nitric acid and dilute sulfuric acid are strong acids.

(a) Explain what is meant by the term *strong acid*.

....

.... [1]

(b) Describe a test to distinguish between a solution of dilute nitric acid and a solution of dilute sulfuric acid.

test ....

result ....

.... [2]

(c) Use the following information to suggest the steps needed to prepare by precipitation pure lead(II) sulfate, starting from powdered lead(II) oxide.

- lead(II) sulfate is insoluble in water
- lead(II) oxide is insoluble in water
- lead(II) nitrate is soluble in water

....

....

....

....

....

.... [3]

[Total: 6]

A4 Hydrogen peroxide is a colourless liquid.

(a) **(i)** Draw a 'dot-and-cross' diagram for a molecule of hydrogen peroxide.

Show outer electrons only.

[2]

(ii) The melting point of hydrogen peroxide is 0 °C while the boiling point of hydrogen peroxide is 150 °C.

Use this information to suggest why hydrogen peroxide is a solid at –5 °C.

....

.... [1]

(b) The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2 \rightarrow 2H_2O + O_2 \qquad \Delta H = -98 \text{ kJ/mol}$$

(i) Calculate the heat energy released when 680 g of hydrogen peroxide is completely decomposed.

heat energy released = ... kJ [2]

(ii) Use ideas about bond breaking and bond forming to explain why the decomposition of hydrogen peroxide is exothermic.

....

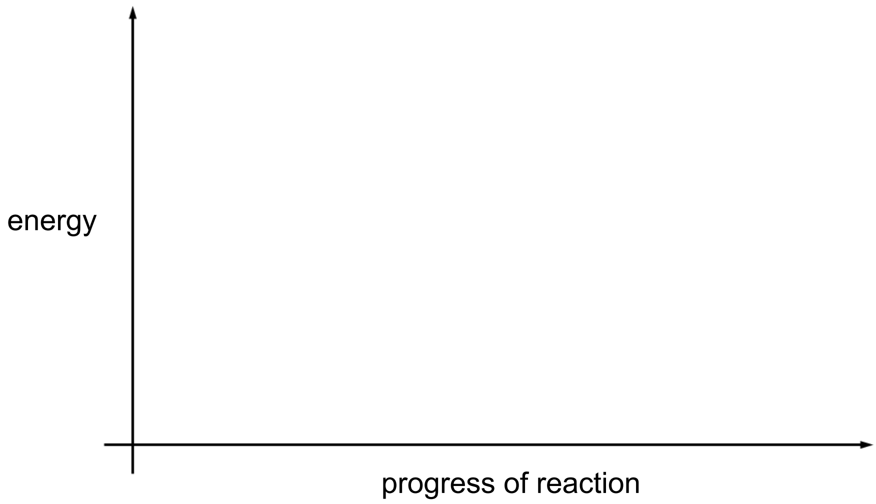
....

.... [2]

(iii) Draw an energy profile diagram for the decomposition of hydrogen peroxide.

Your diagram should show and label

- the chemical formula of reactants and products,
- the enthalpy change of reaction,
- the activation energy.



[3]

[Total: 10]

A5 Sodium is extracted from molten sodium chloride by electrolysis.

Fig. 5.1 shows how the process works.

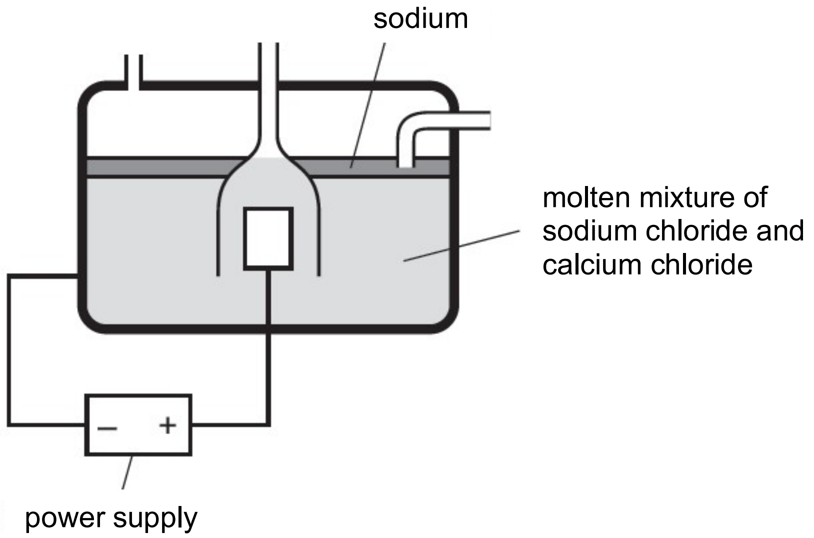


Fig. 5.1

(a) **(i)** Label the anode on the diagram. [1]

(ii) Write an ionic half equation, with state symbols, to show the reaction that happens at the anode.

……………………………………………………………………………………………… [1]

(iii) Describe a simple test to identify the gas given off at the anode.

test ………………………………………………………………………………………

result ……………………………………………………………………………………

……………………………………………………………………………………………… [2]

(b) Compare the difference in the density of molten sodium and molten mixture of sodium chloride and calcium chloride.

Explain your answer with reference to the diagram.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(c) Explain why calcium chloride is added to sodium chloride during the extraction of sodium.

……………………………………………………………………………………………………..........

……………………………………………………………………………………………………..........

……………………………………………………………………………………………......... [2]

(d) Molten sodium contains metallic impurities.

Name the main metal impurity you would expect to find and explain how it forms.

……………………………………………………………………………………………………..........

……………………………………………………………………………………………………..........

……………………………………………………………………………………………......... [2]

(e) Explain why sodium **cannot** be extracted from aqueous sodium chloride by electrolysis.

……………………………………………………………………………………………………..........

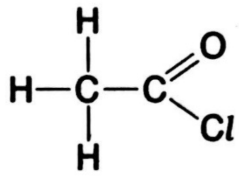
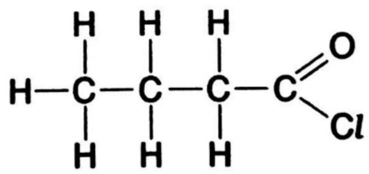
……………………………………………………………………………………………………..........

…....………………………………………………………………………………………….......... [2]

[Total: 12]

A6 Table 6.1 shows some information about the homologous series of a class of organic compounds called acyl chlorides.

Table 6.1

name	condensed formula	displayed formula	melting point/ °C	boiling point/ °C
ethanoyl chloride	CH_3COCl		–112	52
			–94	80
butanoyl chloride	C_3H_7COCl		–89	102

(a) **(i)** Complete Table 6.1. [2]

(ii) Explain how you can tell that these molecules are from the same homologous series.

....

....

.... [2]

(b) Which statements about acyl chlorides are **true** and which are **false**?

Put a tick (✓) in one box in each row.

	true	**false**
The acyl chlorides are all liquids at room temperature and pressure.		
The acyl chlorides are hydrocarbons.		
The acyl chlorides are saturated compounds.		
The acyl chlorides can undergo addition reactions.		

[2]

(c) Ethanoyl chloride reacts with ethanol in the following reaction.

$$CH_3COCl + C_2H_5OH \rightarrow \underset{\text{compound } \mathbf{X}}{CH_3COOC_2H_5} + HCl$$

(i) Give the name of compound **X**.

.... [1]

(ii) Ethanoic acid also reacts with ethanol.

Give one **similarity** and one **difference** between the reaction of ethanoyl chloride with ethanol and the reaction of ethanoic acid with ethanol.

similarity ....

....

difference ....

.... [2]

[Total: 9]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Reaction rate

The reaction rate for a given chemical reaction is the measure of the change in concentration of the reactants or the change in concentration of the products per unit time.

One way to measure the rate of reaction is the initial rate method. The initial rate method measures the initial rate of a reaction for several sets of initial concentration conditions to see how the initial reaction rate varies.

A common experiment used to study reaction rate is the 'iodine clock' reaction. The 'iodine clock' reaction involves carrying out a series of experiments to investigate the effect of different initial concentrations of colourless peroxodisulfate(VI) ions, $S_2O_8^{2-}$, and iodide ions, I^-, on the initial rate of reaction. The equation below shows the reaction between peroxodisulfate(VI) ions and iodide ions.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

The same volumes of $S_2O_8^{2-}$(aq) and I^-(aq) are used for each experiment.

Table 7.1 shows the results of each experiment.

Table 7.1

experiment	initial concentration in mol/dm^3		initial rate of reaction in mol/dm^{3}s
	$S_2O_8^{2-}$	I^-	
1	0.008	0.020	1.22×10^{-3}
2	0.016	0.020	2.44×10^{-3}
3	0.032	0.020	4.88×10^{-3}
4	0.008	0.040	2.44×10^{-3}
5	0.008	0.080	4.88×10^{-3}

Order of reactions

The order of a reaction refers to the relationship between the concentrations of reactants and the rate of reaction. Determining the reaction order from the reaction rate enables us to classify specific chemical reactions as zero-order, first-order or second-order.

In a zero-order reaction, the concentration of reactants does not affect the rate of a reaction.

In a first-order reaction, the initial reaction rate is directly proportional to the concentration of one of the reactants.

In a second-order reaction, the initial rate of reaction increases by four times when the concentration of one of the reactants is doubled.

Changing the rate of reaction

When a small amount of Fe^{2+} ions is added to the reaction mixture, the rate of reaction increases.

The reaction occurs in two stages as shown.

Stage 1: $2Fe^{2+}(aq) + S_2O_8^{2-}(aq) \rightarrow 2Fe^{3+}(aq) + 2SO_4^{2-}(aq)$

Stage 2: $2Fe^{3+}(aq) + 2I^{-}(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$

Reference:
https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Kinetics/02%3A_Reaction_Rates/2.05%3A_Reaction_Rate

(a) Suggest another method to measure the rate of reaction between peroxodisulfate(VI) ions and iodide ions.

....

.... [1]

(b) The initial concentration of $S_2O_8^{2-}(aq)$ in experiment 2 is twice the initial concentration of $S_2O_8^{2-}(aq)$ in experiment 1.

Use the information from Table 7.1 to describe and explain the effect of this change on the initial rate of reaction.

....

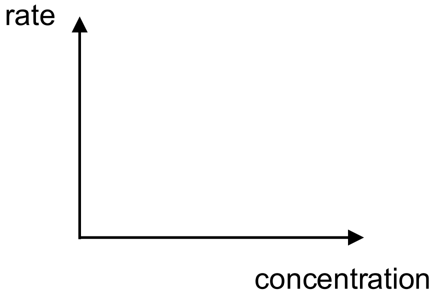
....

....

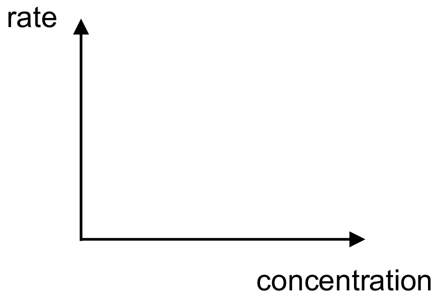
....

.... [3]

(c) Sketch the graphs to show the effect of concentration of reactant on the rate of reaction for a zero-order reaction and a first-order reaction.



zero-order reaction



first-order reaction

[2]

(d) Two students talk about the data.

Student 1: 'I think the reaction is first-order with respect to $S_2O_8^{2-}$.'

Student 2: 'I think the reaction is second-order with respect to I^-.'

Which student is correct?

Use the information from Table 7.1 to explain your reasoning.

....

....

....

....

.... [3]

(e) Another experiment was carried out with the same volumes of reactants.

Complete Table 7.2 to predict the initial concentration of $S_2O_8^{2-}$(aq) in experiment 6.

Table 7.2

experiment	initial concentration in mol/dm^3		initial rate of reaction in mol/dm^{3}s
	$S_2O_8^{2-}$	I^-	
6		0.080	9.76×10^{-3}

[1]

(f) Suggest the role of Fe^{2+} ions in the reaction mixture.

Use the information to explain your reasoning.

....

....

.... [2]

[Total: 12]

B8 Hydrochloric acid, HCl, reacts with barium hydroxide, $Ba(OH)_2$, as shown.

$$2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$$

A sample of 25.0 cm^3 of 0.0500 mol/dm^3 barium hydroxide is placed in a beaker.

Dilute hydrochloric acid is added slowly, from a burette, to the barium hydroxide in the beaker.

A pH probe is used to measure the pH of the solution in the beaker until a total of 40.0 cm^3 of dilute hydrochloric acid is added.

Table 8.1 shows how the pH of the solution in the beaker changes.

Table 8.1

volume of dilute HCl added/ cm^3	pH of the solution in the beaker
0.0	13.0
5.0	12.9
10.0	12.5
15.0	11.6
20.0	7.0
25.0	3.0
30.0	1.6
35.0	1.1
40.0	0.9

(a) Explain, in terms of the ions present, why the pH of the solution in the beaker changes from 13.0 to 0.9.

....

....

.... [2]

(b) **(i)** Use the data in Table 8.1 to state the volume of dilute hydrochloric acid that completely neutralises the sample of barium hydroxide in the beaker.

volume of dilute HCl = ... cm^3 [1]

(ii) Use your answer in **(b)(i)** to calculate the concentration, in mol/dm^3, of the dilute hydrochloric acid.

concentration of dilute HCl = ………………….……........ mol/dm^3 [3]

(c) Describe a practical method, other than using a pH probe, by which the volume of dilute hydrochloric acid can be determined.

…………………………………………………………………………………………………..............

…………………………………………………………………………………………………..............

…………………………………………………………………………………………………...........[2]

[Total: 8]

EITHER

B9 This information is about the elements in Period 2 of the Periodic Table.

Graph 9.1 shows the melting point plotted against the elements across Period 2.

Graph 9.1

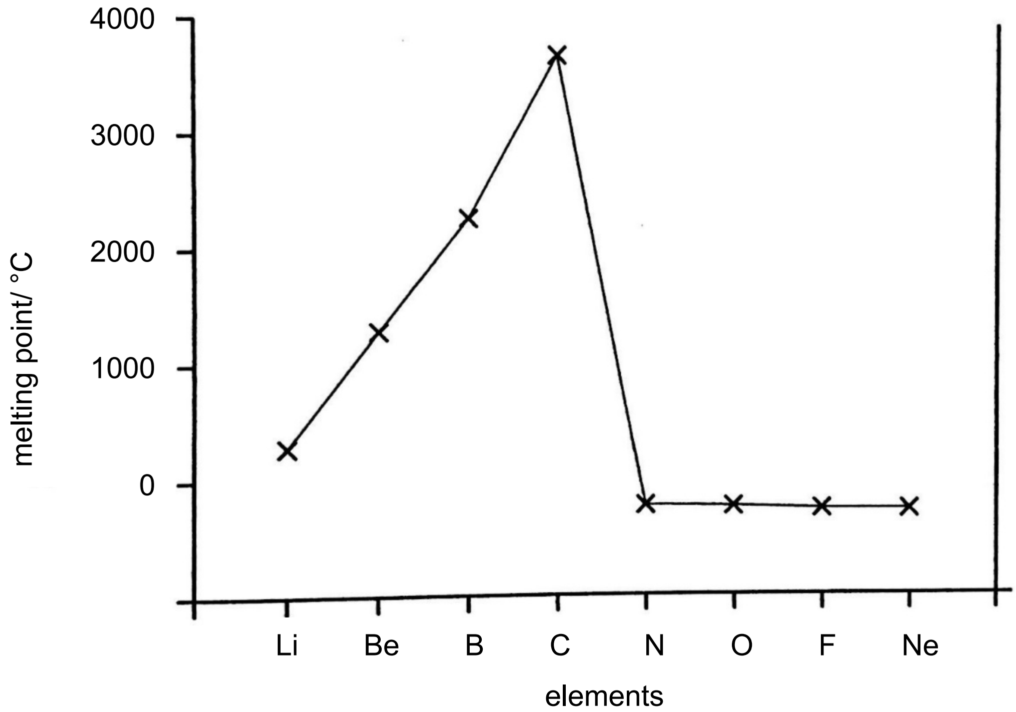


Table 9.1 shows the electrical conductivity of elements across Period 2.

Table 9.1

element	electrical conductivity (at room temperature and pressure)
Li	good
Be	good
B	poor
C	good
N	does not conduct
O	does not conduct
F	does not conduct
Ne	does not conduct

(a) On moving across Period 2 from Group I to Group VII, the character of the elements changes.

Describe and explain the change.

....

....

.... [2]

(b) Use the information to describe the trends in melting point and electrical conductivity across Period 2.

....

....

....

.... [2]

(c) How does the melting point of carbon compare to the other elements in the period?

Explain your answer.

....

....

.... [2]

(d) Diamond and graphite are two allotropes of carbon.

(i) Explain what is meant by the term *allotropes*.

....

.... [1]

(ii) Which allotrope of carbon is the data referring to?

Explain your answer with reference to the structure of the substance chosen.

....

....

....

....

.... [3]

[Total: 10]

OR

B9 Styrene-butadiene rubber is a synthetic rubber. It is made by polymerising a mixture of the monomers styrene and butadiene.

styrene butadiene

(a) What type of polymerisation takes place when the monomers react with each other?

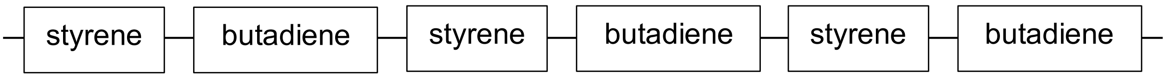
Explain your reasoning.

....

....

.... [2]

(b) One possible structure for the polymer is shown below.



Draw the structural formula for **one** repeating unit in this polymer.

[2]

(c) When the mixture of styrene and butadiene polymerises, the polymer is unlikely to contain only this repeating pattern.

Explain why.

....

....

.... [2]

(d) Explain why careless disposal of polymers result in long-term pollution problems.

……..…………………………..………………………………………………..……………….................

…………………………………….....……………………………………….……………..……........... [1]

(e) Butadiene can be made by cracking butane in a cracking tower.

(i) Describe a simple test that can be used to distinguish between butane and butadiene.

………………………………………..…………………………………………………………..……...

………………………………………..…………………………………………………………........... [2]

(ii) Another product, **Y**, is produced during the cracking of butane to form butadiene.

Write an equation for the cracking of butane.

………………………………………..…………………………………………………………........... [1]

[Total: 10]

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

COMMONWEALTH SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2022

CHEMISTRY
PAPER 2

Name: ________________________________ (   )   Class: __________

Secondary Four Express
6092/02

Tues 13 Sep 2022
1 h 45 min
0800 – 0945 h

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on the question paper and any separate answer sheets used.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough work.
Do not use staples, paper clips, highlighters, glue or correction fluid.
An approved scientific calculator may be used.

Section A
Answer **all** questions in the spaces provided on the Question Paper.

Section B
Answer all **three** questions. The last question is in the form of either/or and only one of the alternatives should be attempted.
Circle the question B11E or B11O that you have attempted.
Write your answers in the spaces provided on the Question Paper.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 20.

For Examiner's Use	
Section A	**/ 50**
B9	**/ 10**
B10	**/ 10**
B11 E / O	**/ 10**
Total	**/ 80**

Name of setter: Ms Tian Yilin

Parent's / Guardian's Signature

This paper consists of **<20>** printed pages including the cover page.

[Turn over

For examiner's use

Section A (50 marks)

Answer **all** the questions in the spaces provided.

A1 A list of substances is shown below.

potassium	hydrogen	argon
water	ammonia	magnesium oxide
air	helium	diamond

Each substance can be used once, more than once, or not at all.

Name a substance from the list above which

(a) conducts electricity in the molten state only,

....[1]

(b) contains the greatest number of particles in 5 g of the substance,

....[1]

(c) has a giant molecular structure,

....[1]

(d) combines with chlorine to form a solid compound at room conditions,

....[1]

(e) is diatomic.

....[1]

[Total: 5]

For examiner's use

A2 The table gives information about substances **A** to **F**.

Substance	Melting point / °C	Boiling point / °C	Solubility in water	Electrical conductivity	
				solid state	molten state
A	3550	4827	insoluble	poor	poor
B	–210	–196	very soluble	poor	poor
C	808	1465	soluble	poor	good
D	-10	161	insoluble	poor	poor
E	98	890	reacts with water	good	good
F	778	1600	soluble	poor	good

(a) Which substance(s) is/are solid(s) at room temperature?

……………………………………………………………………………………………………[1]

(b) Describe the change in movement and arrangement of the particles of substance **D** as it is heated from room temperature to 200 °C.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(c) Substance **E** is soft and can be easily cut with a knife. It reacts with water to form a colourless solution that turns Universal Indicator violet. Effervescence of a colourless and odourless gas is also produced.

(i) Suggest which Group of the Periodic Table substance **E** is likely to belong to.

……………………………………………………………………………………[1]

(ii) Describe a chemical test to confirm the identity of the gas produced.

……………………………………………………………………………………

……………………………………………………………………………………[1]

[Total: 5]

For examiner's use

A3 The production of the main component of bleach, sodium hypochlorite, $NaClO$, involves bubbling gaseous chlorine into cold dilute aqueous sodium hydroxide.

$$Cl_2\ (g) + 2NaOH\ (aq) \rightarrow NaClO\ (aq) + NaCl\ (aq) + H_2O\ (l)$$

(a) **(i)** Identify the two ions found in sodium hypochlorite.

…………………………………………………………………………………………………[1]

(ii) What is the volume of 0.1 mol/dm^3 of sodium hydroxide needed to produce 1 kg of sodium hypochlorite?

volume of sodium hydroxide = ……………………..[3]

(iii) Suggest one way to increase the rate of reaction between chlorine gas and aqueous sodium hydroxide.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

(b) Very often, the accidental use of sodium hypochlorite with other cleaning agents can lead to detrimental effects on humans. One example is when sodium hypochlorite comes into contact with a solution of hydrogen peroxide, H_2O_2, a vigorous reaction occurs, producing a salt and releasing a large amount of oxygen gas and steam.

(i) Write a balanced chemical equation, with state symbols, for the reaction between sodium hypochlorite and hydrogen peroxide solution.

…………………………………………………………………………………………………[2]

(ii) Explain, in terms of oxidation number, whether sodium hypochlorite is oxidised or reduced in the reaction.

…………………………………………………………………………………………………

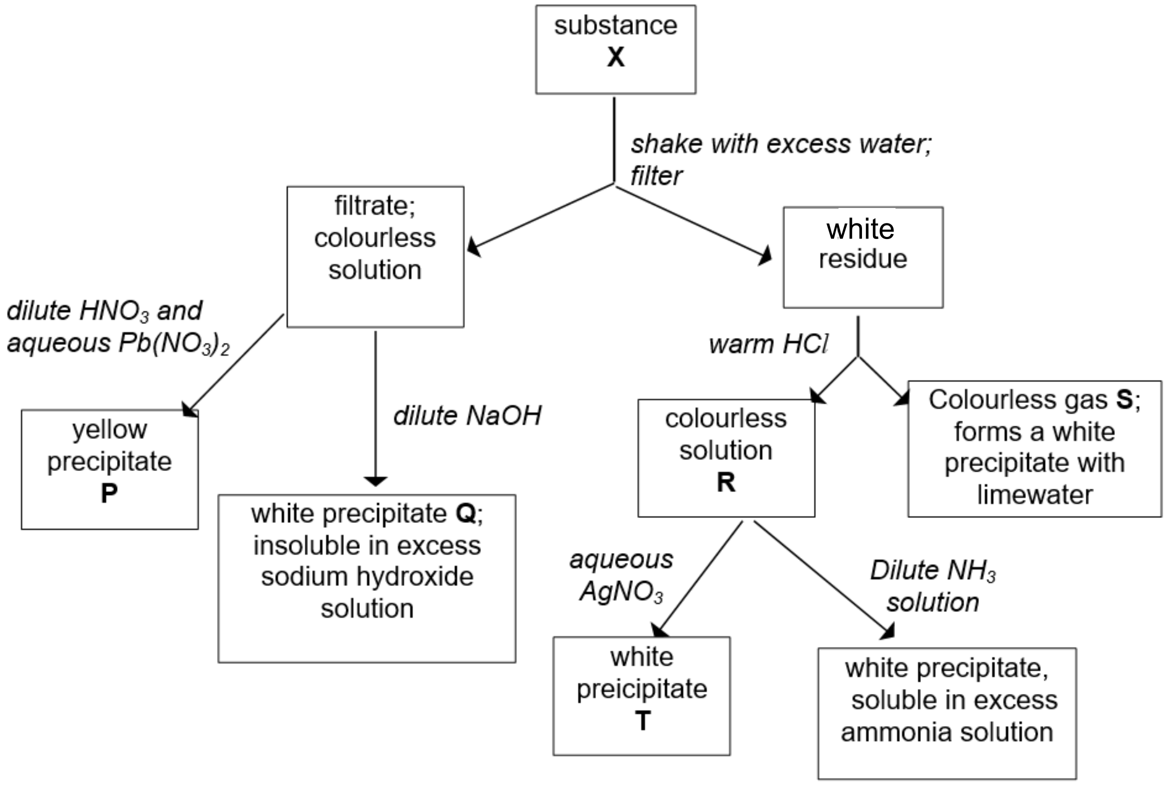
…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

[Total: 9]

For examiner's use

A4 Substance **X** is a mixture of compound **A** and compound **B**. Compound **A** is soluble in water but compound **B** is insoluble. The reaction scheme shows the results of some experiments on substance **X**.



(a) Name the following substances

(i) yellow precipitate **P**, ……………………………………………………….[1]

(ii) white precipitate **Q**, ……………………………………………………….[1]

(iii) colourless gas **S**, ……………………………………………………….[1]

(iv) colourless solution **R**. ……………………………………………………….[1]

(b) Write the ionic equation, including state symbols, for the reaction of the white residue with dilute hydrochloric acid.

…………………………………………………………………………………………….[2]

(c) Outline how a pure and dry sample of silver chloride can be obtained from silver carbonate as one of the starting reagent.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

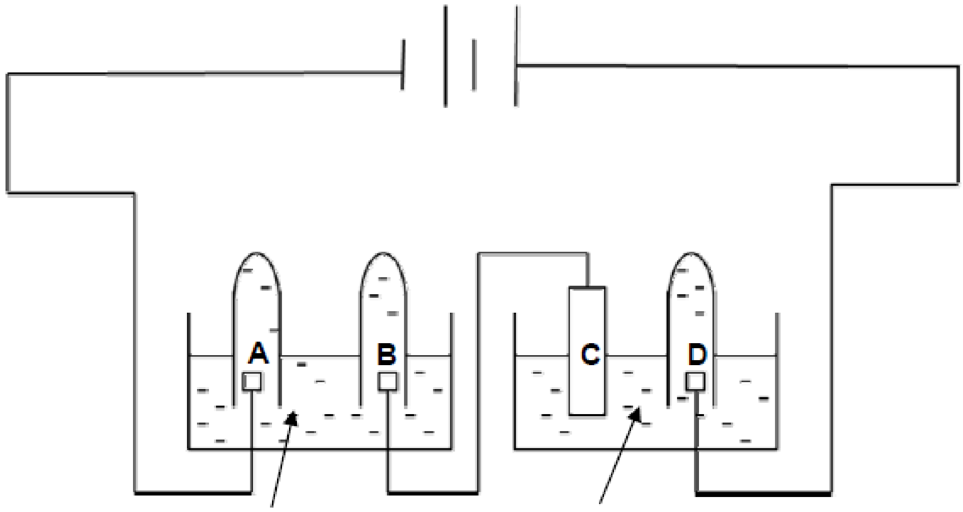
……………………………………………………………………………………………..

…………………………………………………………………………………………….[3]

[Total: 9]

For examiner's use

A5 The following set-up can be used for the electrolysis of solution **Q** and dilute nitric acid using inert electrodes.



(a) After electrolysis for 15 minutes, 140 cm^3 of gas was collected in the test-tube at electrode **A**.

(i) Predict the maximum volume of gas that can be collected at electrode **B**.

....[1]

(ii) Write the ionic equation for the reaction at electrode **B**.

....[1]

(b) The products formed at electrodes **C** and **D** are copper and chlorine respectively.

(i) Suggest the name of electrolyte **Q**.

....[1]

(ii) Write the ionic equation for the reaction at electrode **D**.

....[1]

(iii) What is the maximum volume of chlorine gas that can be collected at electrode **D** from this electrolysis? Explain your answer.

....

....

....

....[2]

[Total: 6]

For examiner's use

A6 Ethyne, C_2H_2 is a gas at room conditions. The equation for the combustion of ethyne is given below.

$$2C_2H_2\ (g) + 5O_2\ (g) \rightarrow 4CO_2\ (g) + 2H_2O\ (g)$$

(a) Use appropriate bond energy data provided below to calculate the enthalpy change, ΔH for the reaction above.

Bond	**Bond energy (kJ/mol)**
H – H	436
H – O	464
C – H	413
C – O	358
C = O	805
C – C	347
C = C	607
C ≡ C	812
O – O	204
O = O	498

[3]

(b) From your answer in **(a)**, explain in terms of bond breaking and bond making, why combustion of ethyne is an exothermic reaction.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

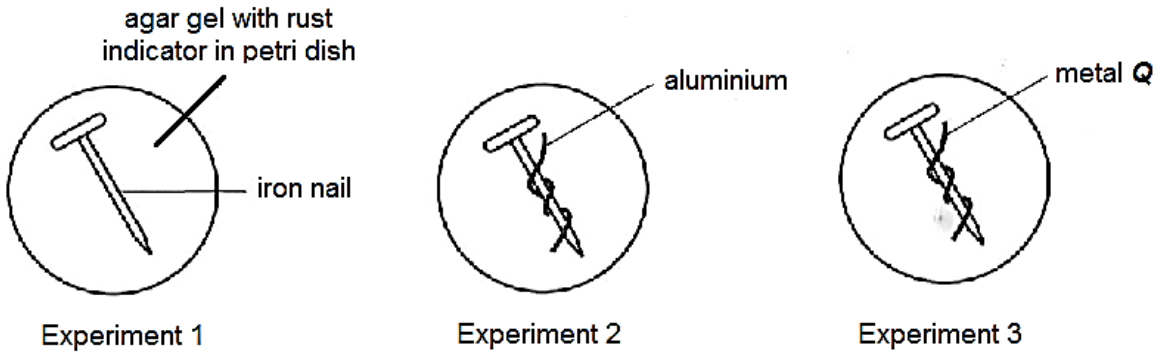
……………………………………………………………………………………………………..

…………………………………………………………………………………………………….[2]

[Total: 5]

For examiner's use

A7 Three experiments were set-up to investigate the factors that affect the rate of rusting in iron.



Agar gel with a few drops of rust indicator is placed in all the petri dishes. If the rusting of iron occurs, the indicator turns blue.

The table shows the results of experiments 1 and 3 after a week.

Experiment	**Observation**
1	Small blue patches were formed around the nail.
2	
3	Large blue patches were formed around the nail.

(a) State the conditions required for rusting of iron to occur.

....[1]

(b) Using the observation in experiment **3**, what conclusion can you make about metal **Q**? Explain your answer.

....

....

....[2]

(c) Aluminium used in experiment **2** was cleaned with sand paper before coiling around the nail. Explain why this is necessary.

....

....[1]

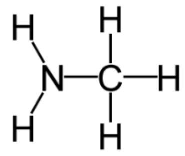
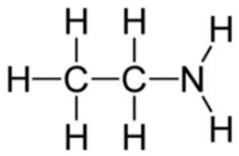
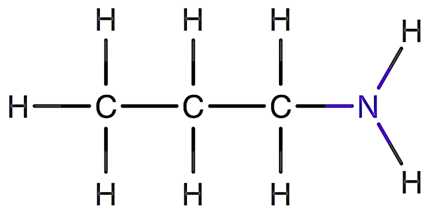
(d) Suggest an observation for experiment **2**.

....[1]

[Total: 5]

For examiner's use

A8 The table shows some information of the first four members of a homologous series, amines.

Name	**Chemical formulae**	Full structural formulae
methanamine	CH_3NH_2	
ethanamine	$CH_3CH_2NH_2$	
propanamine	$CH_3CH_2CH_2NH_2$	
butanamine	$CH_3CH_2CH_2CH_2NH_2$	

(a) **(i)** Draw the full structural formula of butanamine in the table above. [1]

(ii) Explain, using the information in the table, two characteristics of compounds in a homologous series.

....

....

....

....

....[2]

For examiner's use

(b) 1 mole of propanamine can be formed by the addition of 2 mole of hydrogen gas to 1 mole of substance **X**.

(i) What is the molecular formula of substance **X**?

…………………………………………………………………………………………………...[1]

(ii) What are the conditions necessary for this reaction?

…………………………………………………………………………………………………...[1]

(iii) Explain why the melting point of propanamine is higher than substance **X**.

……………………………………………………………………………………………………

…………………………………………………………………………………………………...[1]

[Total: 6]

For examiner's use

Section B (30 marks)

Answer all three questions from this section.

The last question is in the form of either/or and only one of the alternatives should be attempted.

B9 Read the following article on reactive oxygen species (ROS) and answer the questions that follow.

> *Reactive oxygen species (ROS) are generally very small molecules and are highly reactive due to the presence of unpaired electrons in their outermost shells. Superoxides and peroxides are two examples of ROS. They are formed as a natural by-product of the normal metabolism of oxygen in living things. They are oxidising in nature and high levels will result in cell damage which may eventually lead to many forms of cancer and aging effect.*
>
> *A superoxide is the anion O_2^- which occurs widely in nature. It contains an oxygen-oxygen single bond. With one unpaired electron, the superoxide ion is a highly reactive particle. A peroxide also contains an oxygen-oxygen single bond. The simplest stable peroxide is hydrogen peroxide.*
>
> *Hydrogen peroxide, H_2O_2 can undergo disproportionation.* ***Disproportionation*** *is used to describe a specific type of redox reaction, in which a species is simultaneously reduced and oxidised to form two different products.*

(a) **(i)** Determine the oxidation state of oxygen in the superoxide anion and hydrogen peroxide respectively.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(ii) Draw a 'dot-and-cross' diagram to show the bonding in the superoxide anion. Show only the outermost electrons.

[3]

(iii) With reference to the 'dot-and-cross' diagram in **(a)(ii)**, explain why the superoxide anion is a strong oxidising agent.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

For examiner's use

(b) Decomposition of hydrogen peroxide into water and oxygen is a disproportionation reaction. Using a chemical equation, explain in terms of oxidation states, why the decomposition of hydrogen peroxide is a disproportionation reaction.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………[3]

For examiner's use

B10 **(a)** In chemistry, pH, historically denotes "power of hydrogen". It is a scale that is used to specify the acidity or basicity of an aqueous solution. The pH value is inversely proportional to the concentration of the hydrogen ions in the solution.

A solution of sodium thiosulfate, on being acidified with dilute hydrochloric acid, becomes cloudy due to the precipitation of sulfur. Sulfur dioxide gas and water are also produced. The reaction is shown below.

$$S_2O_3^{2-}\ (aq) + 2H^+\ (aq) \rightarrow SO_2\ (g) + S\ (s) + H_2O\ (l)$$

(i) How would the rate of this reaction be affected by an increase in pH of the acid used?

……………………………………………………………………………………………..

……………………………………………………………………………………………..[1]

(ii) Explain your answer to **(a)(i)**, using your understanding on particle collision.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..[2]

(iii) In this experiment, 50.0 cm^3 of 1.0 mol/dm^3 dilute hydrochloric acid was added to 50.0 cm^3 of 1.0 mol/dm^3 sodium thiosulfate solution. What caused the reaction to stop?
All workings should be clearly shown.

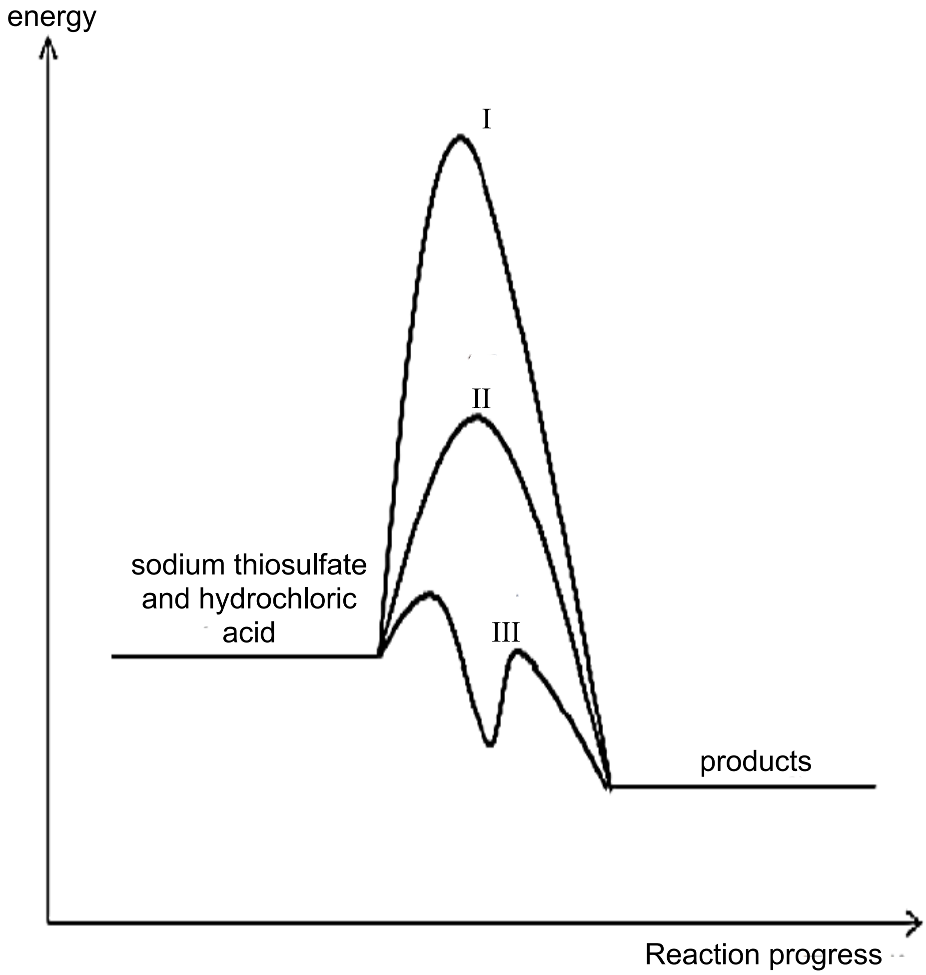
[3]

(b) The reaction between sodium thiosulfate solution and dilute hydrochloric acid can be catalysed by various transition metal ions. In this case, iron(II) and cobalt(II) are used.

The table shows the time taken to collect 100 cm^3 of sulfur dioxide gas when the different catalysts are used.

catalyst used	Time taken to collect 100 cm^3 of sulfur dioxide gas / s
iron(II) ion	44
cobalt(III) ion	15

Three experiments, I, II and III are conducted. The graph shows the energy profile diagram for the three experiments.



(i) Describe, in detail, how a catalyst affects the rate of the reaction.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………….[2]

(ii) On the energy profile diagram above, label the activation energy, E_a for experiment III. [1]

For examiner's use

(iii) Complete the table by identifying which row describes the experiment conducted.

catalyst used	**experiment I, II or III**
iron(II) ion	
cobalt(III) ion	
no catalyst	

[1]
[Total: 10]

For examiner's use

EITHER

B11 **(a)** Polyethene is formed from polymerisation of many monomers of ethene.

(i) Draw the structural formula of polyethene.

[1]

(ii) Determine the number of $H_2C{=}CH_2$ monomeric units, *n*, in one molecule of polyethene with molar mass of 140 000 g. Hence, how many carbon atoms are present in one molecule of polyethene?

[3]

(iii) Plastics are non-biodegradable.

Explain what *non-biodegradable* means and discuss how this is both an advantage and a disadvantage.

…………………………………………………………………………………………..

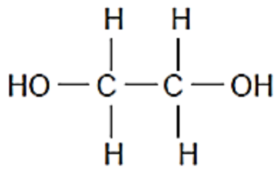
…………………………………………………………………………………………..

…………………………………………………………………………………………..

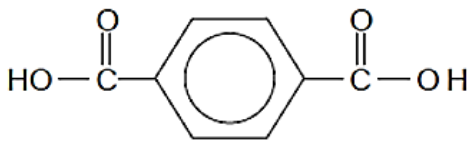
…………………………………………………………………………………………..

…………………………………………………………………………………………..[2]

(b) Dacron is an example of a polymer that is formed by condensation polymerisation of the two monomers as shown below.



Monomer **A**



Monomer **B**

(i) What does *condensation polymerisation* mean?

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[1]

(ii) Draw the full structural formula of the repeating unit in Dacron.

[1]

(iii) Describe a chemical test that can distinguish between monomer **A** and monomer **B**.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[2]

[Total: 10]

For examiner's use

For examiner's use

OR
B11 Vegetable oils can be used both to make margarine and fuels such a bio-diesel.

(a) Many vegetable oils are polyunsaturated.

(i) Explain the meaning of the term *polyunsaturated*.

…………………………………………………………………………………………….

…………………………………………………………………………………………….[1]

(ii) Describe how you could distinguish between samples of saturated and unsaturated vegetable oils.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….[2]

(b) Another potential biofuel is butanol.

Butanol can be made from petroleum.

(i) Describe how butanol is made from petroleum by the following route.

petroleum → butene → butanol

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….[3]

(ii) A sweet smelling compound with formula $CH_3COOCH_2CH_2CH_2CH_3$ can be formed by reacting butanol with substance **X** under suitable conditions. Give the name of substance **X** and state the conditions necessary for this reaction to occur.

…………………………………………………………………………………………….

…………………………………………………………………………………………….[2]

For examiner's use

(c) Farmers that grow vegetable crops often use large quantities of ammonium nitrate fertiliser.

Compounds containing hydroxide ions can be added to the soil to reduce its acidity.

Explain why adding such compounds to the soil immediately after fertiliser has been added is not recommended.
Construct an ionic equation for this reaction.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….[2]

[Total: 10]

**** END OF PAPER ****

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Class:	Candidate Name:	Candidate Index Number:

EDGEFIELD SECONDARY SCHOOL
2022 PRELIMINARY EXAMINATION
Secondary 4

O Syllabus

CHEMISTRY

6092/02

Paper 2 Theory

August 2022

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, name and class register number in the above boxes.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form *either/or*.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 22.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
Section A	**/ 50**
Section B	**/ 30**
TOTAL	**/ 80**

My target grade/mark: _________

Parent's signature

This document consists of **22** printed pages.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Choose from the following equations to answer the questions below.

A	$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$
B	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
C	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
D	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$
E	$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$
F	$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
G	$2I^-(aq) + Br_2(aq) \rightarrow I_2(aq) + 2Br^-(aq)$
H	$NH_4^+(aq) + OH^-(aq) \rightarrow H_2O(l) + NH_3(g)$
I	$4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

Each equation can be used once, more than once or not at all.

Give the letter of an equation which

(a) shows the formation of gas that forms a white precipitate with limewater,

.... [1]

(b) shows a reaction that forms a blue precipitate,

.... [1]

(c) shows only oxidation,

.... [1]

(d) shows the neutralisation of hydrochloric acid by sodium hydroxide,

.... [1]

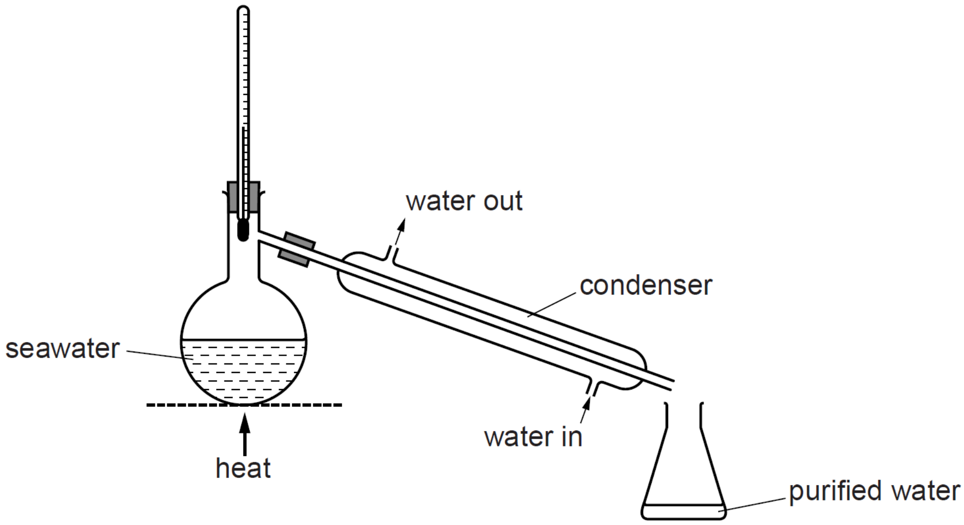
(e) shows the reaction at an inert positive electrode when copper(II) sulfate is electrolysed.

.... [1]

[Total: 5]

A2 Seawater contains a variety of dissolved salts.

(a) The diagram shows a simple distillation apparatus that can be used to produce purified water from seawater.



Explain how distillation purifies seawater.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

…………………………………………………………………………………… [3]

(b) Magnesium chloride, $MgCl_2$, is present in seawater at a concentration of 1.26 g/dm^3.

(i) Write the formulae for the ions present in magnesium chloride.

…………………………………………………………………………….... [1]

(ii) Calculate the concentration of chloride ions, in mol/dm^3, arising from the magnesium chloride in seawater.

[1]

(iii) Aqueous silver nitrate is added to a small sample of seawater. Describe what you would observe.

…………………………………………………………………….... [1]

(c) The concentration of sulfate ions in seawater is 1.24 g/dm^3.

Excess aqueous barium chloride is added to a 50.0 cm^3 sample of seawater.

(i) Write the ionic equation for the precipitation reaction

…………………………………………………………………….... [1]

(ii) Hence, calculate the mass of barium sulfate precipitated.

[3]

[Total: 10]

A3 Silicon is an element in Group IV of the Periodic Table.

(a) Give the electronic configuration for a silicon atom.

…………………………………………………………………………………… [1]

(b) Silicon reacts with chlorine on heating to form silicon(IV) chloride, $SiCl_4$.

Construct an equation for this reaction.

…………………………………………………………………………………… [1]

(c) Silicon(IV) chloride is a simple molecular compound.

(i) Suggest two physical properties of silicon(IV) chloride other than solubility.

1 ……………………………………………………………………………

2 …………………………………………………………………………… [2]

(ii) Draw a 'dot-and-cross' diagram to show the bonding in silicon(IV) chloride. Show the outer electrons only.

[2]

[Total: 6]

A4 Analysis of compound **Y** shows it has the following composition.

element	percentage by mass
hydrogen	3.4
nitrogen	12.0
oxygen	41.0
vanadium	43.6

(a) Determine the empirical formula of **Y**.

[3]

(b) Suggest one property of aqueous **Y** caused by the presence of vanadium.

…………………………………………………………………………………… [1]

(c) Aqueous sodium hydroxide is added to solid **Y** and the mixture is warmed.

A colourless gas that turns moist red litmus blue is evolved.

Deduce the formula of each of the two ions present in **Y**.

……………………………………………………………………………………...

…………………………………………………………………………………… [2]

(d) An acidified aqueous solution of **Y** reacts with aqueous potassium iodide to form iodine.

State and explain what you can deduce about the redox nature of **Y**.

………………………………………………………………………………………...

……………………………………………………………………………….…… [2]

(e) When solid **Y** is heated, only V_2O_5, water and gas **Z** are formed.

(i) Name gas **Z**.

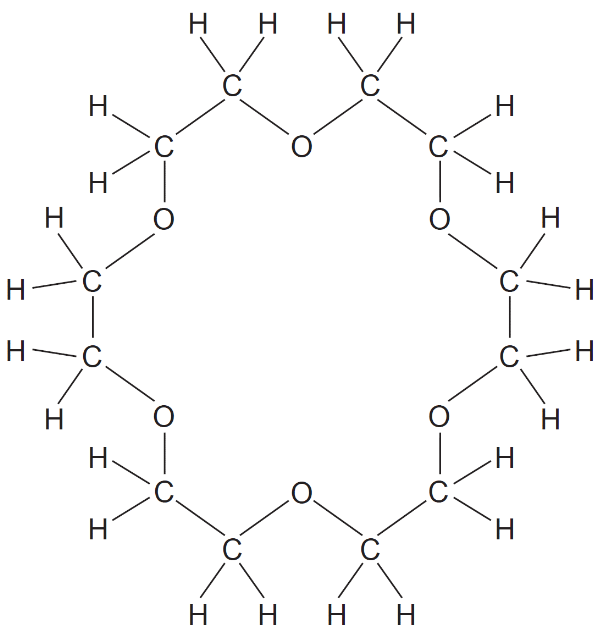
……………………………………………………………………….…..... [1]

(ii) Write an equation for the reaction.

……………………………………………………………………….…..... [1]

[Total: 10]

A5 Sodium can react with compounds called crown ethers. A typical crown ether is shown below.



(a) Write the empirical formula for this crown ether.

……………………………………………………………………………….…… [1]

(b) When sodium reacts with crown ethers it forms Na^+ and Na^- ions. Draw the structure of an Na^- ion. Show all the electrons.

[1]

(c) Sodium reacts violently with chlorine gas to form sodium chloride.

Write an equation for the reaction of sodium with chlorine.

…………………………………………………………………………………… [1]

(d) The melting point of sodium chloride is 801 °C.
The melting point of chlorine is –101 °C.

Explain, in terms of structure and bonding, the difference between the melting points of these two substances.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

…………………………………………………………………………………… [4]

(e) Sodium chloride can be broken down into its elements by electrolysis.

Explain why pure sodium chloride can be electrolysed at 1000 °C but not at 600 °C.

……………………………………………………………………………………...

……………………………………………………………………………………...

…………………………………………………………………………….… [2]

[Total: 9]

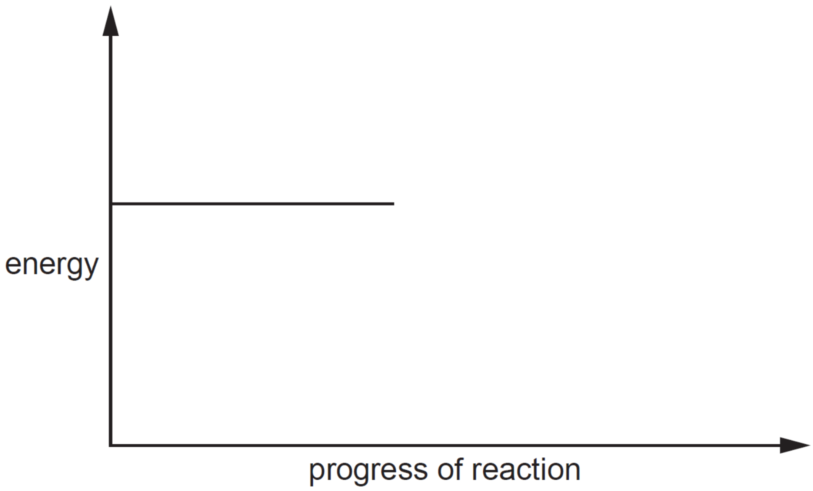
A6 Ethanoic acid is manufactured in the factories by a reaction between methanol, CH_3OH, and carbon monoxide.

$$CH_3OH + CO \rightarrow CH_3COOH \qquad \Delta H = -137 \text{ kJ/mol}$$

(a) Complete the energy profile diagram for the reaction between methanol and carbon monoxide.

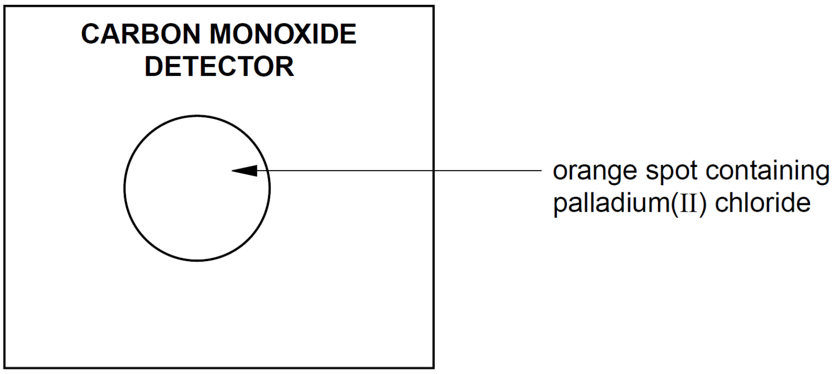
On your diagram label

- the reactants and products,
- the enthalpy change for the reaction,
- the activation energy.



[3]

(b) As a safety measure, carbon monoxide detectors are fitted in the factories.



The orange spot turns black if there is a high concentration of carbon monoxide in the air.

(i) Why is carbon monoxide hazardous?

………………………………………………………………………………..

…………………………………………………………………………..... [1]

(ii) Complete the equation by writing the formula of the missing reactant in the box.

$PdCl_2(s)$ + $\boxed{\quad}$ + $CO(g) \rightarrow Pd(s) + 2HCl(g) + CO_2(g)$

Complete the equation by writing the formula of the missing reactant in the box.

[1]

(iii) Complete the table to show the oxidation states of palladium and carbon before and after the reaction takes place.

element	oxidation state before reaction	oxidation state after reaction
palladium		
carbon		

[2]

(iv) Use information from the table to explain why this is a redox reaction.

……………………………………………………………………………………..

……………………………………………………………………………..... [2]

(c) Name one industrial process that used carbon monoxide as a reducing agent.

…………………………………………………………………………….…. [1]

[Total: 10]

Section B (30 marks)
Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Reactivity of metals

The reactivity of metals may determine by reacting them with either cold water or steam or with both. Table 7.1 shows the reactivity of five metals.

Table 7.1

metal	reactivity
barium	reacts rapidly with cold water
copper	no reaction with steam or cold water
magnesium	reacts very slowly with cold water but reacts with steam
sodium	reacts very rapidly with cold water
nickel	only reacts when powdered and heated strongly in steam

Standard Electrode Potentials

The reactivity of a metal is related to the ease at which the metal is oxidised or loses electrons. The ease at which a substance is oxidised or reduced can be quantified using standard reduction potentials.

The standard reduction potential (E°) of a substance measures how easily a substance is reduced, or how easily a substance gains electrons.

The E° value of a substance is measured relative to a standard hydrogen electrode, in which the following reaction takes place:

$$2H^+(aq) + e^- \rightleftharpoons H_2(g)$$

The reduction reaction of hydrogen ions to hydrogen is assigned an E° value of 0.00 V.

Table 7.2 shows the electrode reactions and E° values of some metals.

The more positive the E° value, the more likely the forward reaction takes place and the more easily the substance is reduced.

Conversely, the more negative the E° value, the more likely the reverse reaction takes place and the more easily the substance is oxidised.

Table 7.2

metal	electrode reaction	E°/ V
chromium	$Cr^{3+}(aq) + 3e^{-} \rightleftharpoons Cr(s)$	-0.74
copper	$Cu^{2+}(aq) + 2e^{-} \rightleftharpoons Cu(s)$	+0.34
iron	$Fe^{3+}(aq) + 3e^{-} \rightleftharpoons Fe(s)$	-0.04
magnesium	$Mg^{2+}(aq) + 2e^{-} \rightleftharpoons Mg(s)$	-2.38
nickel	$Ni^{2+}(aq) + 2e^{-} \rightleftharpoons Ni(s)$	-0.25
sodium	$Na^{+}(aq) + e^{-} \rightleftharpoons Na(s)$	-2.71
tin	$Sn^{2+}(aq) + 2e^{-} \rightleftharpoons Sn(s)$	-0.14
zinc	$Zn^{2+}(aq) + 2e^{-} \rightleftharpoons Zn(s)$	-0.76

Determining the Products of Electrolysis

When two or more positive ions are present in the solution during electrolysis, the ion that is preferentially discharged at the cathode can be determined using the electrochemical series.

The electrochemical series is also related to the standard electrode potentials for the metal ions.

(a) Deduce the order of reactivity of these metals using the information in Table 7.1.

most reactive ……………………………………

……………………………………

……………………………………

……………………………………

least reactive ……………………………………

[1]

(b) Deduce the relationship between the E° value and reactivity of metals.

………………………………………………………………………………………...

………………………………………………………………………………….… [1]

(c) **(i)** Some E° values are shown below.

-2.55 V -0.44 V +0.16 V +0.80 V

What is the most suitable E° value for silver? Explain your reasoning.

……………………………………………………………………………......

……………………………………………………………………………......

……………………………………………………………………….…..... [2]

(ii) Write the equation for the electrode reaction for silver.

……………………………………………………………………….…..... [1]

(d) Which of the following displacement reactions is likely to occur? Put a tick (✓) if a reaction is likely to occur.

metal	chromium	tin
aqueous solution of nickel(II) ions		
dilute nitric acid		

[2]

(e) **(i)** Describe how the electrochemical series is related to the standard reduction potentials shown in Table 7.2.

……………………………………………………………………………......

……………………………………………………………………….... [1]

(ii) Complete the table below for the electrolysis of a molten mixture of iron(III) chloride and tin(II) chloride using graphite electrodes.

electrode	substance that would be produced first	ionic half-equation for the reaction at each electrode
positive		
negative		

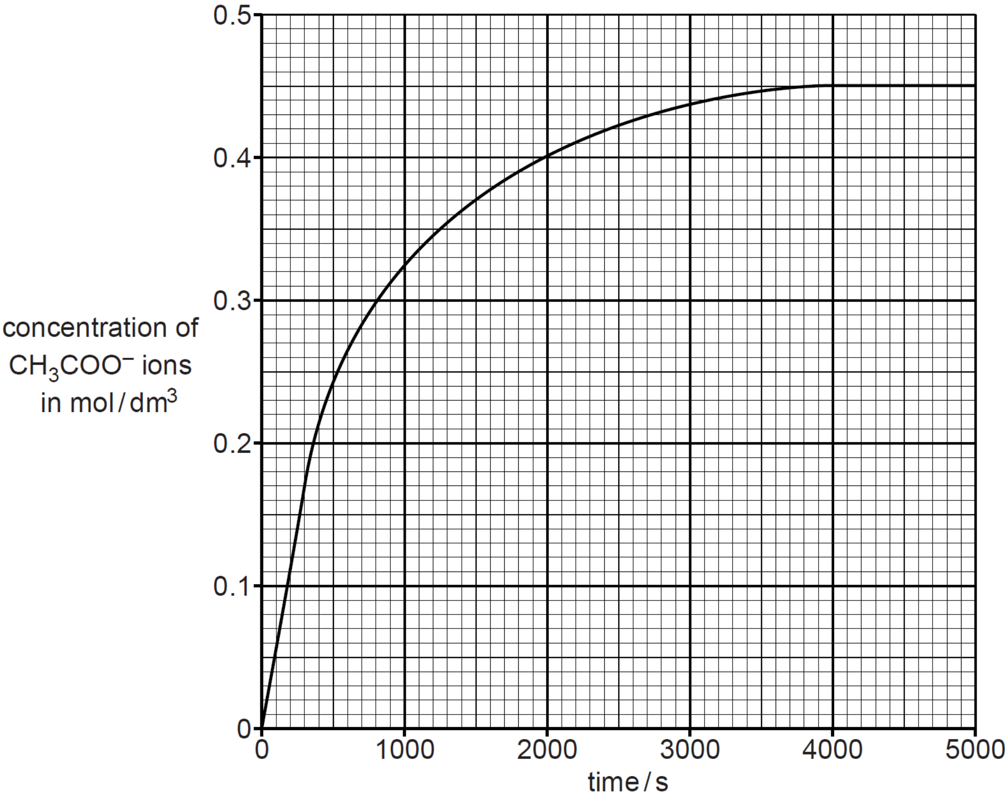
[2]

[Total: 10]

B8 The ester, ethyl ethanoate, reacts with hydroxide ions to form ethanoate ions and ethanol.

$$\underset{\text{ethyl ethanoate}}{CH_3COOC_2H_5} + OH^- \rightarrow \underset{\text{ethanoate ions}}{CH_3COO^-} + C_2H_5OH$$

(a) The graph shows how the concentration of ethanoate ions, CH_3COO^-, changes as the reaction proceeds.



(i) Use the information in the graph to deduce the mass of ethanoate ions in 200 cm^3 of solution when the reaction is complete.

mass of ethanoate ions .... g [2]

(ii) Use the information in the graph to calculate the average rate of reaction, in mol/dm^3/s, during the first 300 seconds.

average rate of reaction ....mol/dm^3/s [1]

(iii) Describe the change in the rate of reaction with time. Use information from the graph to support your answer.

……………………………………………………………………………......

……………………………………………………………………………......

……………………………………………………………………………..... [2]

(iv) Explain, using collision theory, the observed change in the rate of reaction with time.

……………………………………………………………………………......

……………………………………………………………………………......

……………………………………………………………………………......

……………………………………………………………………………..... [3]

(b) Explain why liquid ethanol does not conduct electricity.

……………………………………………………………………………………...

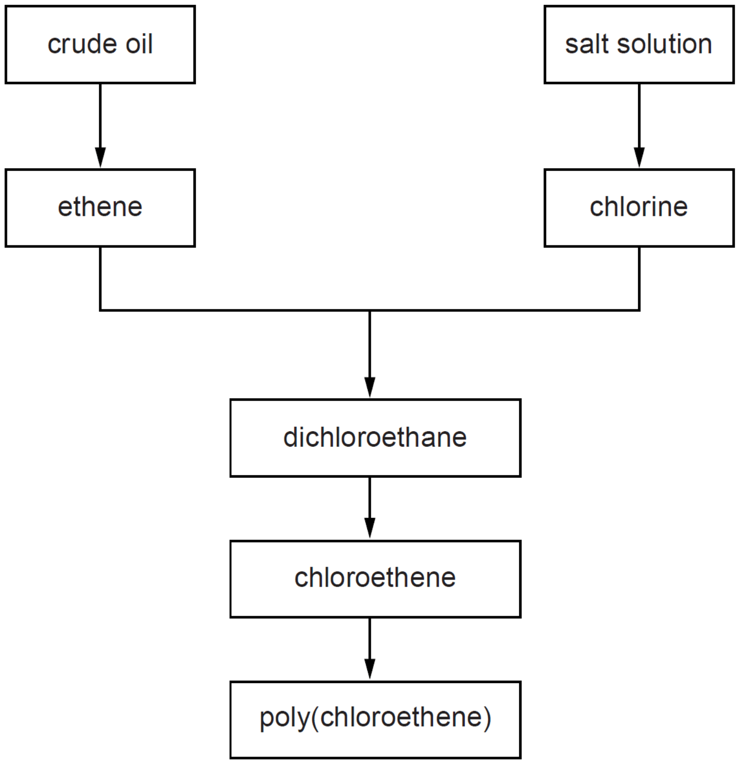
……………………………………………………………………………………...

………………………………………………………………………………… [2]

[Total: 10]

EITHER

B9 Large quantities of poly(chloroethene) are manufactured annually. The flow chart shows the steps involved in the manufacture of poly(chloroethene).



(a) Name the two processes used to obtain ethene from crude oil.

…………………………………………………………………………………...

…………………………………………………………………………….… [2]

(b) Chlorine gas is produced from the electrolysis of salt solution (aqueous sodium chloride).

Explain why the salt solution used must be concentrated.

…………………………………………………………………………….… [1]

(c) Draw the structure, showing all the atoms and all the bonds, of the dichloroethane.

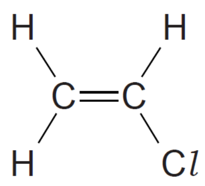
[1]

(d) When dichloroethane, $C_2H_4Cl_2$, is heated strongly, chloroethene, C_2H_3Cl, is formed.

Name the other product of this reaction.

.... [1]

(e) The structure of chloroethene is shown.



Draw the structure of a section of poly(chloroethene). Show three repeat units.

[2]

(f) A factory uses 2250 tonnes of chloroethene to make poly(chloroethene). [1 tonne = 1000 kg]

(i) Deduce the maximum mass of poly(chloroethene) the factory could make.

[1]

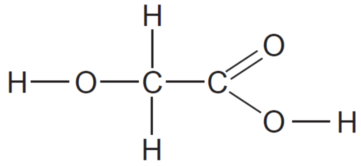
(ii) The actual yield of poly(chloroethene) is 2175 tonnes. Calculate the percentage yield.

[2]

[Total: 10]

OR

B9 The structure of glycollic acid is shown below.



(a) Name the two functional groups present in glycollic acid.

.... and .... [1]

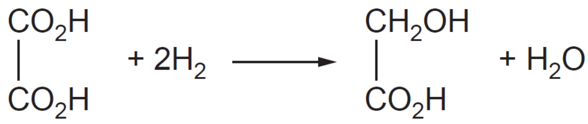
(b) Glycollic acid undergoes similar reactions to ethanoic acid.

Complete the equation for the reaction of glycollic acid with sodium carbonate.

..... $HOCH_2CO_2H + Na_2CO_3 \rightarrow$ .... + ... + ...

[2]

(c) Glycollic acid can be prepared from oxalic acid.

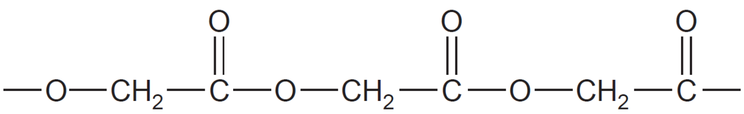


oxalic acid glycollic acid

How does this equation shows that oxalic acid has been reduced?

.... [1]

(d) Glycollic acid polymerises to form poly(glycollic acid). The diagram shows a section of this polymer.



(i) Is poly(glycollic acid) an addition polymer or a condensation polymer? Give a reason for your answer.

....

.... [1]

(ii) Name another polymer with the same linkage as poly(glycollic acid).

.... [1]

(e) Poly(glycollic acid) is biodegradable whereas poly(ethene) is non-biodegradable.

(i) Suggest one environmental advantage of using biodegradable polymers.

…………………………………………………………………………......

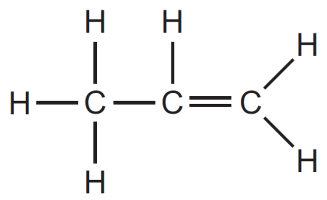
…………………………………………………………………………......

………………………………………………………………………..... [1]

(ii) State one use of poly(ethene).

………………………………………………………………………..... [1]

(iii) The structure of propene is shown.



Draw the structure of a section of poly(propene). Show three repeat units.

[2]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

East Spring Secondary School
Towards Excellence and Success

Name: ………………………………………………………………………………… ( )

Class: ……………….

Preliminary Examination 2022
Secondary 4 Express

CHEMISTRY **6092/02**
Paper 2

Monday **1 hour 45 minutes**
29 August 2022 **0800 – 0945**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 27.

The use of an approved scientific calculation is expected, where appropriate.

Section	Marks
Section A	50
Section B	30
Total	**80**

This Question Paper consists of **27** printed pages including the cover page.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Fig. 1.1 shows the structures of six substances containing carbon.

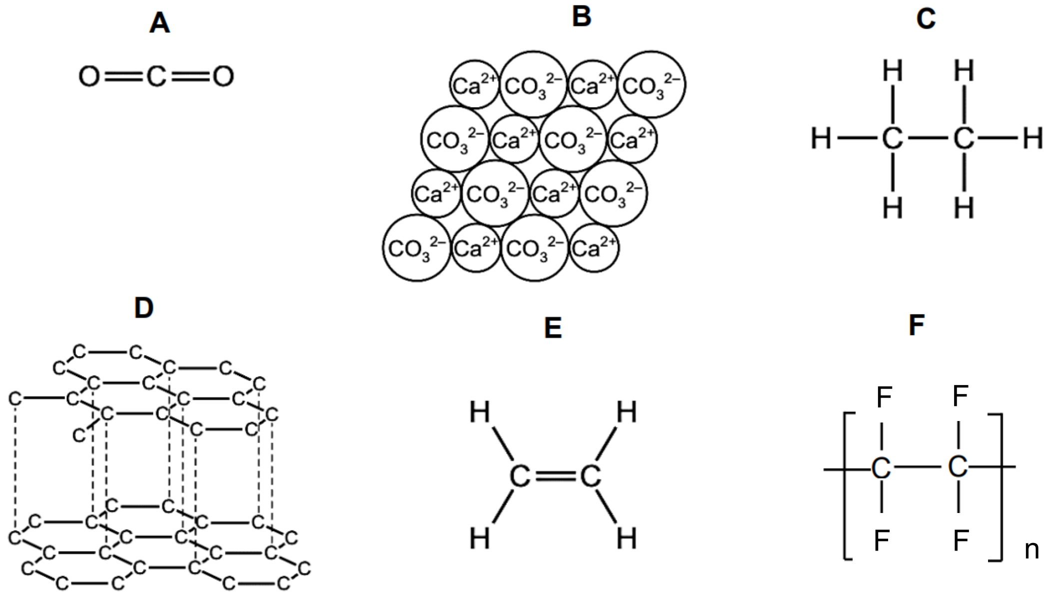


Fig. 1.1

Use the letters **A**, **B**, **C**, **D**, **E** or **F** to answer the questions.

Each letter may be used once, more than once or not at all.

(a) Which substance is able to conduct electricity due to mobile electrons?

....[1]

(b) Which substance is a saturated hydrocarbon?

....[1]

(c) Which substance is added to the blast furnace in the extraction of iron?

....[1]

(d) Which substance is used to line non-stick pans?

....[1]

(e) Which substance contributes to global warming?

....[1]

[Total: 5]

A2 The structure of magnesium oxide is shown in Fig. 2.1.

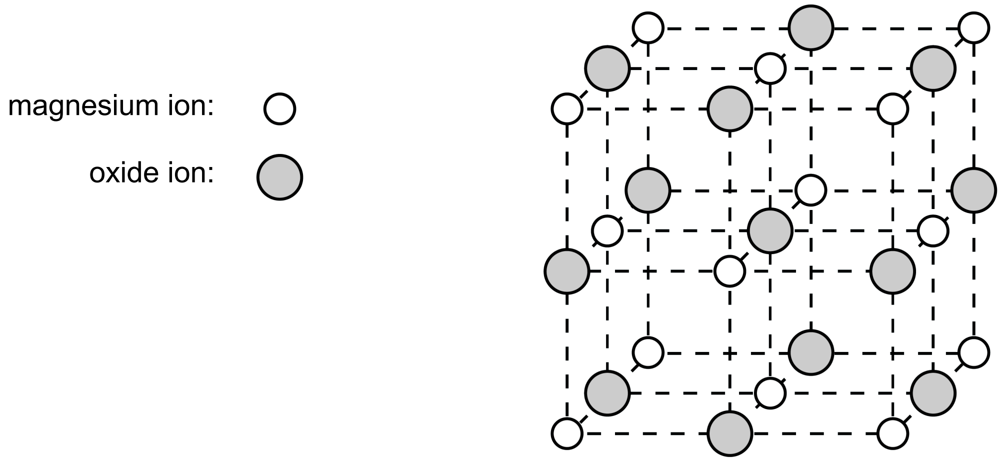


Fig. 2.1

(a) Draw a 'dot-and-cross' diagram to show the bonding in magnesium oxide.
Show the outer shell electrons only.

[2]

(b) Predict the physical state of magnesium oxide at room temperature.

Explain your answer, with reference to the structure and bonding of magnesium oxide.

………

………

………

………

……………………………………………………………………………………………………[3]

(c) Describe, with reference to their structures, how the conduction of electricity in magnesium oxide differs from that in magnesium.

....

....

....

....[3]

[Total: 8]

A3 Fig. 3.1 shows two tubes, 1 and 2, to investigate the rate of diffusion of gases.

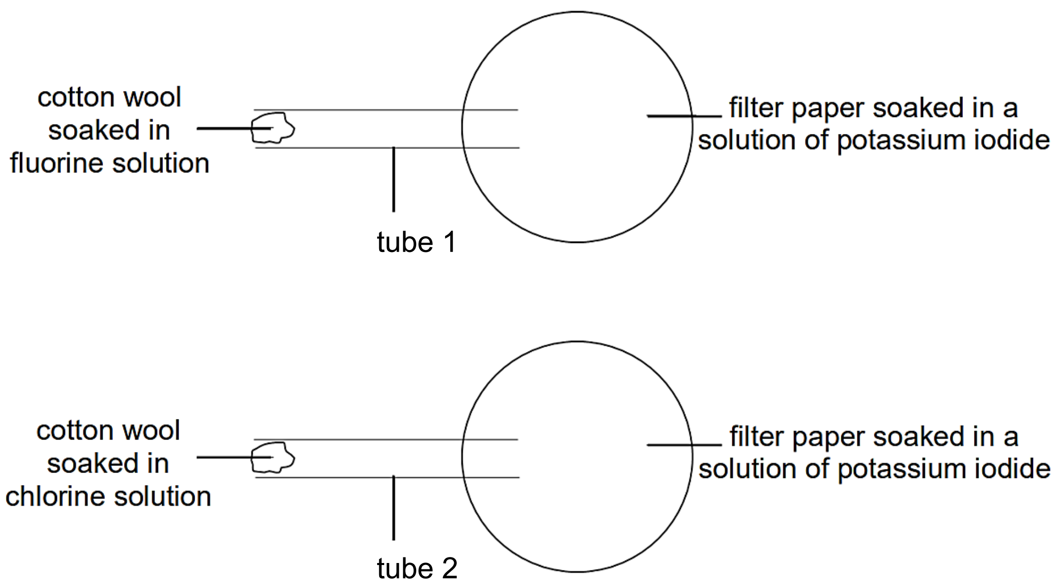


Fig. 3.1

Two pieces of cotton wool soaked in fluorine and chlorine solution were placed in one end of a glass rod in tubes 1 and 2 respectively. The solution on the filter papers of both tubes turned brown.

Table 3.2 shows the time taken for the gases to diffuse and for the solution on the filter paper to turn brown.

Table 3.2

gas	M_r	time taken / s
fluorine, F_2		16
chlorine, Cl_2		29

(a) Complete Table 3.2 by filling in the M_r for each gas. [1]

(b) Construct a balanced chemical equation, including state symbols, for the reaction in tube 1.

……………………………………………………………………………………………...[2]

(c) A student makes this conclusion:

'The time taken for the diffusion of the gases is directly proportional to the relative molecular mass of each gas.'

Do the measurements obtained in the experiment support this conclusion?

Explain your reasoning.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………...[2]

(d) The experiment in each tube is repeated at a lower temperature.

Suggest one difference in the observation made.

……………………………………………………………………………………………...[1]

[Total: 6]

A4 A student did some tests using four reagents, **A**, **B**, **C** and **D**.

In each test, a different reagent was added to separate fresh samples of aqueous copper(II) chloride and aqueous copper(II) sulfate.

Table 4.1 shows the reagents he used.

Table 4.1

	reagent
A	magnesium ribbon
B	acidified aqueous silver nitrate
C	acidified aqueous barium chloride
D	aqueous ammonia

Describe what the student would observe when he adds each of the four reagents to separate fresh samples of aqueous copper(II) chloride and aqueous copper(II) sulfate.

....

....

....

....

....

....

....

....

....

....

....

....[5]

[Total: 5]

A5 Chlorofluorocarbons (CFCs) have been used in large quantities as solvents and aerosol propellants. CFCs are chemically inert and do not react with air or water.

The use of CFCs, however, lead to the depletion of the ozone layer. They are now being replaced with other organic compounds that cause little or no harm to the ozone layer.

One of the most widely used CFCs is CCl_2F_2, which can be made from methane in a series of reactions.

(a) Name the type of reaction that is used to make CCl_2F_2 from methane.

………………………………………………………………………………………………….[1]

(b) By means of a "dot and cross" diagram, show the arrangement of the electrons in a CCl_2F_2 molecule. Show only the valence electrons.

[2]

(c) When CFC compounds are released into the atmosphere, the C-C*l* bond would be broken by ultraviolet light, releasing C*l* atoms.

These C*l* atoms would break down ozone, O_3, in a two-step process.

step 1 $\quad Cl + O_3 \rightarrow ClO + O_2$

step 2 $\quad ClO + O \rightarrow Cl + O_2$

Use the equations for step 1 and 2 to explain why one C*l* atom can destroy 100 000 ozone molecules.

……..…………………………………………………..………………………………..……..

………………..…………………………………………..………………………………..……..

……………………..……………………………………………………………………...……[2]

(d) Explain the importance of the ozone layer.

…………………………..…………………………………………………………………………..

…………………………..……………………………………………………………………….[1]

[Total: 6]

A6 Group VII elements react with hydrogen to form hydrogen halides.

The hydrogen halides are gases at room temperature and pressure, and dissolve in water to form hydrofluoric acid, hydrochloric acid and hydroiodic acid respectively.

The dissociation constant for an acid indicates the extent to which it dissociates into ions.

The higher the dissociation constant, the stronger the acid.

The dissociation constants for some acids are given in Table 6.1.

Table 6.1

acid	formula of acid	dissociation constant
hydrofluoric acid	HF	6.8×10^{-4}
hydrochloric acid	HCl	1.0×10^{7}
hydroiodic acid	HI	3.0×10^{9}
hydrocyanic acid	HCN	6.2×10^{-10}

(a) With reference to Table 6.1, deduce which substance is the strongest acid.

……………………………………………………………………………………………………….[1]

(b) Write an ionic equation to show the dissociation of dilute hydrochloric acid in water.

……………………………………………………………………………………………………….[1]

(c) Table 6.2 shows the atomic size of some Group VII elements in picometre (pm).

Table 6.2

Group VII element	atomic size (pm)
fluorine	64
chlorine	99
bromine	114
iodine	133

(i) With reference to Table 6.1 and Table 6.2, describe how the atomic size of Group VII element affects the strength of the acid formed by the hydrogen halide.

……

……[1]

(ii) Predict whether dilute hydrobromic acid, HBr, is a stronger acid or a weaker acid than dilute hydroiodic acid, HI.

Explain your reasoning.

……

……

……

……[2]

[Total: 5]

A7 In an experiment, hydrogen gas was passed over equal masses of three heated metal oxides in identical porcelain boats as shown in Fig. 7.1.

Boat 1 contains copper(II) oxide, boat 2 contains an oxide of metal X, X_2O, and boat 3 contains an oxide of metal Y.

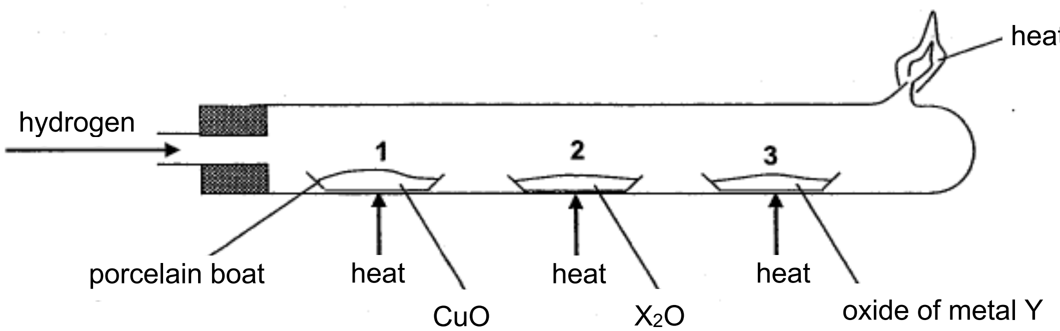


Fig. 7.1

The porcelain boats were weighed 5 minutes into the experiment. After weighing, the experiment was allowed to continue for another 30 minutes, until no further changes to the mass of the porcelain boats and its contents were observed.

At the end of the experiment, the heat source was turned off. However, the hydrogen gas is kept flowing until the tube has cooled down.

Table 7.2 shows some data from this experiment.

Table 7.2

mass of	at the start of experiment	5 minutes into the experiment	at the end of experiment
empty porcelain boat / g	16.35	-	16.35
porcelain boat 1 and its contents / g	22.35	21.15	20.15
porcelain boat 2 and its contents / g	22.35	22.35	22.35
porcelain boat 3 and its contents / g	22.35	21.20	20.55

(a) What would you expect to see happen in porcelain boat 1?

Explain, with the aid of a balanced chemical equation, for the reaction that had occurred.

……………………………………………………………………………………………………

…………………………………………………………………………………………………....[2]

(b) **(i)** Arrange the three metals, Cu, X, and Y, in the order of their reactivity, starting with the most reactive.

……………………………………………………………………………………………….[1]

(ii) With reference to Table 7.2, explain how you reached the conclusion in **(b)(i)**.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………….[3]

(i) With reference to Table 7.2, calculate the mass of oxygen in the oxide of metal Y.

[1]

(ii) Given that the relative atomic mass of metal Y is 56, deduce the empirical formula of the oxide of metal Y. Show your working.

[2]

[Total: 9]

A8 The experiment in Fig. 8.1 shows the electrolysis of concentrated aqueous zinc chloride solution using carbon electrodes.

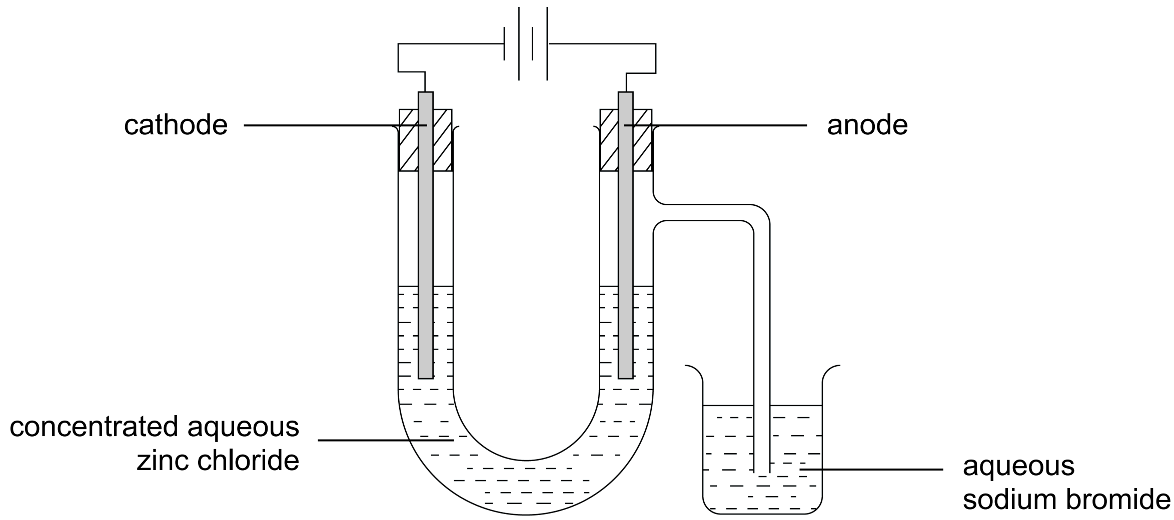


Fig. 8.1

(a) Write equations for the reactions that happen at each electrode.

cathode: ……………………………………………………………………………………………...

anode: …………………………………………………………………………………………… [2]

(b) Describe and explain the observation in the beaker of aqueous sodium bromide during the electrolysis.

…………………………………………………………………………………………………….

……………………………………………………………………………………………………....

…………………………………………………………………………………………………….[2]

(c) At the end of the experiment, a student removes a sample of the electrolyte and puts it in a beaker.

The student then uses a data logger to test the pH of the sample, and a pH value of 9 was recorded.

Explain this observation.

……………………………………………………………………………………………………...

…………………………………………………………………………………………………….[1]

(d) The electrolysis was repeated using dilute aqueous zinc chloride solution.

State one difference between the products of the electrolysis using dilute aqueous zinc chloride and concentrated aqueous zinc chloride.

………

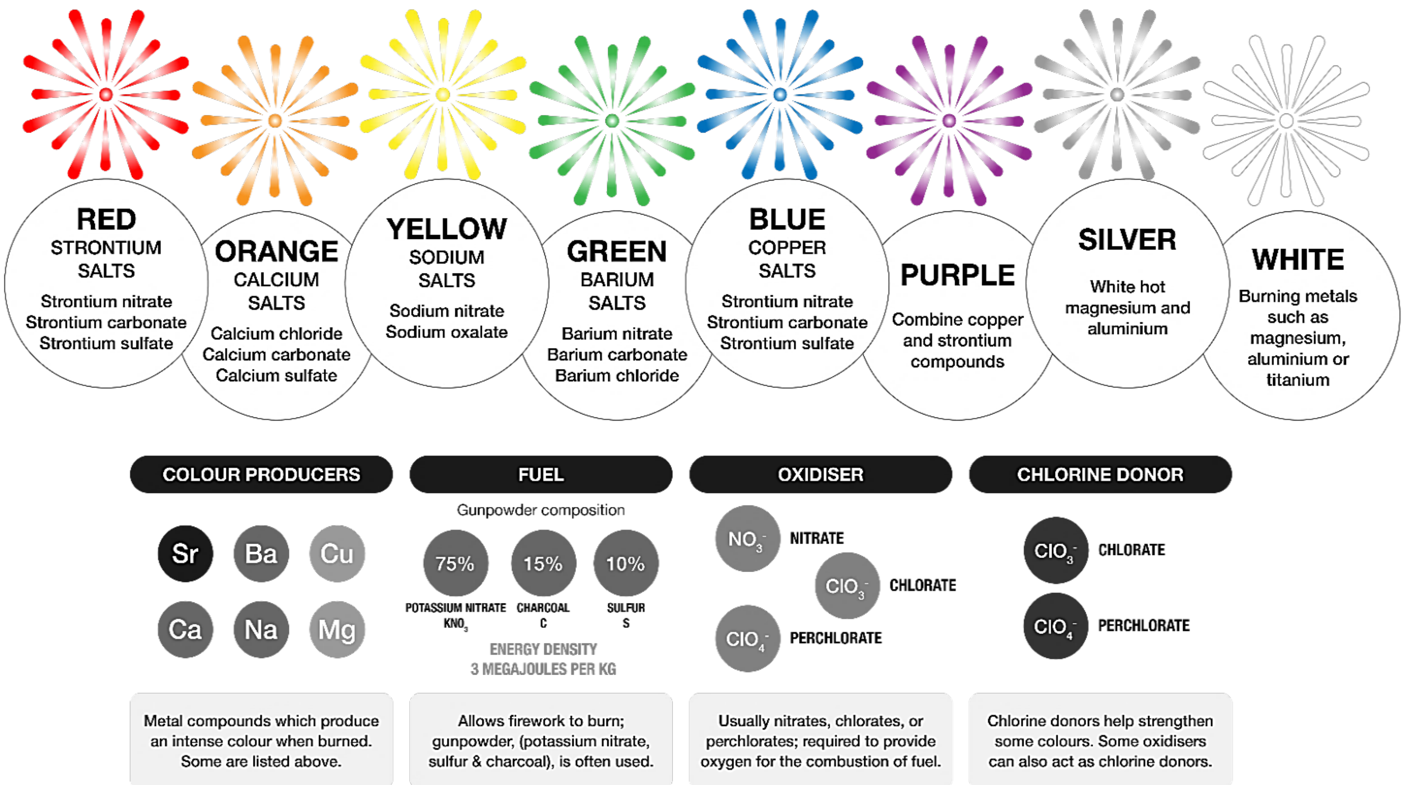
……[1]

[Total: 6]

Section B

Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 The Chemistry of Firework Colours



The sights and sounds of each firework explosion are the result of several chemical reactions taking place within the firework as it ascends into the sky. Fireworks consist of a mixture of gunpowder and other chemicals that create the spectacular colours. The colours in fireworks stem from a wide variety of metal compounds, particularly metal salts.

Gunpowder and Oxidisers

Gunpowder is made up of potassium nitrate, charcoal (carbon) and sulfur in the percentages by mass of 75 : 15 : 10. Each of these components plays an important role in the combustion of the black powder in the form of self-sustaining exothermic reactions that do not rely on oxygen from external sources.

Potassium nitrate acts as an oxidiser, decomposing into potassium oxide, nitrogen gas, and oxygen gas in the reaction process, as shown in the equation below.

$$2KNO_3\ (s) \rightarrow K_2O\ (s) + N_2\ (g) + 2.5\ O_2\ (g)$$

Oxidisers supply oxygen to the reducing agents, carbon and sulfur, which serve as a fuel. Carbon and sulfur react with oxygen to produce carbon dioxide and sulfur dioxide respectively.

$$O_2\,(g) + C\,(s) \rightarrow CO_2\,(g) \quad \Delta H = -393\text{ kJ / mol of C}$$

$$O_2\,(g) + S\,(s) \rightarrow SO_2\,(g) \quad \Delta H = -2368\text{ kJ / mol of S}$$

The reactions that produce these gases release a lot of heat energy, so not only are the gases produced rapidly, they are hot and rapidly expanding gases. This adds to the explosive force of the reaction. More than 10 000 kJ of energy is released for every kilogram of gunpowder used, and the resulting temperatures can reach 2000°C and beyond.

In recent years, a group of more explosive oxidisers called perchlorates are more commonly used. Perchlorates contain the perchlorate ion (ClO_4^-), in which each chlorine atom is bonded to four oxygen atoms. Perchlorate is able to release all four of its oxygen atoms, making it a better oxidiser than potassium nitrate.

$$KClO_4\,(s) \rightarrow KCl\,(s) + 2O_2\,(g)$$

Colours in fireworks

Fireworks get their colours from metal salts. The colour of the flame depends on the metal cation. The anion of the salt has no direct influence. The anions however influence the flame brightness, both by increasing it (e.g. nitrates and chlorates) and decreasing it (e.g. carbonates and oxalates). Some examples of metal salts used in fireworks are given in Table 9.1.

Table 9.1

colour	chemical name	chemical formula
blue	copper(II) carbonate	$CuCO_3$
green	barium carbonate	$BaCO_3$
green	barium chlorate	$Ba(ClO_3)_2$
orange	calcium carbonate	$CaCO_3$
red	strontium oxalate	SrC_2O_4
yellow	sodium nitrate	$NaNO_3$
yellow	sodium oxalate	$Na_2C_2O_4$

The chemistry of fireworks includes the formation of gases that pollute the air. Burning of fireworks releases atmospheric pollutants such as carbon monoxide, sulfur dioxide and nitrogen oxides.

Source: https://www.compoundchem.com/2013/12/30/the-chemistry-of-fireworks/

(a) **(i)** With reference to the oxidation state of nitrogen in potassium nitrate, explain why potassium nitrate acts as an oxidiser.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

……………………………………………………………………………………………[2]

(ii) Use equations from the text to explain why potassium perchlorate acts as a better oxidiser than potassium nitrate.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

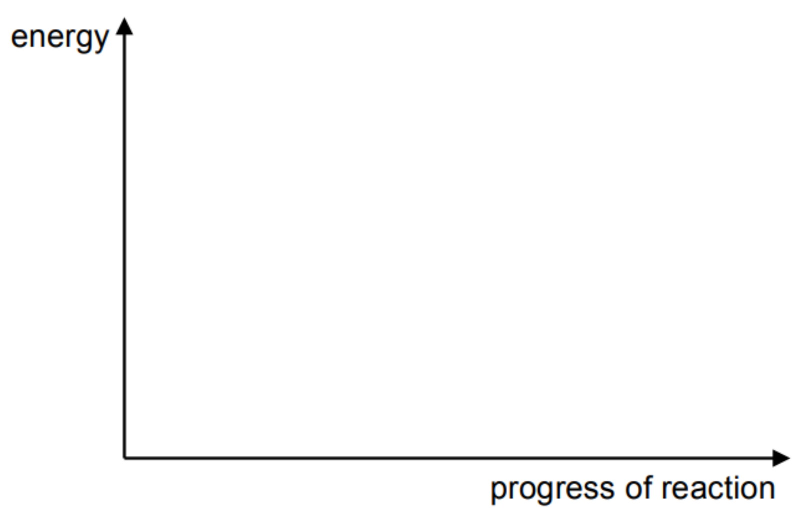
…………………………………………………………………………………………….[1]

(b) Gunpowder contains carbon and sulfur which serve as fuels in fireworks.

(i) Draw an energy profile diagram for the complete combustion of 1 mole of sulfur.

Your diagram should include:

- the formulae of the reactant(s) and product(s),
- the labels to show the activation energy and the enthalpy change of reaction.



[3]

(ii) Calculate the masses, in g, of carbon and sulfur in 1 kg of gunpowder.

[1]

(iii) Calculate the energy produced by the complete combustion of 1 g of **each** carbon and sulfur fuel.

Hence, use your calculations in **(ii)** and **(iii)** to show that the total energy released from the complete combustion of the carbon and sulfur content in 1 kg of gunpowder exceeds 10 000 kJ.

[2]

(c) Fireworks come in a mixture of different compounds.

Mixture 1 contains calcium oxalate, CaC_2O_4, and strontium carbonate , $SrCO_3$.

Mixture 2 contains barium nitrate, $Ba(NO_3)_2$, and copper(II) chlorate, $Cu(ClO_3)_2$.

Describe the differences in the colour and the flame brightness of the fireworks produced by mixtures 1 and 2.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………..[2]

(d) Describe how nitrogen oxides are formed during the burning of fireworks.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………..[1]

[Total: 12]

B10 Dichromate salts contain the anion dichromate, $Cr_2O_7^{2-}$. Dichromates are used in chrome plating to protect metals such as zinc from corrosion and to improve paint adhesion.

Aqueous dichromate salt solutions are orange in colour. When an aqueous solution of a dichromate salt reacts with zinc under acidic conditions, the solution changes from orange to green due to the formation of the chromium(III) ion.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 3Zn(s) \rightarrow 2Cr^{3+}(aq) + 3Zn^{2+}(aq) + 7H_2O(l)$$

The conditions of the reaction are changed by changing the concentration of dichromate ions or concentration of hydrogen ions.

The rate of reaction can be measured by the initial rate of disappearance of the dichromate ion per second.

Table 10.1 shows the conditions and results for a series of experiments.

Table 10.1

experiment	concentration of $Cr_2O_7^{2-}$ / mol/dm^3	concentration of H^+ / mol/dm^3	initial rate of disappearance of $Cr_2O_7^{2-}$ per second / mol/dm^3
1	0.020	0.030	0.00276
2	0.040	0.030	0.01104
3	0.020	0.060	0.00552
4	0.040	0.060	0.02208
5	0.040	0.090	0.03312
6	0.120	0.030	0.09936

(a) Explain, in terms of collisions between reacting particles, the effect of the concentration of the dichromate ion on the rate of reaction.

....

....

....

....[2]

(b) Does the rate of reaction depend on the concentration of $Cr_2O_7^{2-}$ and H^+ equally?

Explain your answer using the results in Table 10.1, stating clearly the set of experimental data you are using.

....

....

....

....

....

....

....

....[4]

(c) Predict the initial rate of disappearance per second of $Cr_2O_7^{2-}$, if the experiment was conducted using 0.040 mol/dm^3 of $Cr_2O_7^{2-}$ and 0.120 mol/dm^3 of H^+.

....[1]

(d) Suggest one way to increase the rate of reaction in Experiment 1, without changing the concentration of $Cr_2O_7^{2-}$ and H^+.

....[1]

[Total: 8]

EITHER

B11 Alcohols are a homologous series of organic compounds.

Table 11.1 shows some information about the first five alcohols.

Table 11.1

name	molecular formula	melting point / °C	boiling point / °C
methanol	CH_4O	–98	65
ethanol	C_2H_6O	–114	78
propanol	C_3H_8O	–126	97
	$C_4H_{10}O$	–89	118
pentanol	$C_5H_{12}O$		

(a) State the name of the alcohol with the molecular formula $C_4H_{10}O$.

....[1]

(b) Deduce the molecular formula of an alcohol that contains seven carbon atoms.

....[1]

(c) Explain why it is easier to predict the boiling point of pentanol rather than its melting point.

....

....[1]

(d) Propanol reacts with ethanoic acid.

State the conditions for this reaction and draw the full structural formula of the organic product formed.

conditions: ....

full structural formula of the organic product formed:

[2]

(e) A solution containing 0.159 g of an unknown carboxylic acid, $C_xH_yCO_2H$, is titrated with 0.10 mol/dm^3 aqueous sodium hydroxide. The volume of sodium hydroxide solution needed to neutralize the acid is 21.5 cm^3.

$$C_xH_yCO_2H + NaOH \rightarrow C_xH_yCO_2Na + H_2O$$

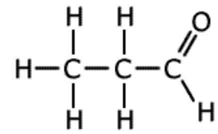
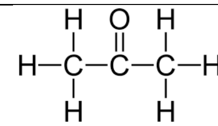
Calculate the relative molecular mass, M_r, of the carboxylic acid and suggest its identity.

relative molecular mass of carboxylic acid = ……………….…………….…

identity of carboxylic acid = …………………………..[3]

(f) Table 11.2 shows the names and formulae of two organic compounds.

Table 11.2

compound	name	full structural formula
1	propanal	
2	propanone	

A student makes a comment about the compounds.

“I think compound 1 and 2 are from the same homologous series because their relative molecular masses are the same.”

Do you agree with the student?

Explain your reasoning.

……

……

…………………………………………………………………………………………………..[2]

[Total: 10]

OR

B11 (a) Ethane-1,2-diol is a colourless liquid which is used as an antifreeze in car radiators.

Chemicals which prevent oxidation are added to ethane-1,2-diol when it is used as an antifreeze. Ethane-1,2-diol has the full structural formula as shown in Fig. 11.1.

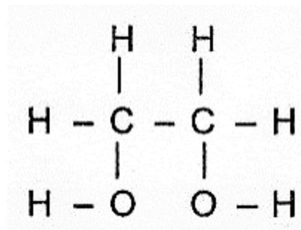


Fig. 11.1

(i) When ethane-1,2-diol is oxidised, compound X is produced.

State the homologous series that compound X belongs to.

……………………………………………………………………………………………………[1]

(ii) State and explain what would happen to a radiator made of iron if compound X were to be formed.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(iii) Ethanoic acid is a colourless liquid present in vinegar.

Briefly describe the chemical test that can be carried out to distinguish between ethane-1,2-diol and ethanoic acid.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(b) Ethane-1,2-diol can be made from the oxidation of ethene in an alkaline solution.

When one mole of ethene is oxidised, one mole of ethane-1,2-diol is produced.

(i) In an experiment, 20.0 g of ethane-1,2-diol was produced from the oxidation of 12.4 g of ethene.

Calculate the maximum mass of ethane-1,2-diol that can be obtained from the experiment.

[2]

(ii) Hence, calculate the percentage yield of ethane-1,2-diol.

[1]

(c) A polymer known as ethene-ethenyl-ethanoate (EEE) is used in the making of slippers and sandals. EEE is known for its properties such as being lightweight, elastic, and soft.

EEE is made of ethene and ethenyl ethanoate, as shown in Fig. 11.3.

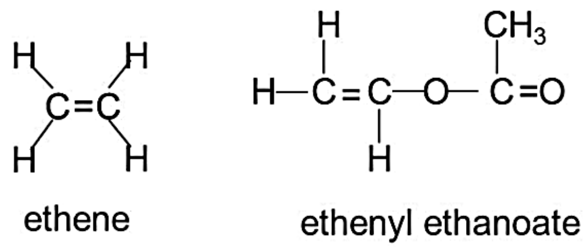


Fig. 11.3

One possible structure of EEE polymer is shown below:
- ethene - ethenyl ethanoate - ethene - ethenyl ethanoate - ethene - ethenyl ethanoate -

(i) Draw the structural formula of the repeat unit of the EEE polymer.

[1]

(ii) The EEE polymer that is newly synthesised from its monomers usually consists of a mixture of different polymers as products.

Explain why a mixture of different polymers are formed and draw the repeat unit of one other possible product.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………[2]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			Key atomic number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

	Class	Index No.
Candidate Name: ______________		

FUHUA SECONDARY SCHOOL

Secondary Four Express

Preliminary Examination 2022

4E

CHEMISTRY 6092/02

Paper 2

23 August 2022
1040 – 1225
1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form of either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.

The use of an approved scientific calculator is expected, where appropriate.

PARENT'S SIGNATURE

FOR EXAMINER'S USE		
Section A	Section B	**Total**
/50	**/30**	**/80**

Setter: Mdm Hia Soo Ching

Vetters: Mr Elton Tan, Ms Veron Lee,
Ms Nur Hanis & Ms Choo Hui En

This document consists of **20** printed pages.

Section A

Answer **all** questions in this section in the spaces provided.

The total mark for this section is 50.

A1 The diagram below shows part of the Periodic Table.

				H						
Li	Be					B	C	N	O	F
Na	Mg					Al	Si	P	S	Cl
K	Ca				Zn	Ga	Ge	As	Se	Br
Rb	Sr									I

Answer the following questions using only the elements shown in the diagram above. Each element can be used once, more than once or not at all.

(a) Which two elements react together to give the most vigorous reaction?

.... [1]

(b) **(i)** Which two elements in Period 3 form an ionic compound with a formula of the type $\mathbf{Y_2Z}$?

.... [1]

(ii) Draw a dot and cross diagram to represent the bonding in $\mathbf{Y_2Z}$.
Show only outer electrons.

[2]

(c) Which elements react with oxygen to give an oxide that dissolves in both aqueous sodium hydroxide and dilute hydrochloric acid?

.... [1]

(d) Describe the trends in melting point and reactivity for Group I and Group VII.

....

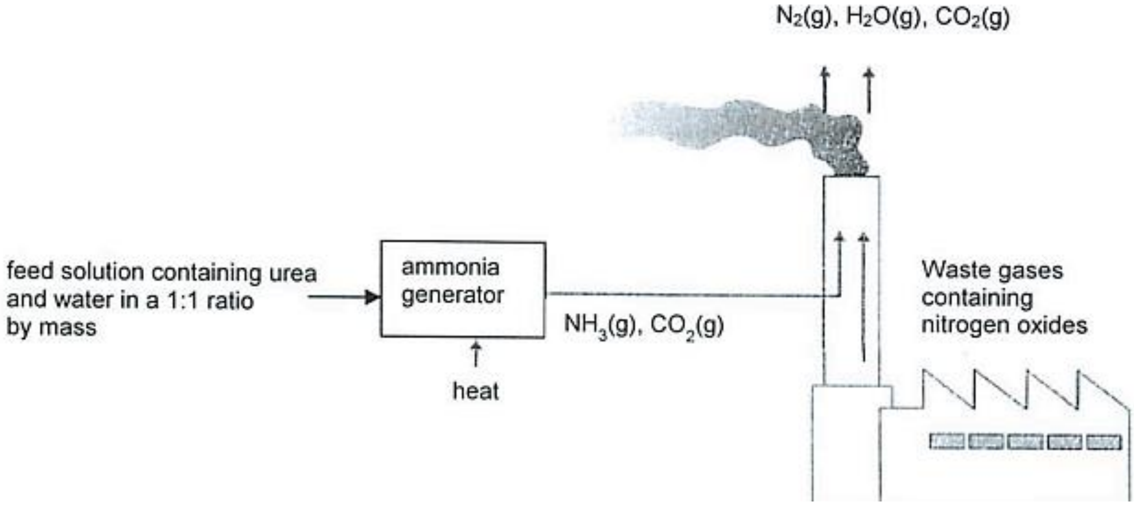
.... [2]

(e) Construct a balanced chemical equation when a piece of calcium is added to water.

.... [1]

[Total: 8]

A2 In a particular factory, ammonia generated in a small-scale ammonia generator is used to treat waste gases containing nitrogen oxides. This treatment converts nitrogen monoxide to nitrogen and water.



(a) **(i)** Write an equation to show the reaction between nitrogen monoxide and ammonia.

.... [1]

(ii) Explain, in terms of oxidation state, why the reaction in **(a)(i)** is a redox reaction.

....

....

.... [2]

(b) Explain how waste gases released by the factory affects the environment if they are not treated by reacting with ammonia.

....

....

.... [2]

(c) Suggest one advantage, other than cost, of producing ammonia on-site by this method rather than having ammonia delivered from a plant at another location.

....

.... [1]

(d) In terms of colliding particles, explain why increasing the temperature of the ammonia generator is necessary.

....

....

....

.... [2]

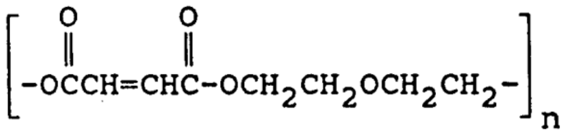
(e) Ammonia has a boiling point of -33.3°C. Explain, in terms of structure and bonding, why ammonia has a low boiling point.

[2]

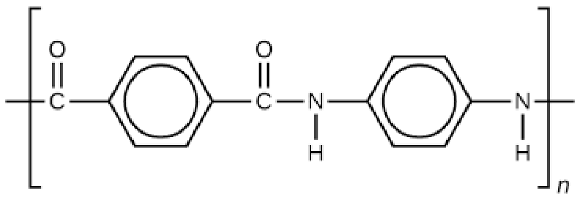
[Total: 10]

A3 The diagram below shows the structure of some polymers **A**, **B**, **C** and **D**.

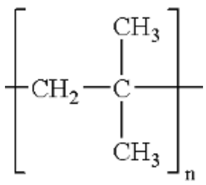
A



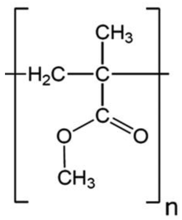
B



C



D



(a) A sample of **C** contains molecules with an average relative molecular mass of 14 000. How many carbon atoms are there in an average molecule of the polymer?

[1]

(b) Describe a test to distinguish between polymer **A** and **C**.

[2]

(c) Which of these statements would you predict to be true and which to be false?
Put a tick (√) in one box in each row.

	true	false
D is a polyester.		
Water is formed as a by-product when monomers react to form **A** and **B**.		
The empirical formula of **C** is the same as its monomer.		
One of the monomers that react to form **B** must be an alcohol.		

[2]

(d) Draw the displayed formulae of the monomers that react to form **A**.

[2]

(e) **(i)** Draw the structural formula of the monomer that react to form **D**.

[1]

(ii) The monomer in **(e)(i)** can be formed by reacting an acid and an alcohol under suitable conditions. State the name and formula of the alcohol.

.... [1]

(iii) A student states that the acid in **(e)(ii)** is butanoic acid.
Do you agree with his statement? Explain your reasoning.

....

.... [1]

(f) Some polymers are non-biodegradable.
Explain why being non-biodegradable is both an advantage and a disadvantage.

....

....

.... [2]

[Total: 12]

A4 A student carried out a series of experiments according to the following procedure:

- She added excess magnesium powder to 25.0 cm^3 of various aqueous salt solutions with the same concentration.
- She calculated the maximum temperature rise in each experiment.

She tabulated the results obtained in the table below.

experiment	solution	maximum temperature rise / °C
1	copper(II) sulfate	42.0
2	lead(II) nitrate	32.0
3	calcium chloride	0.0
4	sodium nitrate	0.0
5	sulfuric acid	38.0
6	zinc sulfate	14.0

(a) Explain why there is no rise in temperature for experiments 3 and 4.

....

.... [1]

(b) **(i)** Predict the temperature rise when she added excess magnesium powder to 25.0 cm^3 of iron(II) sulfate of the same concentration.

.... [1]

(ii) Write an ionic equation for the reaction in **(b)(i).**

.... [1]

(iii) Suggest the temperature rise when she added excess magnesium powder to 25.0 cm^3 of ethanoic acid of the same concentration.
Explain your answer.

....

....

....

....

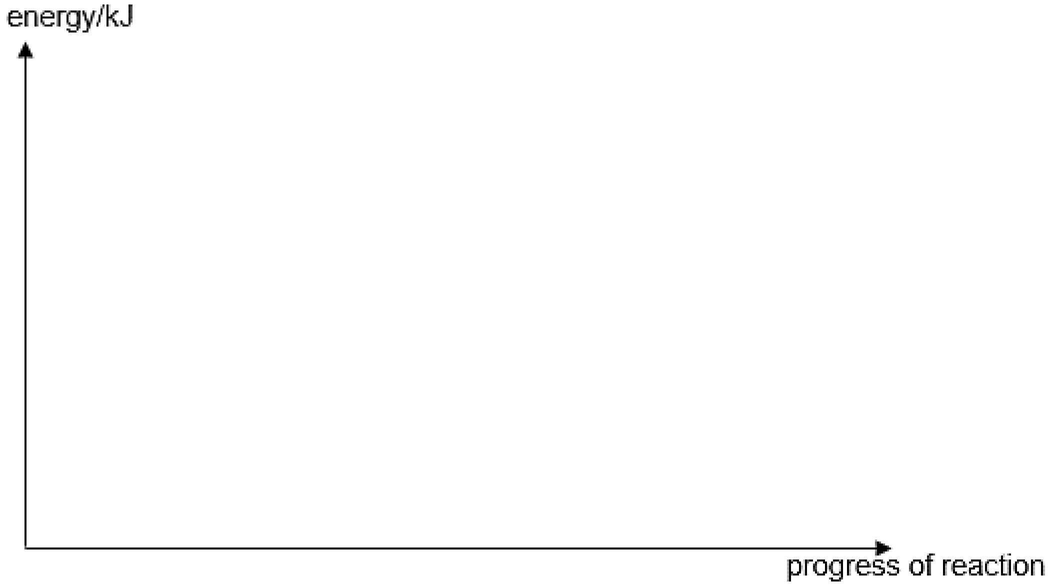
....

.... [3]

(c) Complete the energy profile diagram for experiment 1.

Your diagram should include

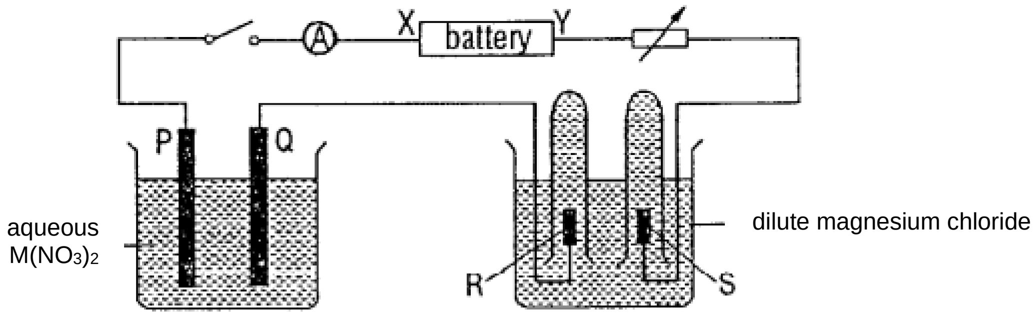
- formulae of reactants and products
- enthalpy change of reaction
- activation energy



[2]

[Total: 8]

A5 The following figure shows an electrolytic setup.
Electrodes **P** and **Q** are made of metal **M**.
Electrodes **R** and **S** are made of graphite.
X and **Y** are terminals of a battery.



cell 1 cell 2

When the switch is closed and electrolysis is allowed to run for some time, the ratio of the volume of gases produced at **R** and **S** is 2:1 respectively.

(a) (i) Deduce the polarity of terminals **X** and **Y** of the battery.

.... [1]

(ii) Write an overall equation for the reaction occurring in cell 2.

.... [1]

(iii) In cell 2, concentrated aqueous magnesium chloride is used instead of dilute magnesium chloride. Give one similarity and one difference between the products of the electrolysis of dilute and concentrated aqueous magnesium chloride.

....

....

.... [2]

(b) (i) Construct the ionic equations, including state symbols for the reactions occurring at electrode **P** and **Q** respectively.

electrode **P**: ....

electrode **Q**: .... [2]

(ii) If the relative atomic mass of **M** is 64, describe the observation at electrode **P**.

....

.... [1]

(iii) If 150 cm^3 of gas is produced at **S**, calculate the change in mass of electrode **Q**.

[2]

(c) Describe and explain the results you would expect when the pH of the electrolyte in cell 1 and cell 2 is tested separately.

[3]

[Total: 12]

Section B

Answer **all** three questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B6 Bronsted-Lowry Theory

The definition of acids and bases you have learnt so far is the Arrhenius theory and is limited to acid and base reactions occurring in aqueous solutions. However, acid and base reactions can occur in the absence of aqueous solutions. Hence, other theories like Bronsted-Lowry and Lewis theories extend to these reactions.

The Bronsted-Lowry theory defines acid as a substance which donates a H^+ ion or a proton and forms its conjugate base while the base is a substance which accepts a H^+ ion or a proton and forms its conjugate acid.

For example, consider a reaction in which ammonia (base) is dissolved in water (acid). Ammonia accepts a proton from water and the reaction is as follows,

$$\underset{\text{acid}}{H_2O(l)} + \underset{\text{base}}{NH_3\,(aq)} \rightleftharpoons \underset{\text{conjugate base}}{OH^-\,(aq)} + \underset{\text{conjugate acid}}{NH_4^+\,(aq)}$$

In this example, H_2O is the acid that donates a proton and it forms the conjugate base OH^-. On the other hand, NH_3 is the base that accepts a proton and it forms the conjugate acid NH_4^+. In the reverse reaction, $NH_4^+(aq)$ is the acid and OH^- is the base.

Strength of acids

The strength of an acid is indicated by the dissociation constant, K_a.

For any acid, HA, we can write the dissociation process as

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

If the value of K_a is large, this means the acid is mostly dissociated, hence the acid is strong. If K_a is small, little dissociation has occurred, hence the acid is weak.

Table B6.1 gives the K_a of some common acids.

Table B6.1

acid	**K_a / molL^{-1}**
HI	3.2×10^{9}
HBr	1.0×10^{9}
HC*l*	1.3×10^{6}
HF	6.4×10^{-4}
H_2CO_3	4.5×10^{-7}
HNO_3	2.8×10^{1}
HNO_2	4.5×10^{-4}
H_3PO_4	7.1×10^{-3}
H_2SO_4	1.0×10^{3}
H_2SO_3	1.4×10^{-2}
$HClO_4$	1.0×10^{10}

Electronegativity

Electronegativity is a measurement of the tendency of an atom to attract a bonding pair of electrons. A bonding pair of electrons is the pair of electrons shared in a chemical bond. The higher the electronegativity, the greater the tendency of an atom to attract the bonding pair of electrons towards itself.

The Pauling scale is used to measure the electronegativity of elements. It ranges from 0.7 to 4.0, with a higher value representing greater electronegativity.

Table B6.2 shows the electronegativity values of some elements in the Periodic Table.

Table B6.2

element	electronegativity
N	3.0
H	2.2
F	4.0
C*l*	3.2
Br	3.0
I	2.7
Ar	undefined

The difference in electronegativity between two elements involved in a chemical bond, Σ, can be calculated by the following equation

$$\Sigma = \text{larger electronegativity value} - \text{smaller electronegativity value}$$

An example is the H-F bond, where

$$\Sigma = 4.0 - 2.2 = 1.8$$

Σ gives an indication of the polarity of a covalent bond formed between two non-metallic elements. It is said that if Σ is greater, then the covalent bond is more polar.

Bond Energy

The strength of a bond can be measured by its bond energy. Bond energy is the amount of energy taken in to break one mole of a particular bond. It is a measure of the strength of a chemical bond.

Table B6.3 shows the bond energies of some bonds.

Table B6.3

bond	bond energy in kJ/mol
H–F	566
H–C*l*	431
H–Br	366
H–I	298

(a) **(i)** Explain why H^+ ion is known as a proton.

[1]

(ii) Two reactions are shown below. For each reaction, based on the Bronsted-Lowry theory, state in the boxes provided, whether the substance is acting as a

acid **base** **conjugate base** **conjugate acid**

you may use each word once, more than once or not at all.

$$HNO_3 \quad + \quad H_2SO_4 \quad \rightleftharpoons \quad H_2NO_3^+ \quad + \quad HSO_4^-$$

$$CH_3NH_2 \quad + \quad H_2O \quad \rightleftharpoons \quad CH_3NH_3^+ \quad + \quad OH^-$$

[2]

(b) For the halogen halide acids, HX (X is the halide), two students made the following comments.

Student 1: The more polar the H-X bond, the more easily the acid will ionise in aqueous solution and hence the stronger the acid.

Student 2: The less energy taken in to break the H-X bond, the stronger the acid.

Do you agree with the students?
Use evidence from the information to explain your reasoning.

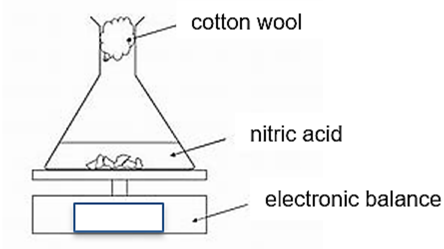
[4]

(c) For the oxoacids H_nYO_m, m is the number of oxygen atoms and n is the number of hydrogen atoms in the acids. Y is a non-metallic element.
Identify two factors that affect the strength of the oxoacids.
Using the information provided, explain your reasoning.

[4]

[Total: 11]

B7 A student conducted an experiment using 2.00 g of impure lead(II) carbonate and excess nitric acid of concentration 0.150 mol/dm^3 in a conical flask.



She measured the mass of the setup at fixed time intervals and obtained the following graph, experiment I, as shown in Figure B7.1.

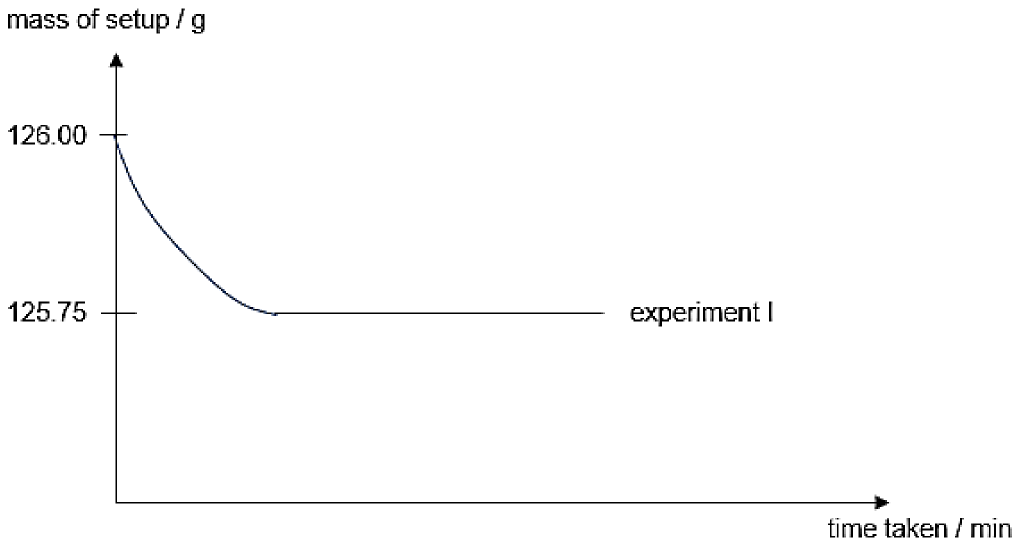


Figure B7.1

(a) Calculate the percentage purity of the lead (II) carbonate sample.

[2]

(b) The student conducted a second experiment using sulfuric acid of the same concentration and volume. All other variables are kept constant.

(i) On the same axes in Figure B7.1, draw the graph that he would obtain for the experiment using sulfuric acid. Label it as experiment II. [1]

(ii) Explain the difference between the graphs drawn for experiment I and II.

....

....

.... [1]

(c) The student conducted a third experiment using ethanoic acid of the same concentration and volume. All other variables are kept constant. Lead(II) ethanoate is soluble in water.

(i) On the same axes in Figure B7.1, draw the graph that he would obtain for the experiment using ethanoic acid. Label it as experiment III.

[1]

(ii) Explain your reasoning for the graph obtained for **(c)(i)**.

....

....

....

.... [2]

(d) Describe how you would prepare lead(II) carbonate in the laboratory.

....

....

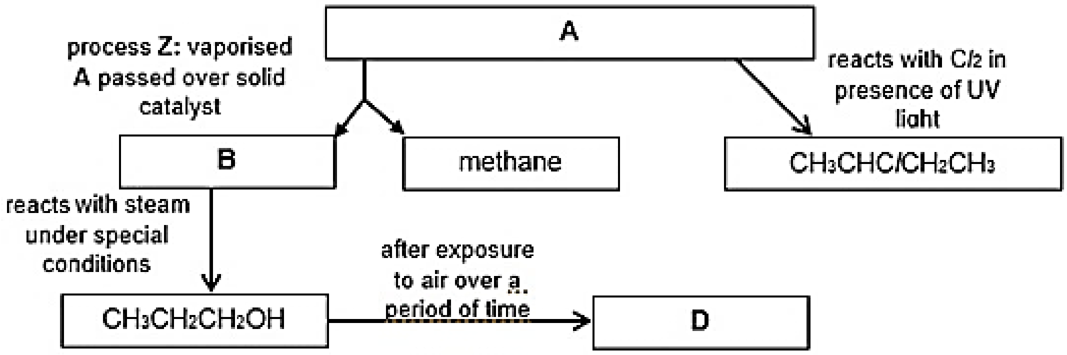
....

.... [2]

[Total: 9]

Either
B8

(a) The diagram below gives the reaction scheme of organic compound **A**.



.

(i) Name the process **Z** and state the solid catalyst used.

.... [1]

(ii) Construct a balanced chemical equation for process **Z**.

.... [1]

(iii) Describe a test to confirm that $CH_3CH_2CH_2OH$ has been completely converted to **D**.

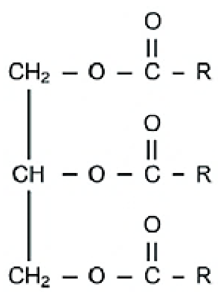
....

....

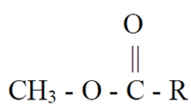
.... [2]

(b) Used cooking oil being processed to produce biodiesel has gained a significant amount of consideration within the world of fuel production.
During the conversion process, fatty acid triglycerides in vegetable oil react with methanol, in presence of an alkali catalyst, to produce biodiesel. Biodiesels are fatty acid methyl esters (FAME), which has similar properties to petrol diesel. The by-product of this reaction is glycerol, a tri-ol, which is extracted and used for other products including soaps and cosmetics.

The structure of triglycerides and FAME are



fatty acid triglycerides
where R is a hydrocarbon chain



FAME

(i) One mole of fatty acid triglyceride reacts with 3 moles of methanol to produce FAME and glycerol.

Construct a chemical equation for this reaction. Show the structural formulae of the organic molecules.

[2]

(ii) Suggest why glycerol is known as a tri-ol.

[1]

(iii) Most often methanol is used due to its accessibility and low cost. However, other alcohols such as ethanol and propanol can also be used in the conversion process.

Draw the structure of FAME if propanol is used in place of methanol.

[1]

(iv) Flashpoint is the lowest temperature at which a fuel vaporises and causes ignition. Fuels with lower flashpoints burn more easily at lower temperatures and usually burn more smoothly in the car engine.

The average flashpoint of biodiesel fuel is 150°C while petrol diesel ranges from 55 to 66°C.

State one advantage and disadvantage that biodiesel have over petrol diesel.

[2]

[Total: 10]

OR

B8 **(a)** In the stratosphere, chlorofluorocarbons (CFCs) can cause the destruction of the ozone layer. $CFCl_3$ is an example of chlorofluorocarbons (CFCs). The series of reactions below show how the ozone layer is being destroyed by $CFCl_3$.

Step 1 (slow): $CFCl_3 \rightarrow CFCl_2 + Cl$
Step 2 (fast): $Cl + O_3 \rightarrow ClO + O_2$
Step 3 (fast): $ClO + O_3 \rightarrow Cl + 2O_2$

The table shows the bond energies for some of the bonds in CFCs.

bond	**bond energy in kJ/mol**
C–F	485
C–C*l*	327

(i) A website states that '*a single CFC molecule can destroy up to 100 000 ozone molecules*'.
Using the above equations, comment on whether this statement is true.

....

....

.... [2]

(ii) The first step happens when energy from sunlight breaks a bond in a CFC to produce a chlorine atom. Use the data in the table to explain why the ozone layer contains many more chlorine atoms than fluorine atoms.

....

....

.... [2]

(b) Zinc blende is an ore containing compounds of zinc. One of the compounds in the ore is zinc sulfide, ZnS.
The first step in the extraction of zinc is roasting. Zinc sulfide is heated in air, producing zinc oxide and sulfur dioxide.
The second step is heating zinc oxide in a smelting furnace with coke and limestone at 1400°C. Coke burns in oxygen to form carbon monoxide, which reduces zinc oxide to zinc as shown:

$$ZnO + CO \rightarrow Zn + CO_2$$

Since the boiling point of zinc is 907°C, the zinc is produced in the gaseous state. Zinc vapour passes out of the furnace and is cooled and condensed in a tray placed at the top of the furnace. The slag and other impurities such as lead and cadmium form two layers which can be tapped off at the base of the furnace.

(i) Describe one similarity and one difference between the extraction of zinc and iron.

....

....

....

.... [2]

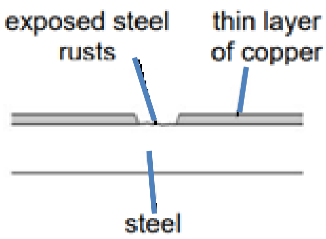
(ii) Explain, with the help of equations, why calcium carbonate is essential in the process of extracting zinc from zinc blende.

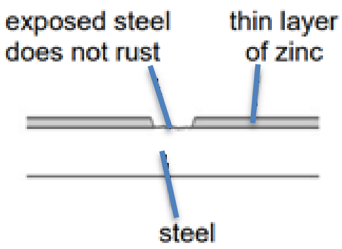
....

....

.... [2]

(iii) One important application of zinc is galvanising. In an experiment to investigate the rate of rusting of steel, two pieces of steel were used. One piece of steel was completely coated with copper, another piece completely coated with zinc. The coatings on both pieces were scratched, exposing the steel.





The piece of steel coated with zinc did not rust but the copper-coated piece of steel rusted very rapidly.
Explain these observations in terms of the transfer of electrons.

....

....

.... [2]

[Total: 10]

– End of Paper –

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name: ( )	Class:

GREENDALE SECONDARY SCHOOL
Preliminary Examination 2022

Chemistry **6092/02**

Paper 2
Secondary 4 Express

19 August 2022
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form of either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 26.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Paper 1	**/ 40**
Paper 2 Section A	**/ 50**
Paper 2 Section B	**/ 30**
Total	**/ 120**

This document consists of **26** printed pages.

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Use the list of the substances to answer the questions.

potassium	lead(II) bromide	oxygen
zinc oxide	hydrogen	carbon

Each substance can be used once, more than once, or not at all.

Name a substance from the list above which

(a) reacts violently with water,

.... [1]

(b) conducts electricity when molten but not when solid,

.... [1]

(c) is amphoteric,

.... [1]

(d) has a formula of the type XY_2,

.... [1]

(e) has the lowest boiling point,

.... [1]

(f) is produced at the negative electrode during electrolysis of dilute sulfuric acid.

.... [1]

[Total: 6]

A2 **(a)** Table 2.1 shows information about the preparation of pure samples of solid salts.

Complete the table by filling in the missing information. Include state symbols with any formula.

Table 2.1

formula of salt	formulae of reagents used	method used
$CuCl_2(s)$	……………… $HCl(aq)$	addition of excess solid to acid filtration evaporation and crystallisation
………………..	$KOH(aq)$ $HNO_3(aq)$	…………………………………………….. evaporation and crystallisation
$PbSO_4(s)$	……………… ………………	…………………………………………….. ……………………………………………..

[5]

(b) Explain why

(i) excess solid is added to acid to prepare the salt, $CuCl_2$,

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) crystals are formed in the process of crystallisation.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

[Total: 7]

A3 Fig. 3.1 shows giant molecular structures of diamond and graphite.

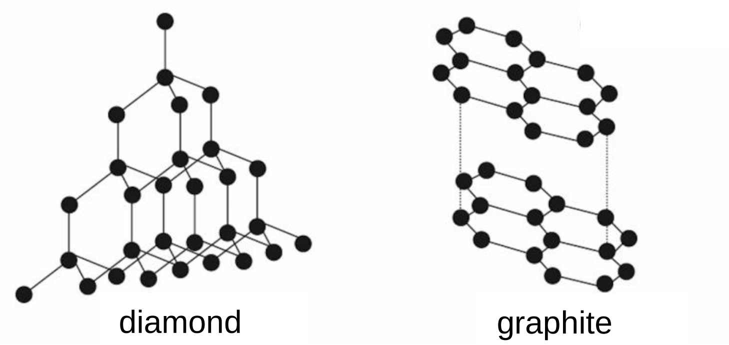


Fig. 3.1

(a) Describe how a simple molecular structure differs from a giant molecular structure.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(b) Diamonds are used as drill tips because they are very hard.

Explain why diamond is very hard. Refer to the structure of diamond in your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(c) Graphite is used as lubricant for engines.

Explain why graphite acts as a lubricant. Refer to the structure of graphite in your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[Total: 6]

A4 Lithium metal and its compounds have many uses, ranging from nuclear chemistry, rechargeable batteries and pharmaceuticals.

(a) Naturally occurring lithium contains the isotopes ^{6}Li and ^{7}Li.

(i) Describe the similarities and differences between the structure of the nuclei of the two isotopes of lithium.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(ii) A nuclear reaction is a reaction in which there is a change to an atomic nucleus.

An experimental nuclear reactor uses ^{6}Li and deuterium, ^{2}H, as fuel. Three nuclear reactions between these two atoms are described below.
(p^{+} is a proton; n is a neutron).

$$^{6}Li + {}^{2}H \rightarrow 2\,{}^{4}He$$

$$^{6}Li + {}^{2}H \rightarrow {}^{4}He + \mathbf{X} + n$$

$$^{6}Li + {}^{2}H \rightarrow \mathbf{Y} + p^{+}$$

Given that the number of nucleons is conserved in these nuclear reactions, suggest the identities of **X** and **Y**.

X ………………………… **Y** ………………………… [2]

(b) Lithium-ion batteries are light in weight and can hold a large amount of charge.

One type of lithium-ion battery consists of

- an electrolyte of $LiBF_4$ dissolved in an organic solvent,
- a cathode made from cobalt oxide, CoO_2,
- and an anode made from graphite with lithium atoms inserted between layers.

During discharge, Li atoms at the anode give up electrons to become Li^+ ions. The electrons travel round the external circuit and are picked up by the cathode. A Li^+ ion from the electrolyte also moves to the cathode.

This is illustrated in Fig 4.1 in which C–C–C–C–C is also a simplified representation of a layer of carbon atoms in graphite.

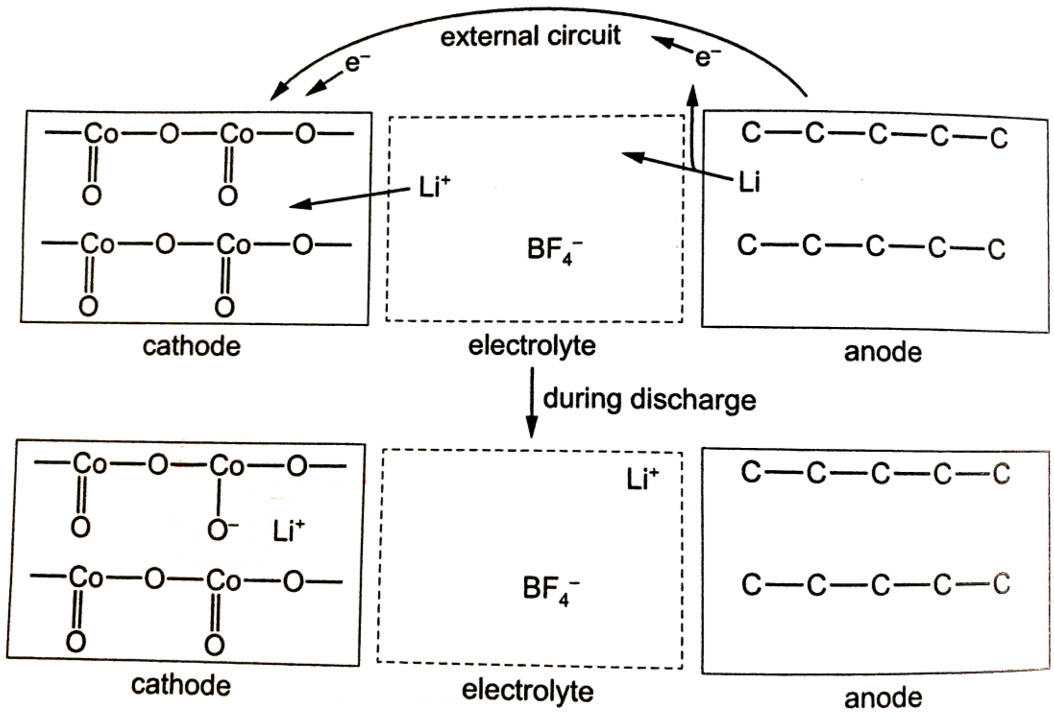


Fig. 4.1

(i) Suggest the type of bonding between lithium atoms and the layers of carbon atoms in graphite.

Give your reasoning.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(ii) State the oxidation state of cobalt in the cobalt oxide cathode before discharge and after the cell is totally discharged.

before discharge ………………

after cell is totally discharged ……………… [2]

[Total: 8]

A5 Ethanol belongs to the homologous series called alcohols.

(a) Write the general formula of alcohols.

…..……………………………………………………………………………… [1]

(b) Explain why ethanol **cannot** be described as a hydrocarbon.

…..………………………………………………………………………………….

…...……………………………………………………………………………… [1]

(c) Ethanol can be manufactured from different substances by reaction with steam or by fermentation. Give the formulae of these substances.

substance which reacts with steam to form ethanol …………………………….

substance which will undergo fermentation to form ethanol ………………... [2]

(d) Fig. 5.1 shows ethane-1,2-diol has two alcohol functional groups.

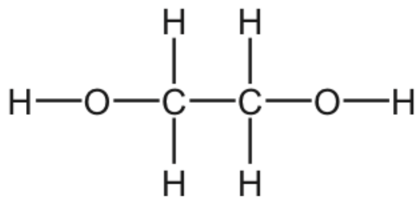


Fig. 5.1

One molecule of ethane-1,2-diol will react with two molecules of ethanoic acid to form molecule **X**.

X has two ester functional groups and a molecular formula of $C_6H_{10}O_4$.

(i) State the empirical formula of **X**.

……………………………………………………………………………………[1]

(ii) Draw the structure of **X**.

Show all of the atoms and all of the bonds.

[1]

(iii) Name the other substance formed in this reaction.

……………………………………………………………………………………[1]

(e) Each alcohol functional group in ethane-1,2-diol reacts with acidified potassium manganate(VII) to form a different organic compound, **Y**.

(i) Name the functional group formed in **Y**.

……………………………………………………………………………………[1]

(ii) Draw the structure of **Y**.

Show all of the atoms and all of the bonds.

[1]

[Total: 9]

A6 **(a)** Hydrogen peroxide can behave as an oxidising agent or a reducing agent depending on the reactant added to it. When solid silver(I) oxide is added to aqueous hydrogen peroxide, the reaction shown in equation 1 takes place.

equation 1 $Ag_2O(s) + H_2O_2(aq) \rightarrow 2Ag(s) + O_2(g) + H_2O(l)$

(i) State, with reasoning, whether hydrogen peroxide is behaving as an oxidising agent or a reducing agent in this reaction.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) Describe a simple test and its result that would identify the gas given off in the reaction.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(b) **(i)** 1.0 cm^3 of '20-volume' hydrogen peroxide produces 20.0 cm^3 of oxygen gas at room temperature and pressure, as shown in equation 2.

equation 2 $2H_2O_2 \rightarrow 2H_2O + O_2$

Use this information to calculate the concentration, in mol/dm^3, of '20-volume' hydrogen peroxide.

[2]

(ii) Use the value obtained in **(b)(i)** to calculate the minimum mass of silver(I) oxide which must be used to ensure that 10.0 cm^3 of '20-volume' hydrogen peroxide reacts completely at room temperature and pressure, according to equation 1.

[1]

[Total: 5]

A7 Methane, methanol and hydrogen have all been investigated as possible alternative fuels for motor vehicles that currently used petrol. Table 7.1 shows some information of these fuels.

Table 7.1

fuel	density at r.t.p (g/dm^3)	enthalpy change of combustion (kJ/mol)	energy released per gram (kJ/g)	energy released per dm^3 at r.t.p (kJ/dm^3)
petrol	710 – 770	–	47.3	33 600 – 36 400
methane	0.645	– 891	55.7	35.8
methanol	792	– 726	22.7	18 000
hydrogen	0.0833	– 286	143	12.6

(a) Explain why no value is quoted for the enthalpy change of combustion of petrol in Table 7.1.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(b) Both petrol and methanol have a much higher density than methane and hydrogen. Suggest why.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(c) **(i)** Write down the chemical equation for the complete combustion of methane.

…………………………………………………………………………………… [2]

(ii) Use ideas of about breaking and forming bonds to explain why the value of enthalpy change of combustion for methane is negative.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [3]

(d) Although hydrogen releases less than half the energy per dm^3 than methane, many people believe that hydrogen is a better alternative fuel compared to methane. Explain why.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

[Total: 9]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Dynamics equilibrium

Many reversible reactions are incomplete. We can understand what is happening by examining what happens when a solution of iodine in potassium iodide solution is shaken with the solvent trichloroethane. Water and trichloroethane do not mix.

$$I_2 \text{ in aqueous potassium iodide} \rightleftharpoons I_2 \text{ in trichloroethane}$$

Fig. 8.1 shows the movement of iodine molecules during the shaking.

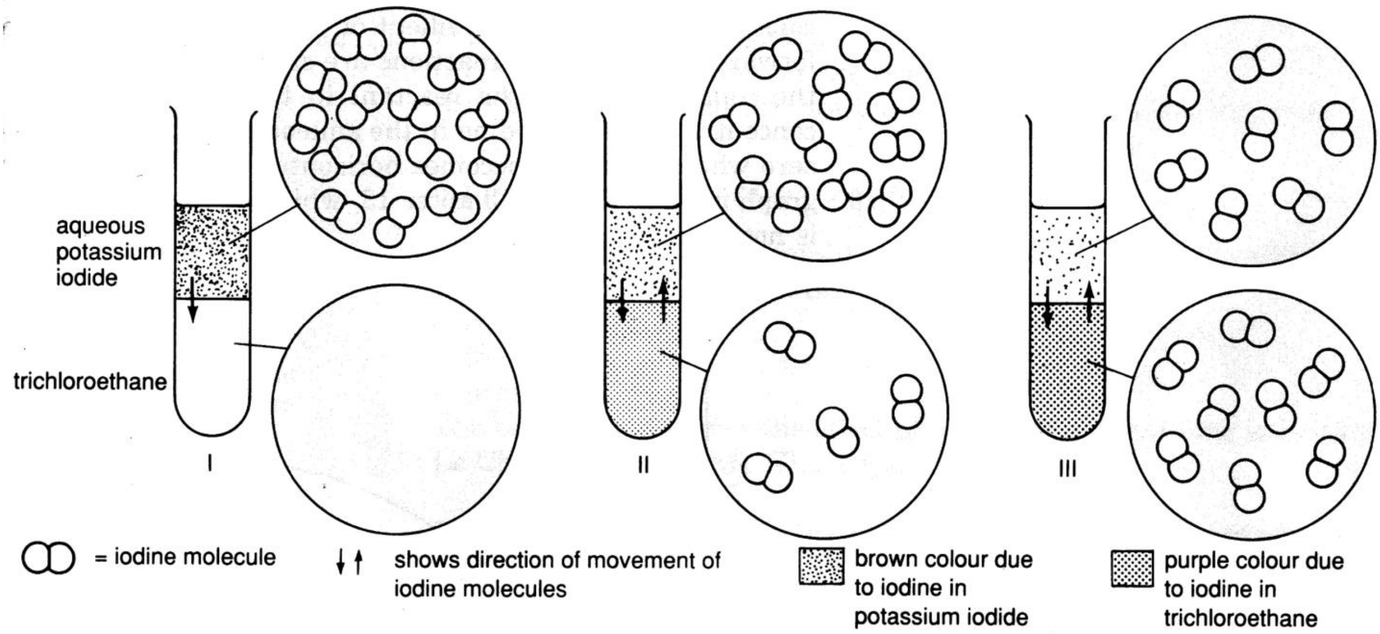


Fig. 8.1

Iodine dissolves in aqueous potassium iodide to form a brown solution, but dissolves in trichloroethane to form a purple solution.

What has happened is the iodine molecules first started going from the aqueous layer into the trichloroethane. As the concentration of iodine in the trichloroethane increased, the molecules started going back into the aqueous layer. As the concentration of iodine in the aqueous layer decreased, the forward reaction slowed down. As the concentration of iodine in the trichloroethane increased, the backward reaction became faster. Eventually *the speed of the forward reaction and backward reaction become equal*.

When the reactants reach equilibrium in a reversible reaction, the concentration of reactants and products become constant and reaction appears to have stopped.

This situation is called *dynamic equilibrium*.

Fig 8.2 shows the concentration of iodine in the two solvents against time.

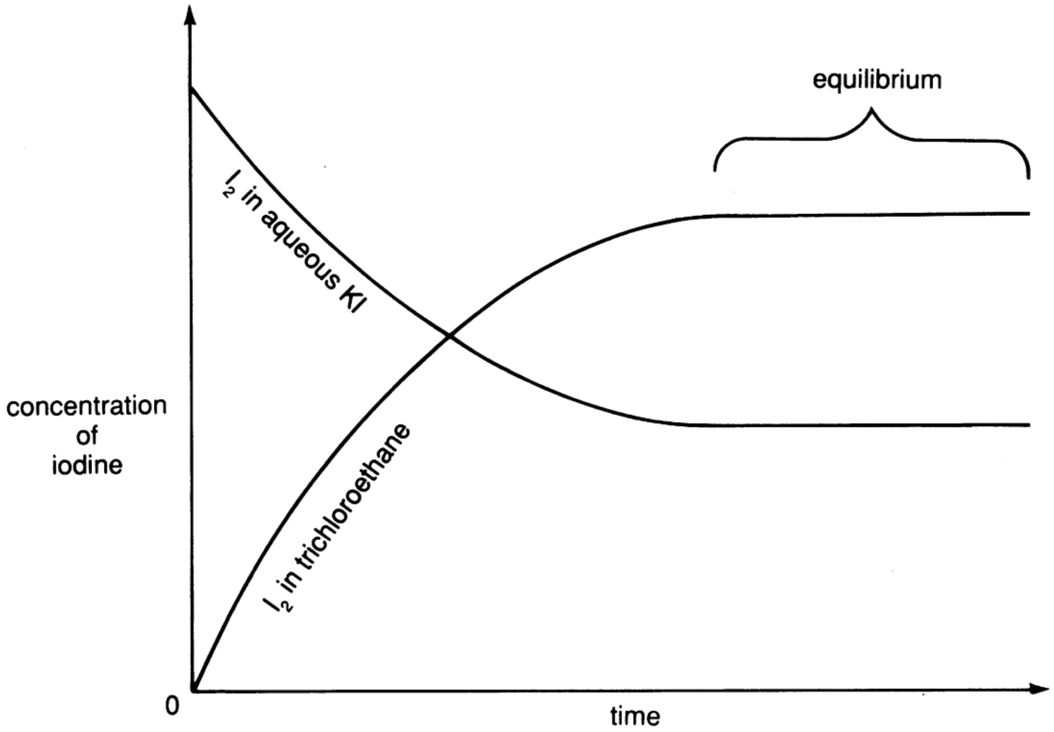


Fig. 8.2

When the graph becomes horizontal, equilibrium is reached. This is when concentration of iodine in two solvents become constant.

Factors affecting equilibrium

The composition of an equilibrium mixture in a reversible reaction can be affected by changes in concentration, temperature and pressure.

The best way to predict the effect of a change in conditions is to use *Le Chaterlier's Principle.*

Le Chaterlier's Principle state that:

If an equilibrium mixture is disturbed by changing the conditions, then the composition of the equilibrium mixture will try to remove the disturbance.

Changing concentration

An example is the formation of a white precipitate of bismuth oxychloride, $BiOCl$, when colourless bismuth(III) chloride, $BiCl_3$, is added to water.

$$BiCl_3(aq) + H_2O(l) \rightleftharpoons BiOCl(s) + 2HCl(aq)$$

At equilibrium, there is a mixture of all four substances. If extra $HCl(aq)$ is added to this mixture, the extra $HCl(aq)$ increases the concentration of $H^+(aq)$ and $Cl^-(aq)$. This is a 'disturbance'. The mixture will try to remove this extra $HCl(aq)$. It removes by increasing the backward reaction to produce more $BiCl_3(aq)$ and $H_2O(l)$ and decreasing the amounts $BiOCl(s)$ and $HCl(aq)$. This removes much of the $HCl(aq)$ 'disturbance'. A new equilibrium is obtained, where there are more $BiCl_3(aq)$ and $H_2O(l)$ and less $BiOCl(s)$.

Changing temperature

An example is the removal of carbon dioxide using hydrogen.

$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g); \ \Delta H = -165 \text{ kJ}$$

A negative ΔH means that the forward reaction at equilibrium releases heat and the backward reaction absorbs heat. If temperature is raised, the reaction mixture absorbs heat. By Le Chatelier's Principle, the reaction mixture will try to get rid of the extra heat by absorbing it. It removes the heat 'disturbance' by increasing the backward reaction to produce more CO_2 and H_2.

Changing pressure

An example is the industrial manufacture of ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

If the pressure of the equilibrium mixture is increased, the reaction mixture will try to remove the pressure 'disturbance' by decreasing the number of moles of gas present. The forward reaction will increase as 4 moles of gas (1 mole of N_2 and 3 moles of H_2) produces only 2 mole of gas (2 moles of NH_3) – a net loss of 2 moles of gas in a fixed volume.

Adapted from Chemistry for 'O' Level – JGR Briggs

(a) Dinitrogen tetroxide, N_2O_4, decomposes into nitrogen dioxide, NO_2. The reaction is reversible.

$$\underset{\text{colourless gas}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown gas}}{2NO_2(g)}$$

Fig. 8.3 shows a gas syringe containing a mixture of dinitrogen tetroxide and nitrogen dioxide gases was sealed and heated. After reaching equilibrium, the mixture was a pale brown colour.

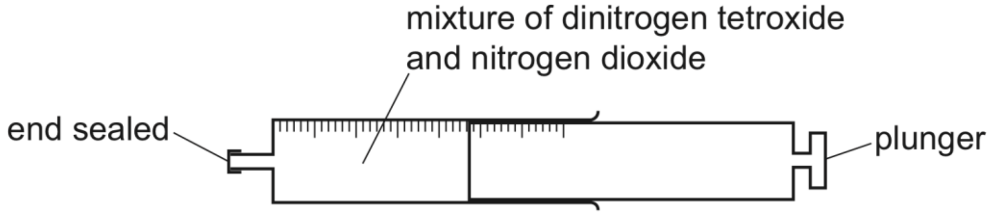


Fig. 8.3

The forward reaction is endothermic.

(i) Using Le Chaterlier's Principle, describe and explain what you would observe when the temperature of the mixture is increased.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Explain, using the ideas of particles, what happens to the speed of the forward reaction when the temperature of the mixture is increased.

……………………………………………………………………………………

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……………………………………………………………………………………

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…………………………………………………………………………………… [3]

(b) The plunger of the gas syringe is pushed in as shown in Fig. 8.4. The temperature does not change. The mixture initially turns darker brown. After a few seconds, the mixture turns lighter brown.

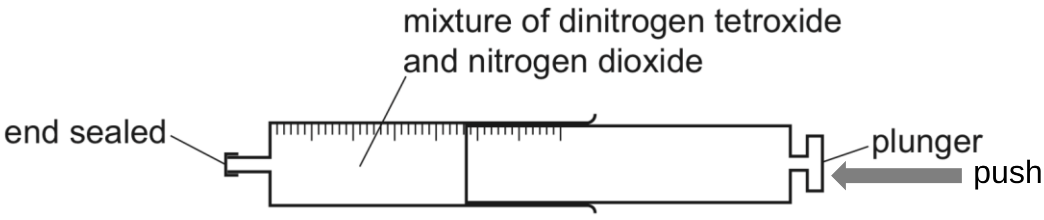

Fig. 8.4

(i) Explain why the mixture initially turns darker brown.

....

.... [1]

(ii) Using Le Chaterlier's Principle, explain why the mixture turns lighter brown after a few seconds.

....

....

....

....

.... [2]

(c) When hydrogen ions are added to methyl orange (Meor), a red coloured complex (H-Meor) is formed.

An equilibrium mixture between the two forms of methyl orange will be established.

$$\text{H-Meor} \rightleftharpoons H^{+}(aq) + \text{Meor}^{-}(aq)$$

Meor $^{-}$ is yellow in colour.

Using Le Chaterlier's Principle, suggest what you would observe when hydroxide ions are added to this equilibrium mixture.

Explain your reasoning.

…..

…..

…..

…..

…..

….. [2]

[Total: 10]

B9 The structure of styrene and butadiene are shown in Fig. 9.1. Styrene-butadiene rubber is a synthetic rubber. It is made by polymerising a mixture of the monomers butadiene and styrene.

styrene butadiene

Fig. 9.1

(a) What type of polymerisation will take place when the monomers polymerise? Explain your reasoning.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

One possible structure for the polymer is shown in Fig. 9.2.

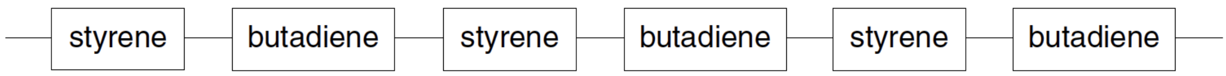

Fig. 9.2

(b) Give the **full structural formula** for the repeating unit in this polymer structure.

[2]

(c) When the mixture of styrene and butadiene polymerises, the polymer is unlikely to contain only this regular, repeating pattern. Explain why.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[1]

Butadiene can be made by cracking butane in a cracking tower.

(d) **(i)** Butane cracks to form butadiene, C_4H_6, and one other product.

Write an equation to show this reaction.

....[1]

(ii) Describe a test to confirm the identity of the other product.

....

....[1]

(e) 2.90 kg of butane entered the cracking tower. After the reaction, 2.16 kg of butadiene had been made.

Calculate the percentage yield of butadiene.

[3]

[Total: 10]

EITHER

B10 A student carried out some experiments to place four metals, **W**, **X**, **Y** and **Z** in order of reactivity.

Table 10.1 shows the results.

key ✓ shows a reaction happened
✗ Shows no reaction happened
– Shows the experiment was not performed

Table 10.1

	metal **W**	metal **X**	metal **Y**	metal **Z**
solution of **W** nitrate	–	✗	✗	✗
solution of **X** nitrate	✓	–	✓	✓
solution of **Y** nitrate	✓	✗	–	✓
solution of **Z** nitrate	✓	✗	✗	–

(a) Place the metals in order of reactivity, starting with the most reactive.

……………………………………………………………………………………… [2]

(b) Metal **Z** reacts with hydrochloric acid.

What would you see when metal **Z** reacts with hydrochloric acid?

Explain your reasoning.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(c) The student carried out further experiments to place metal **M** in the list.

She used dilute hydrochloric acid and samples of the metals.

She found out that metal **M** is the fourth most reactive metal.

Describe the experiments that the student carried out. Your answer should include

- the experiments that she carried out using dilute hydrochloric acid and samples of the metals,
- the measurements that she made,
- how the results showed that metal **M** is the fourth most reactive metal.

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…………………………………………………………………………………………[3]

(d) The five metals, **W**, **X**, **Y**, **Z** and **M** are extracted from their ores in three different ways.

Two of the metals are extracted from their ores by electrolysis.
Metal **M** and one other metal are extracted by heating their ores with carbon.
One of the metals occurs uncombined.

(i) Suggest which other metal, **W**, **X**, **Y** and **Z** is extracted by heating its ore with carbon. Explain your reasoning.

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……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………[2]

(ii) Suggest the name of metal **M**.

…………………………………………………………………………………[1]

[Total: 10]

OR

B10 Sodium metal is extracted from sodium chloride by electrolysis.

Fig. 10.1 shows how the process works.

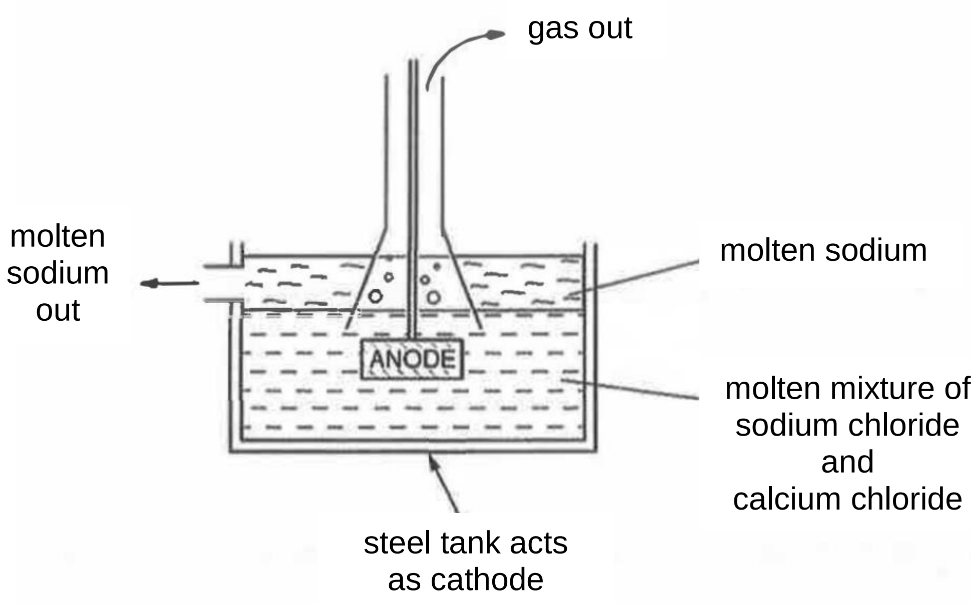


Fig. 10.1

(a) **(i)** Write an ionic half equation, with state symbols, to show the reaction that happens at the anode.

.... [2]

(ii) Describe a simple test and its result that would identify the gas given off at the anode.

....

....

.... [2]

(b) Calcium chloride is added to the sodium chloride to lower the melting point of the mixture.

(i) Explain why lowering the melting point makes the process cheaper to run.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

(ii) The molten sodium contains metallic impurities.

Name the main metal impurity you would expect to find and explain how it forms.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

(c) Sodium chloride can be electrolysed in aqueous solution.

Describe the differences in the products of the electrolysis of concentrated aqueous sodium chloride compared to molten sodium chloride.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

GUANGYANG SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
Secondary Four Express

CANDIDATE NAME	

CENTRE NUMBER					INDEX NUMBER					CLASS/ REG No.	/

CHEMISTRY **6092/02**
Paper 2
23 August 2022
1 hour 45 mins

Additional Materials: Periodic Table

READ THESE INSTRUCTIONS FIRST

Write your name, centre number, index number, class and register number in the spaces above.
Write in dark blue or black ink.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
This section consists of **seven** questions. Answer **all** questions in the spaces provided.

Section B
This section consists of **three** questions. Answer **all three** questions, the last question is in the form either/or.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the data sheet and Periodic Table will be provided.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	
B8	
B9	
B10	
Total	

This question paper consists of 18 printed pages, inclusive of this cover page

SECTION A (50 marks): This section consists of seven structured questions. Answer all questions in the spaces provided.

A1 (a) The following table gives information about six substances.

substance	melting point / °C	boiling point / °C	electrical conductivity as a solid	electrical conductivity as a liquid
A	839	1484	good	good
B	–188	–42	poor	poor
C	776	1497	poor	good
D	–117	78	poor	poor
E	1607	2227	poor	poor
F	–5	102	poor	good

(i) Which substance could be a metal?

.... [1]

(ii) State all the substances that are liquid at room temperature.

.... [1]

(iii) Which substance could have a macromolecular structure similar to that of silicon (IV) oxide?

.... [1]

(iv) Which substance could be sodium chloride?

.... [1]

(b) The symbol equation for the production of sodium hydride is shown below.

$$2Na + H_2 \rightarrow 2NaH$$

(i) Suggest why the hydrogen must be dry.

.... [1]

(ii) Sodium hydride reacts with iron (III) oxide to form iron and sodium hydroxide. Write a balanced chemical equation for the reaction.

.... [1]

(iii) Explain, in terms of electron transfer, how this equation shows that it is a redox reaction.

……………………………………………………………………………………………

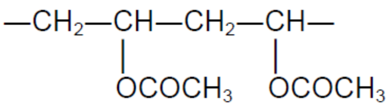
……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

[Total: 9]

A2 The polymer known as PVA is used in paints and adhesives. Its structural formula is shown below.



(a) Deduce the structural formula of its monomer. [1]

(b) A condensation polymer can be made from the following monomers.

$HOOC(CH_2)_4COOH$ and $H_2N(CH_2)_6NH_2$

Draw the structural formula of this polymer, showing two repeating units. [2]

(c) Besides fractional distillation of petroleum, some fractions can be obtained through cracking. More petrol can be made by cracking less useful petroleum fractions.
Write a chemical equation for the cracking of dodecane, $C_{12}H_{26}$, to form ethene and one other hydrocarbon.

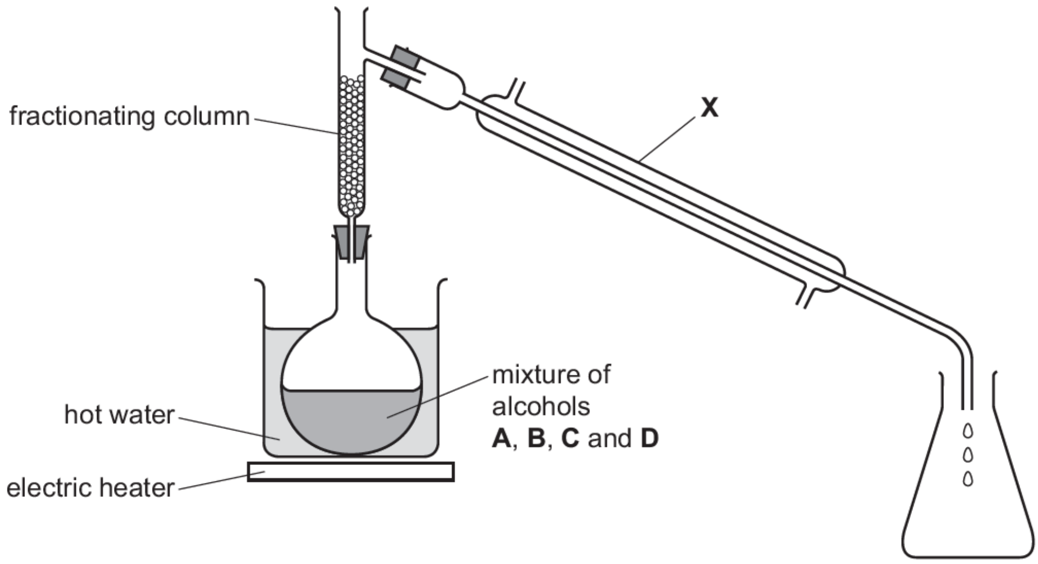
…………………………………………………………………………………………….. [1]

[Total: 4]

A3 Mixtures can be separated by physical processes.
The boiling points of four different alcohols, **A, B, C** and **D**, are shown below.

alcohol	**A**	**B**	**C**	**D**
boiling point / °C	56	78	122	160

A student suggested that the apparatus shown below could be used to separate the mixture of alcohols.



(a) Apparatus **X** needs to have cold water flowing through it.

- Draw an arrow on the diagram to show where the cold water enters apparatus X. [1]
- Name apparatus X.

…………………………………………………………………………………………………. [1]

(b) Part of the fractionating column is missing. This means that the experiment will not work.

- Draw on the diagram the part of the fractionating column which is missing. [1]
- Explain why the experiment will not work with this part of the fractionating column missing.

………………………………………………………………………………………………….

…………………………………………………………………………………………………. [1]

(c) Suggest why a Bunsen burner is **not** used to heat the flask.

…………………………………………………………………………………………………. [1]

(d) A hot water bath cannot be used to separate alcohols **C** and **D**. Explain why.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………… [1]

[Total: 6]

A4 (a) The alcohols form a homologous series.
The following two alcohols are members of a homologous series and they are isomers.

$CH_3 - CH_2 - CH_2 - CH_2 - OH$ and $(CH_3)_2CH - CH_2 - OH$

(i) Explain why they are isomers.

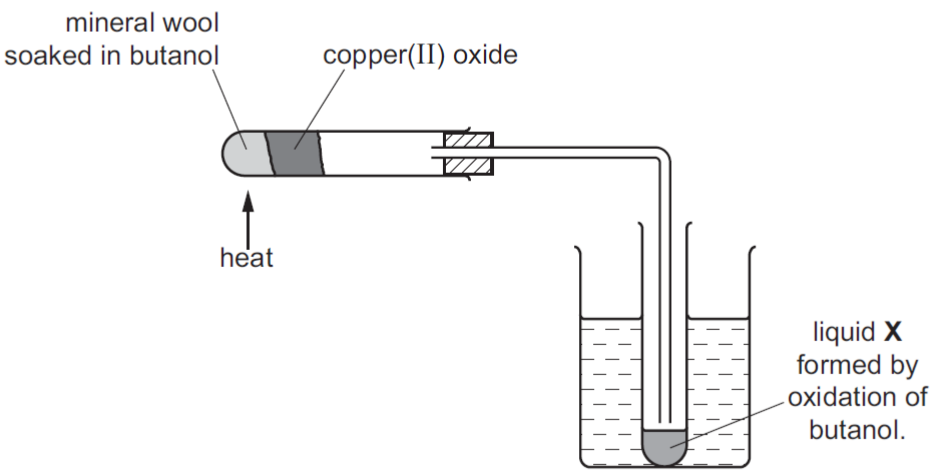
………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(ii) Deduce the structural formula of another alcohol which is also an isomer of these alcohols. [1]

(b) Copper (II) oxide can oxidise butanol to liquid **X**, whose pH is 4.



(i) Give the name of another reagent which can oxidise butanol.

……………………………………………………………………………………… [1]

(ii) Which homologous series does liquid **X** belong to?

.... [1]

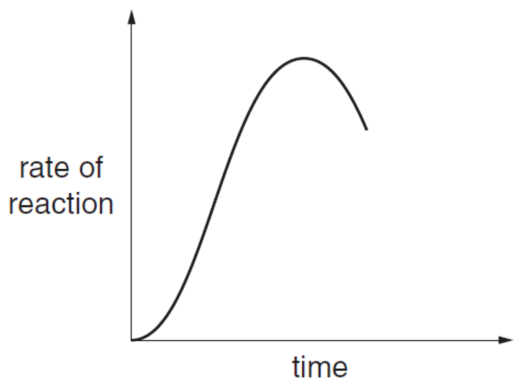
(iii) State the formula of liquid **X**.

.... [1]

(c) The alcohol ethanol can be made by fermentation. Yeast is added to aqueous glucose.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Carbon dioxide is given off and the mixture becomes warm, as the reaction is exothermic.
The graph shows how the rate of reaction varies over several days.



(i) Suggest a method of measuring the rate of this reaction.

....

.... [1]

(ii) Why does the rate initially increase?

....

.... [1]

(iii) Suggest one reason why the rate eventually decreases.

.... [1]

[Total: 9]

A5 Hydrogen reacts with oxygen as shown in the equation.

$$2H_2(g) \quad + \quad O_2(g) \quad \rightarrow \quad 2H_2O(l)$$

A sample containing 1.00 mol of hydrogen, H_2, is completely burnt.
This sample releases 286 kJ of heat energy.

(a) Calculate the heat energy released when 25.0 g of hydrogen is completely burnt. [2]

(b) Use ideas about bond breaking and bond forming to explain why this reaction is exothermic.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….. [2]

(c) The reaction shown also represents the overall process that occurs within a hydrogen-oxygen fuel cell.

(i) Describe one advantage of using a hydrogen-oxygen fuel cell to power a motor vehicle rather than burning petrol.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Complete the equations for the two electrode reactions that happen in a hydrogen-oxygen fuel cell.

$H_2 \rightarrow$ ……................... + $2e^-$

$O_2 + 4H^+ + 4e^- \rightarrow$ ……..................... [2]

[Total: 7]

A6 Sulfur dioxide is a colourless gas which can be found in air.

(a) State one environmental problem caused by the presence of sulfur dioxide in air.

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….. [1]

(b) When heated in air, iron pyrite, FeS_2, reacts with oxygen.
Sulfur dioxide and iron (III) oxide, Fe_2O_3, are the products of this reaction.
Write the equation for this reaction.

…………………………………………………………………………………………………….. [1]

(c) Explain, in terms of oxidation state, if the reaction in (b) is a redox reaction.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….. [3]

(d) Liquid sulfur dioxide is stored in cylinders.
When the cylinder is opened the liquid quickly changes into a gas.
Use the kinetic particle theory to describe the changes in **movement** and **arrangement** of the particles when liquid sulfur dioxide becomes a gas.

……………………………………………………………………………………………………..

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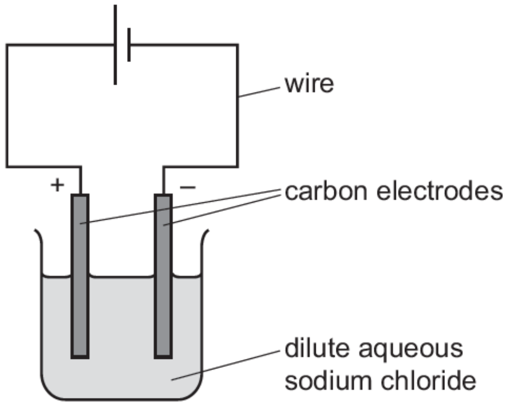
……………………………………………………………………………………………………. [2]

[Total: 7]

A7 A student carries out an electrolysis experiment using the apparatus shown below.



The student uses dilute aqueous sodium chloride.

(a) State the name given to any solution which undergoes electrolysis.

.... [1]

(b) (i) Hydroxide ions are discharged at the anode. Write the ionic half-equation for the anode.

.... [1]

(ii) Explain how the ionic half-equation shows the hydroxide ions are being oxidised.

....

.... [1]

(c) (i) Describe what the student observes at the cathode.

.... [1]

(ii) Write the ionic half-equation for the reaction at the cathode.

.... [1]

(d) The student repeats the experiment using concentrated aqueous sodium chloride.
Describe what the student observes at:

- the cathode .... [1]
- the anode .... [1]

(e) Write the overall chemical equation for (d).

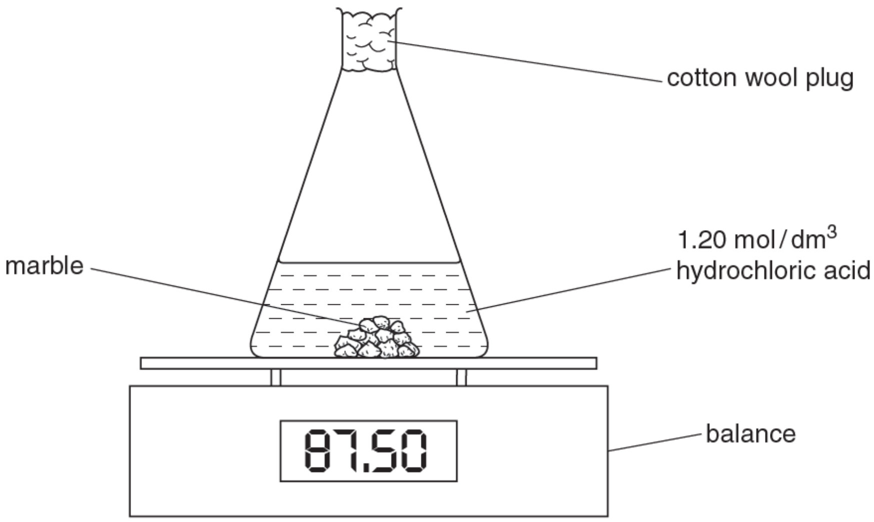
.... [1]

[Total: 8]

End of Section A

SECTION B (30 marks)
Answer all three questions in the spaces provided. The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 A student uses the apparatus shown to investigate the reaction between marble ($CaCO_3$) and hydrochloric acid.
10.0 g of marble lumps (an excess) are added to 30.0 cm^3 of 1.20 mol / dm^3 hydrochloric acid contained in a flask.
The mass of the flask and contents is recorded every 30 seconds. This is experiment **1**.
The experiment is repeated using the same mass of marble but finely powdered instead of lumps.
The volume and concentration of the hydrochloric acid used is unchanged. This is experiment **2**.



(a) The results of the two experiments are recorded in the table.
Complete the table by calculating the total change in mass at each time for both experiments. [2]

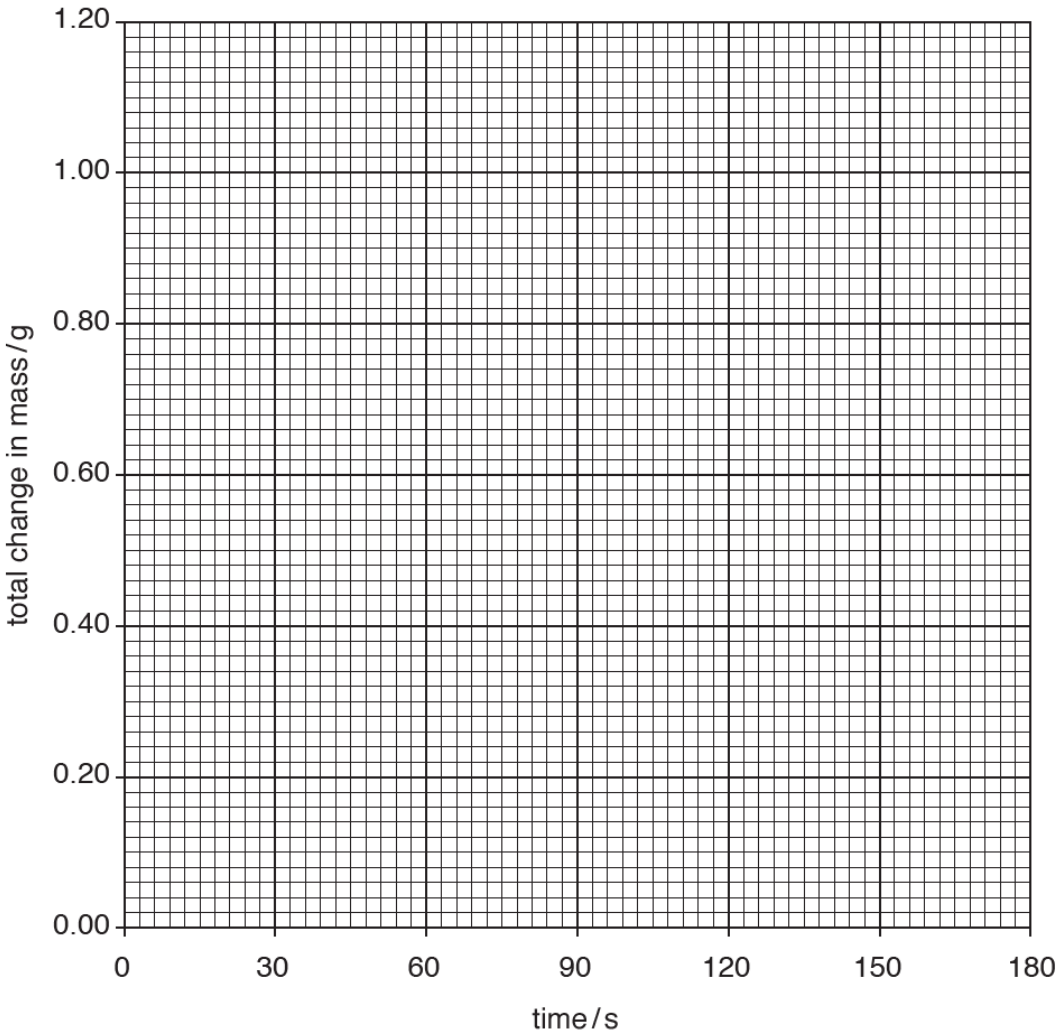
time / s	experiment **1** (lumps)		experiment **2** (powder)	
	mass of flask and contents / g	total change in mass / g	mass of flask and contents / g	total change in mass / g
0	87.50	0.00	87.50	0.00
30	87.22	0.28	87.02	0.48
60	87.02	0.48	86.83	0.67
90	86.87		86.74	
120	86.77		86.69	
150	86.69		86.69	
180	86.69		86.69	

(b) Construct the equation for the reaction between calcium carbonate and hydrochloric acid.
[1]
……………………………………………………………………………………………………

(c) Suggest why the mass of the flask and contents decreases as the reaction progresses.

.... [1]

(d) Plot the points for each experiment on the grid.
Draw a smooth curve through each set of points.
Label the curves 'experiment **1**' and 'experiment **2**'. [3]



Using your graph,

(i) what is the total change in mass in experiment **1** after 75 seconds,

.... [1]

(ii) what is the mass of the flask and contents in experiment **2** after 45 seconds?

.... [1]

(f) Using your equation in **(b)**, calculate the mass of marble that remains after reaction with 30 cm^3 of 1.20 mol / dm^3 hydrochloric acid. [3]

[Total: 12]

B9 (a) Steel may be coated with another metal, e.g. zinc or chromium, or with a polymer, e.g. poly(chloroethene), to prevent rusting.

(i) Suggest a property of poly(chloroethene) that makes it suitable for this purpose.

.... [1]

(ii) Explain why the steel will rust when the protective coating of chromium or polymer is broken.

....

.... [1]

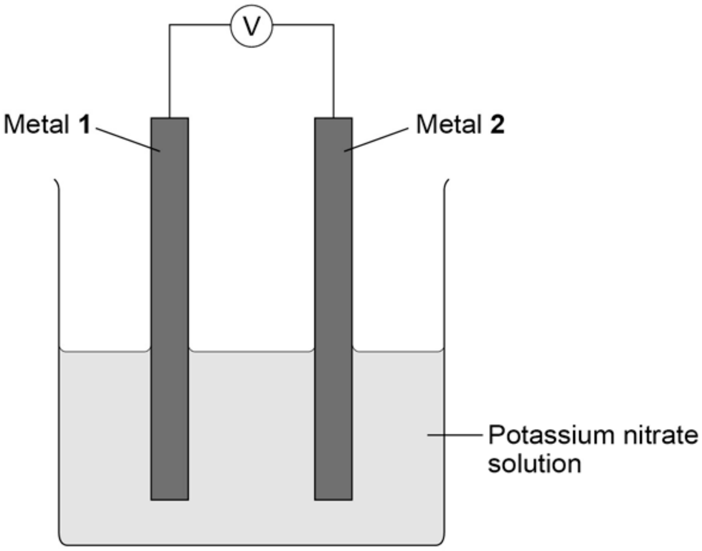
(iii) When the protective layer of zinc is broken, the steel does not rust. Suggest an explanation.

....

....

.... [2]

(b) A student investigated simple cells using the apparatus shown below.



- If metal **2** is more reactive than metal **1** then the voltage measured is positive.
- If metal **1** is more reactive than metal **2** then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

The student's results are shown in the table below.

Metal 1 \ Metal 2	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0 V				
Copper	1.2 V	0.0 V			
Iron	0.5 V	not measured	0.0 V		
Tin	0.8 V	-0.4 V	0.3 V	0.0 V	
Zinc	0.2 V	-1.0 V	-0.3 V	-0.6 V	0.0 V

(i) The ionic equation for the reaction occurring at the zinc electrode in the simple cell made using copper and zinc electrodes is:

$$Zn\ (s) \rightarrow Zn^{2+}\ (aq)\ +\ 2e^{-}$$

Zinc is oxidised in this reaction.
Give a reason why this is oxidation.

.... [1]

(ii) Which one of the metals used was the least reactive?
Give a reason for your answer.

....

.... [1]

(iii) Predict the voltage that would be obtained for a simple cell that has iron as metal **1** and copper as metal **2**.
Explain your answer.

....

....

....

....

.... [2]

[Total: 8]

Either

B10 (a) Nitrogen reacts with fluorine to form nitrogen trifluoride, NF_3.

(i) The chemical equation can be represented as shown below.

$$N{\equiv}N \ + \ 3\ F{-}F \rightarrow 2\ \begin{array}{c} F{-}N{-}F \\ | \\ F \end{array}$$

Some bond energies are shown in the table.

bond	bond energy in kJ/mol
N≡N	945
F–F	160
N–F	300

Calculate the energy change for the reaction between nitrogen and fluorine. [3]

(ii) Use your answer to (i) to deduce whether this reaction is endothermic or exothermic. Explain your answer.

....

.... [1]

(b) Draw a dot-and-cross diagram to show the arrangement of all the electrons in one molecule of nitrogen trifluoride. [2]

(c) (i) Silver nitrate can be prepared by reacting silver oxide with dilute nitric acid as shown below.

$$Ag_2O + 2HNO_3 \rightarrow 2AgNO_3 + H_2O$$

Excess silver oxide is reacted with 30.0 cm^3 of 0.150 mol/dm^3 nitric acid.
After purification the percentage yield of silver nitrate is 80.0 %.
Calculate the mass of silver nitrate prepared. [3]

(ii) Explain why excess silver oxide is used in the preparation of silver nitrate in (i).

……………………………………………………………………………………………. [1]

[Total: 10]

Or

B10 (a) Silicon shows the same type of bonding and structure as diamond.
Silicon reacts with magnesium to form Mg_2Si.
Solid Mg_2Si reacts with dilute hydrochloric acid to form gaseous SiH_4 and a solution of magnesium chloride.

(i) Construct an equation for this reaction. Include state symbols.

…………………………………………………………………………………………….. [2]

(ii) Predict the shape of the SiH_4 molecule.

…………………………………………………………………………………………….. [1]

(b) Calcium chlorate (I), $Ca(ClO)_2$, is used as an alternative to sodium chlorate (I), $NaClO$, in some household products.

(i) The chlorate (I) ion is formed when cold aqueous sodium hydroxide reacts with chlorine. Write an ionic equation for this reaction.

……………………………………………………………………………………………. [1]

(ii) The chlorate(I) ion is unstable and decomposes when heated as shown.

$$3ClO^- \rightarrow 2Cl^- + ClO_3^-$$

This reaction can be described as a disproportionation reaction.
Describe what is meant by disproportionation reaction.

…………………………………………………………………………………………….

……………………………………………………………………………………………. [1]

(iii) Explain, in terms of oxidation state, if the disproportion reaction is a redox reaction.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

……………………………………………………………………………………………. [2]

(c) Phosphorus is a non-metal in Group V of the Periodic Table.
Phosphorus can be manufactured from calcium phosphate, $Ca_3(PO_4)_2$ as shown below.

$$2Ca_3(PO_4)_2 + 6SiO_2 + 10C \rightarrow 6CaSiO_3 + 10CO + P_4$$

What is the maximum mass of phosphorus that can be made using 300 g of silicon dioxide,SiO_2? [3]

[Total: 10]

End of Paper

Setter: Ms Kim

O

JURONG SECONDARY SCHOOL
2022 GRADUATION EXAMINATION 2
SECONDARY 4 EXPRESS

CANDIDATE NAME	

CLASS		INDEX NUMBER	

CHEMISTRY **6092/02**

PAPER 2

25 August 2022

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B.
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 23.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use		
Paper 1 (30%)	MCQ [40 marks]	
Paper 2 (50%)	SECTION A [50 marks]	
	SECTION B [30 marks]	
	SUB-TOTAL [80 marks]	
Paper 3 (20%)	Practical [40 marks]	
OVERALL %	[100 %]	

This document consists of **23** printed pages including this page.

[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 **(a)** Select elements from the list to answer the following questions.

You may use each element once, more than once or not at all.

argon
carbon
copper
hydrogen
oxygen
potassium

(i) Which element relights a glowing splint?

.... [1]

(ii) Which metallic element oxidises very rapidly in air?

.... [1]

(iii) Which element forms a stable ion with the electron arrangement 2, 8, 8?

.... [1]

(iv) Which element is in the same period as helium?

.... [1]

(v) Which element forms an acidic oxide?

.... [1]

(b) The following are statements about transition elements in the Periodic Table.

Put a tick (✓) in **one** box in each row to show which statements are **true** and which are **false**.

	true	**false**
All transition metals react with acids to form hydrogen gas.		
Copper metals are blue in colour.		
Iron can form ions with a charge of +2 and +3.		
Transition metals can be used to speed up chemical reactions.		

[3]

[Total: 8]

A2 Fig. 2.1 shows the vessel to refine crude oil into different fractions.

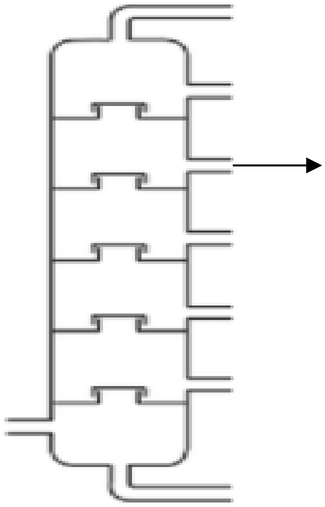


Fig. 2.1

(a) Describe how crude oil is separated into its different fractions.

....

....

....

.... [2]

(b) Name fraction X and state its use.

.... [1]

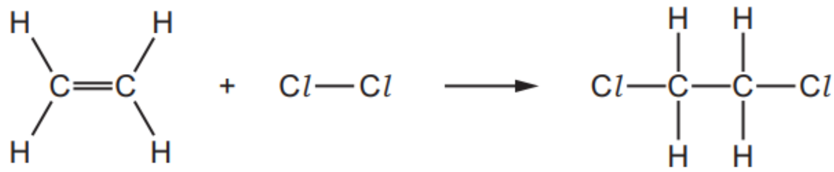
(c) Ethene can be obtained from the hydrocarbon $C_{15}H_{32}$.

$$C_{15}H_{32} \rightarrow 2C_2H_4 + Y + C_8H_{18}$$

Name product Y.

.... [1]

(d) Ethene can undergo a reaction with chlorine to produce dichloroethane. The chemical equation for this reaction can be represented as shown.



The energy change for the reaction is −180 kJ/ mol.

Table 2.1 shows the bond energies of the reaction.

Table 2.1

bond	C–H	C=C	C–C	C–C*l*
bond energy in kJ/ mol	410	610	350	340

(i) Use ideas about breaking and forming bonds to explain why the energy change for the reaction is negative.

....

....

.... [2]

(ii) Use the information from Table 2.1 to calculate the bond energy of a C*l*–C*l* bond.

[3]

(iii) In an experiment involving the reaction between ethene and chlorine, the total enthalpy change was found to be −270 kJ.

Calculate the mass of ethene that reacted.

[2]

[Total: 11]

A3 Pain is often felt when a piece of aluminium foil touches a dental amalgam (alloy used to fill cavities) filling in a tooth. This is known as a galvanic shock. The amalgam contains mainly silver and other metals.

Fig. 3.1 shows the dental amalgam and the aluminium foil on the tooth while Fig. 3.2 shows its corresponding galvanic cell diagram **in the mouth** that causes the galvanic shock**.**

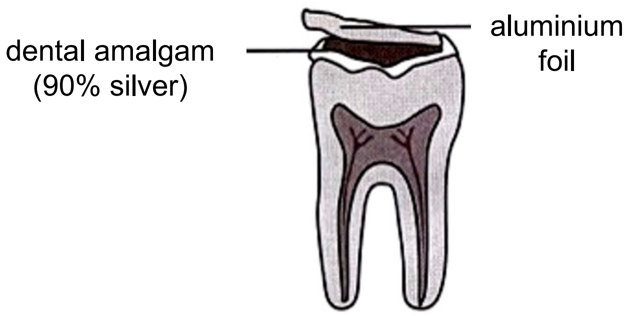


Fig. 3.1

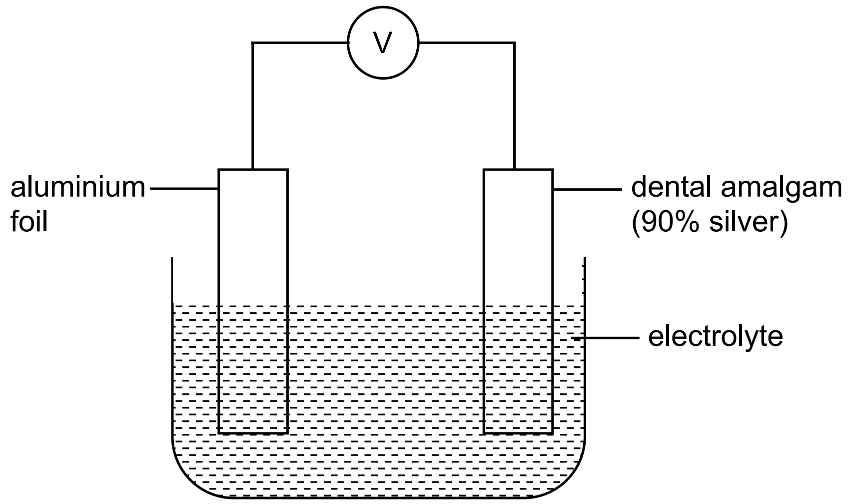


Fig. 3.2

(a) Suggest a natural electrolyte for this galvanic cell.

.... [1]

(b) **(i)** On Fig. 3.2, draw the direction of electron flow using an arrow (→). [1]

(ii) With reference to the reactions taking place in the galvanic cell, explain how the 'pain in the tooth' occurs. You only need to include the half equation of the reaction occurring at the aluminium foil in your answer.

....

....

....

....

.... [3]

(iii) Predict one observation likely to be seen at the dental amalgam.

.... [1]

(iv) With reference to the reaction occurring at the dental amalgam, explain your answer in **(b)(iii)**.

....

....

.... [2]

[Total: 8]

A4 Iron from the Blast Furnace contains carbon as an impurity and is known as cast iron. Cast iron is the raw material used in the manufacturing of different types of steel.

Table 4.1 shows the content and properties of different types of steel.

Table 4.1

material	content	properties
wrought iron	100% iron	very malleable but very weak
mild steel	iron, 0.15 to 0.3% carbon	malleable, ductile, easily shaped
medium carbon steel	iron, 0.35 to 0.7% carbon	strong but less ductile than mild steel
high carbon steel	iron, 0.7 to 1.5% carbon	harder but more brittle than medium steel
cast iron	iron, 2.5% carbon	very strong but very brittle
stainless steel	iron, 16 to 26% chromium and 8 to 22% nickel	malleable, ductile, corrosion resistant

(a) Describe the effect of increasing the percentage of carbon in these materials.

....

.... [1]

(b) Which material can be used in the manufacture of surgical instruments?

Support your answer with evidence from Table 4.1.

....

.... [1]

(c) Recycling steel on a large scale uses only 50% of the energy compared to the enery needed in the extraction of iron from its ore.

Other than the fact that recycling saves energy, state **one** other advantage of large scale recycling of steel.

....

.... [1]

(d) Wrought iron can be formed from cast iron by removing all the carbon using excess oxygen.

(i) State how oxygen can be obtained.

.... [1]

(ii) Construct a balanced chemical equation, including state symbols, for this reaction.

.... [1]

(iii) State an environmental effect of the product formed in **(d)(ii)**.

....

.... [1]

(e) Big objects made of wrought iron need to be protected from rusting. They can be protected by attaching small pieces of metal M at regular distances over the surface of the object.

Metal M reacts slowly with cold water according to the follow equation.

$$M + 2H_2O \longrightarrow M(OH)_2 + H_2$$

When 0.177 g of metal M is added to cold water, 65 cm^3 of hydrogen gas is produced.

Identify metal M by showing relevant calculations and workings.

You may assume that metal M is pure and the yield of the reaction is 100%.

[2]

(f) A piece of wrought iron was placed in a solution of copper(II) nitrate.

After several hours, some observations were made.

Describe and explain **two** observations made.

....

....

.... [3]

[Total: 11]

A5 Natural gas consists mainly of methane and is widely used as a fuel for energy. The main products for complete combustion of methane gas are carbon dioxide and steam.

(a) Draw a ‘dot and cross’ diagram for carbon dioxide.

Show outer electrons only.

[2]

(b) Explain, in terms of structure and bonding, if carbon dioxide has a low boiling point.

....

....

.... [2]

(c) Incomplete combustion of methane may produce a toxic gas **in addition** to carbon dioxide and steam.

(i) Write a balanced chemical equation, including state symbols, for this reaction.

.... [2]

(ii) 20 tonnes of methane is burnt in 64 tonnes of oxygen to produce the reaction in **(c)(i)**.

Show that oxygen is the limiting reagent and hence calculate the volume of the toxic gas formed.

1 tonne = 1 000 kg

[4]

(iii) Describe the harmful effect of the toxic gas to the human body and suggest a method to decrease the toxic gas emission into the atmosphere.

....

....

....

.... [2]

[Total: 12]

Section B

Answer all **three** questions from this section.

The last question is in the form either/or and only **one** of the alternatives should be attempted.

B6 Table 6.1 shows the composition of air and some properties of the gases present in air.

Table 6.1

gas	composition in air (%)	solubility in water	acid formed when dissolved in water	pH of acid
nitrogen	78	insoluble	N.A.	N.A.
oxygen	21	slightly soluble	N.A.	N.A.
carbon dioxide	0.04	slightly soluble	carbonic acid	5.8
argon	0.934	insoluble	N.A.	N.A.

*the remaining 0.026% of air consists of other gases

Countering soil acidification

Soil acidification is a widespread natural phenomenon in regions with medium to high rainfall. Farmers attempt to counter this phenomenon via the addition of fertilisers and soil improvers to ensure that the acidity of the soil is suitable for effective and maximum growth of crops and that the plants get sufficient nutrients.

Examples of active ingredients in some fertilisers

Table 6.2

name of substance	chemical formula	name of reagents	
		acid	other compound
potassium sulfate		sulfuric acid	
potassium phosphate	K_3PO_4	phosphoric acid	
calcium phosphate		phosphoric acid	calcium hydroxide
ammonium sulfate	$(NH_4)_2SO_4$	sulfuric acid	ammonia

Examples of soil improvers

Table 6.3

name of substance	chemical formula	effectiveness at neutralising acidity
limestone	$CaCO_3$	fair
quicklime	CaO	very high
slaked lime	$Ca(OH)_2$	very high

Production of ammonium sulfate, $(NH_4)_2SO_4$

Ammonium sulfate can be produced by two industrial processes. Ammonium sulfate is the useful product in both processes.

Process 1 $2NH_3\ (g) + H_2SO_4\ (aq) \longrightarrow (NH_4)_2SO_4\ (aq)$

Process 2 $(NH_4)_2CO_3\ (aq) + Ca^{2+}\ (aq) + SO_4^{2-}\ (aq) \longrightarrow (NH_4)_2SO_4\ (aq) + CaCO_3\ (s)$

(a) With reference to the data provided on page 13, suggest why soil acidification is a widespread natural phenomenon in regions with medium to high rainfall.

....

.... [1]

(b) Complete Table 6.2 by filling in the missing information. [3]

(c) Name **one** substance from Table 6.2 and **one** substance from Table 6.3 which should not be added to soil at the same time.

Explain your choices.

....

....

....

.... [3]

(d) Atom economy is the maximisation of a material from the starting reagents into the final, useful product.

Process 1 is said to have 100% atom economy while **process 2** is said to have an atom economy of slightly above 50%.

Suggest how the equations in **process 1** and **process 2** support the above statement.

....

.... [1]

(e) Suggest, with a reason, how aqueous ammonium sulfate can be obtained from the reaction mixture formed in process 2.

....

....

....

.... [1]

(f) Crops use nitrogen from ammonium sulfate for growth. A typical bag of fertilizer contains 50 kg of ammonium sulfate, $(NH_4)_2SO_4$.

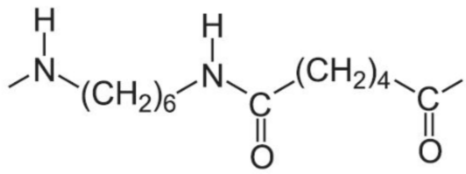
Calculate the mass of nitrogen, in kg, in this bag of fertilizer.

1 kg = 1 000 g

[3]

[Total: 12]

B7 **(a)** The repeat unit of a polymer is shown below. It is made up of monomers **A** and **B**.



(i) Name the type of linkage which joins monomers **A** and **B**.

.... [1]

(ii) A sample of this polymer has a relative molecular mass of 21 500.

Calculate the number of repeat units in the sample.

Give your answer as a **whole** number.

.... [1]

(iii) Draw the structures of monomers **A** and **B**.

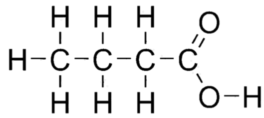
[2]

(iv) Suggest the name for this type of polymer and state one use for it.

....

.... [2]

(b) The molecule below will react with ethanol to form an ester.



(i) Name the ester formed.

.... [1]

(ii) State the conditions for this reaction.

....

.... [1]

[Total: 8]

Either

B8 Some information about oxides are shown in Table 8.1.

Table 8.1

name of oxide	melting point /°C	reaction with hydrochloric acid	reaction with sodium hydroxide
aluminium oxide	2072	react to form salt and water	react to form salt and water
nitrogen monoxide	–164	no reaction	no reaction
potassium oxide	740	react to form salt and water	no reaction
silicon dioxide	1710		
sulfur dioxide	–72	no reaction	react to form salt and water

(a) Complete Table 8.1 for silicon dioxide. [1]

(b) What conclusions can you make about the position of the elements in the Periodic Table and the type of oxides they form?

....

....

....

.... [2]

(c) Although silicon dioxide and aluminium oxide have very high melting points, they differ in their type of bonding.

Use the ideas of bonding to explain their high melting points.

....

....

....

....

....

.... [3]

(d) Aluminum oxide reacts with sodium hydroxide to produce sodium aluminate and water according the equation below.

$$Al_2O_3 + NaOH \longrightarrow NaAlO_2 + H_2O$$

250 kg of impure sample of aluminium oxide was reacted with sodium hydroxide at a temperature of 1100 °C. 164 kg of sodium aluminate was produced at the end of the reaction.

Calculate the percentage purity of aluminium oxide in the sample.

[4]

[Total: 10]

OR

B8 The reaction between iron and dilute hydrochloric acid is represented by the chemical equation

$$Fe(s) + 2HCl(aq) \longrightarrow FeCl_2(aq) + H_2(g)$$

(a) A series of experiments are carried out using different sized pieces of iron to investigate the rate of this reaction.

The approximate sizes of the pieces of iron used in each experiment are:
- granules of 5 mm in diameter
- granules of 10 mm in diameter
- fine powder

(i) Complete the table below by filling in the missing information.

sizes of pieces of iron	**rate of production of gas in cm^3/ min**
	3
	12
	25

[1]

(ii) Use ideas about collision between particles to explain the results in **(a)(i)**.

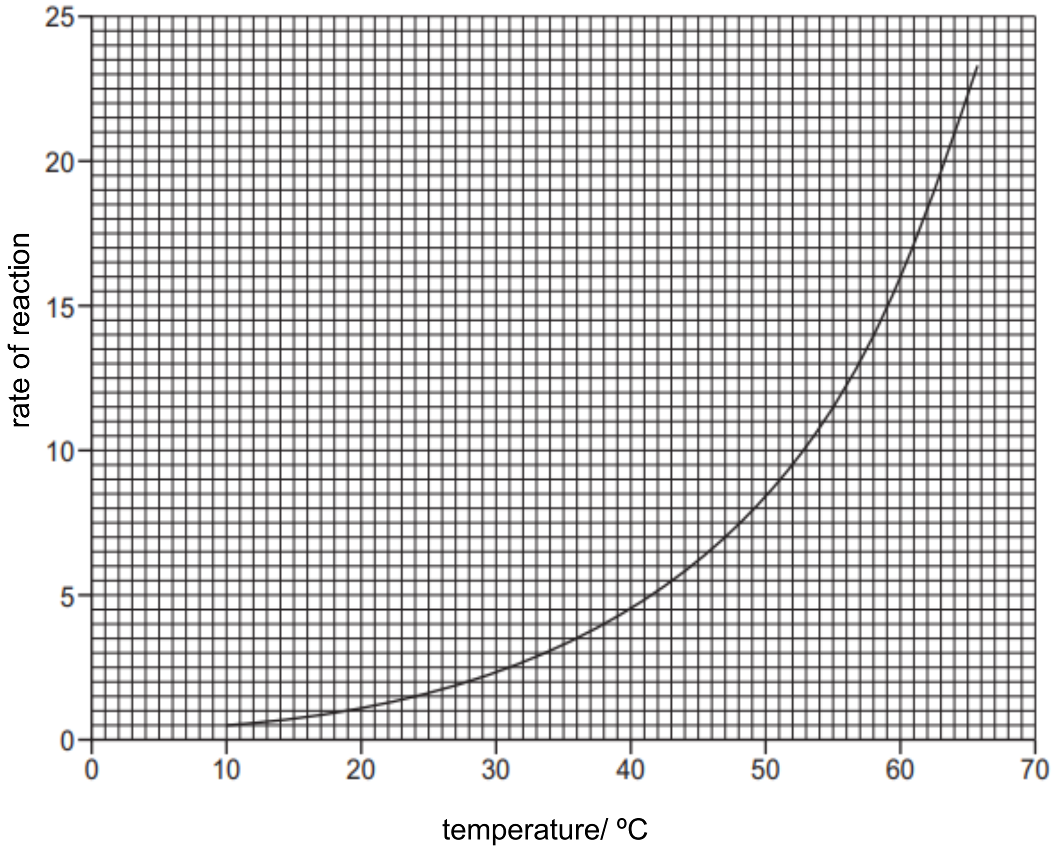
....

....

....

.... [2]

(b) The graph shows the effect of temperature on the **rate of reaction** of hydrochloric acid.



(i) Describe how the graph shows the effect of temperature on the rate of this reaction.

....

.... [1]

(ii) State the rate of reaction at 25 °C.

.... [1]

(c) A catalyst can also be added to change the rate of reaction.

Define the term 'catalyst' and explain how a catalyst affects the rate of reaction.

....

....

.... [2]

(d) In the experiments in **(a)**, 20 cm^3 of 0.05 mol/dm^3 of hydrochloric acid and 0.5 g of iron are used.

Which is the limiting reactant in the experiments?

Show your working.

[3]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

O

JURONGVILLE SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
Secondary 4 Express

STUDENT NAME			
CLASS		INDEX NUMBER	

CHEMISTRY 6092/02

Paper 2

24 August 2022

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces on all the work you hand in.
Write in dark blue or black pen.
You may use pencil for drawing diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either / or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 19.

The use of an approved scientific calculator is expected, where appropriate.

DO NOT OPEN THE BOOKLET UNTIL YOU ARE TOLD TO DO SO

For Examiner's Use	
Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

Setter: Mrs Wong Yan Pure

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Table 1.1 shows some properties of four oxides.

Table 1.1

oxide	melting point / ^{o}C	electrical conductivity when molten	reaction with water	resulting pH of solution
W	17	poor	exothermic	1
X	1280	good	exothermic	14
Y	1720	poor	none	7
Z	2850	good	very little	8

(a) Use the letters W, X, Y and Z to answer the questions.

Each letter may be used once, more than once or not at all.

(i) Which of the oxides are non-metallic oxides?

……………………………………………………………………………………… [1]

(ii) Which of the oxides have a giant lattice structure?

……………………………………………………………………………………… [1]

(iii) Which of the oxide has a giant molecular structure?

……………………………………………………………………………………… [1]

(b) Oxide W is an atmospheric pollutant which changes the colour of potassium manganate(VII), and forms acid rain.

(i) Suggest an identity for oxide W.

……………………………………………………………………………………… [1]

(ii) Write an equation to show how oxide W identified in **(b)(i)** forms acid rain.

……………………………………………………………………………………… [1]

(iii) State two negative impacts of acid rain on the environment.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

[Total: 7]

A2 Magnesium is best known for burning with a characteristic brilliant white light.

The metal was first produced by Sir Humphry Davy in 1808 by the electrolysis of a molten mixture of magnesia, MgO with mercury oxide. Mercury oxide was added as an impurity and inert electrodes were used during the electrolysis.

(a) Construct ionic half-equation with state symbols to show how the product is formed at the cathode.

……………………………………………………………………………………………… [1]

(b) Suggest a reason why the product obtained at the cathode was a mixture.

……………………………………………………………………………………………… [1]

(c) A gas was obtained at the anode.

Describe a positive test to identify the gas formed at the anode.

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(d) Give a reason for adding mercury oxide as an impurity.

……………………………………………………………………………………………… [1]

[Total: 5]

A3 A student tried to prepare magnesium sulfate by reacting sulfuric acid with magnesium oxide.

(a) Explain why this method **cannot** be used to prepare barium sulfate from sulfuric acid and barium oxide.

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(b) Describe a suitable method of preparing a pure and dry sample of barium sulfate. Suggest the reagents required.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [4]

[Total: 6]

[Turn over

A4 Table 4.1 lists some physical properties of the metals found in Period 4 of the Periodic Table.

Table 4.1

	proton number	atomic radius / nm	ionic radius / nm	melting point / °C	density / g / cm^3	electrical conductivity / S / m
calcium	20	0.197	0.114	842	1.54	29.8×10^6
iron	26	0.126	0.075	1538	7.86	9.93×10^6
copper	29	0.128	0.087	1084	8.92	59.6×10^6

(a) Explain why the ionic radius of the metal ion is always smaller than its atomic radius.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) The high electrical conductivity of copper makes it a very useful element for making electrical components.

Using the data from Table 4.1,, suggest why copper is **not** usually used as overhead electrical cables.

………………………………………………………………………………………………… [1]

(c) Using the data from Table 4.1, explain why the other metals are unsuitable for making electrical wires.

calcium: ………………………………………………………………………………………

………………………………………………………………………………………………… [1]

iron: ………………………………………………………………………………………

………………………………………………………………………………………………… [1]

[Total: 5]

A5 Chlorofluorocarbons, CFCs, are sometimes used as propellants in aerosols.

Ozone hole are caused by reactions involving CFCs.

(a) Explain why ozone hole can cause harm to humans.

……………………………………………………………………………………………..

……………………………………………………………………………………….. [2]

(b) Difluoromethane, CH_2F_2, is a hydrofluorocarbon. It can be used instead of CFCs in aerosols.

Draw a dot and cross diagram to show the bonding in CH_2F_2, showing only the valence electrons.

[2]

(c) Difluoromethane can be synthesised by reacting methane with fluorine.

$$CH_4 + F_2 \rightarrow CH_3F + \text{substance X}$$

$$CH_3F + F_2 \rightarrow CH_2F_2 + \text{substance X}$$

(i) Name substance X.

……………………………………………………………………………………… [1]

(ii) What is the name for this type of reaction?

……………………………………………………………………………………… [1]

(iii) State the condition required for the reaction to occur.

……………………………………………………………………………………… [1]

(iv) Gaseous bromine will also react with methane. Suggest whether the reaction is faster or slower than fluorine. Explain your answer.

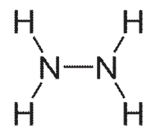
………………………………………………………………………………………

……………………………………………………………………………………… [1]

[Total: 8]

[Turn over

A6 **(a)** One of the early alternative rocket fuels was hydrazine, N_2H_4. The structure of hydrazine is shown.



Liquid hydrazine combined with liquid oxygen in the combustion chamber in the rocket engine to produce thrust for the rocket. The equation of the combustion reaction is shown.

$$N_2H_4(l) + O_2(l) \rightarrow N_2(g) + 2H_2O(l) \qquad \Delta H = -585 \text{ kJ / mol}$$

Table 6.1 shows the bond energies of some covalent bonds.

Table 6.1

bond	N – H	N ≡ N	O = O	O – H	N – N
bond energy / kJ / mol	388	944	496	463	

(i) Calculate the bond energy of N – N bond.

bond energy of N – N bond = ………………………….. kJ / mol [2]

(ii) Explain, using bond energies, why the above reaction is exothermic, in terms of bond breaking and bond forming.

…………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(iii) Draw an energy profile diagram for the reaction, showing the activation energy, enthalpy change, reactants and products.

[3]

(b) Butane is a fuel used in portable heaters.

For complete combustion of one mole of butane, the enthalpy change is –2880 kJ.

Calculate the quantity of heat evolved from the combustion of 16 dm^3 of butane, at room temperature and pressure.

heat evolved = ………………………….. kJ [2]

[Total: 8]

A7 Ammonia is manufactured in the Haber process.

(a) Explain, with the help of an equation, why nitrogen and hydrogen are mixed in a ratio of 1 : 3 by volume.

……………………………………………………………………………………………………

…………………………………………………………………………………………….. [2]

(b) State the essential conditions required in the Haber process.

…………………………………………………………………………………………….. [1]

(c) Ammonia is used to manufacture nitric acid by first converting ammonia to nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$$

(i) In terms of the collision between reacting particles, state and explain how the rate changes when the pressure is increased.

……………………………………………………………………………………………

…………………………………………………………………………………….… [1]

(ii) During the reaction, ammonia and oxygen are passed through a powdered catalyst. Explain how the catalyst increases the speed of reaction.

……………………………………………………………………………………………

…………………………………………………………………………………….… [1]

(iii) The formation of nitrogen monoxide can be determined by pH changes. Explain how this is possible.

……………………………………………………………………………………………

…………………………………………………………………………………….… [1]

[Total: 6]

[Turn over

A8 Fig. 8.1 shows the stages involved in the extraction of zinc from zinc blende, which contains mainly zinc sulfide, ZnS.

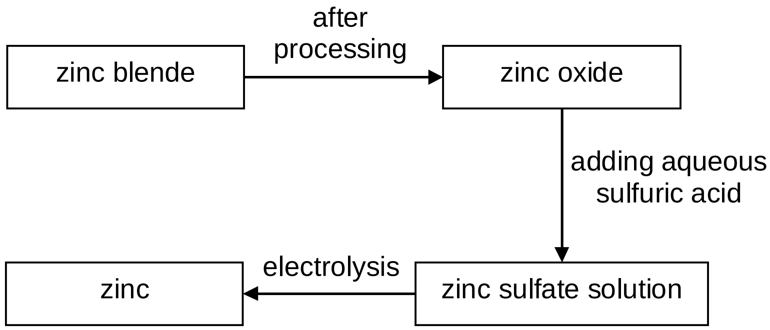


Fig. 8.1

Zinc sulfate solution obtained contained ions of other metals, which are present as impurities in zinc oxide.

(a) It is necessary to remove ions of metals which are less reactive than zinc from zinc sulfate solution before electrolysis.

However, it is not necessary to remove ions of metals which are more reactive than zinc.

Explain why.

....

....

....

.... [2]

(b) Suggest how to remove the metal ions that are less reactive than zinc from zinc sulfate solution before electrolysis.

....

....

.... [2]

(c) Suggest a more economical method to reduce zinc oxide to zinc metal.

....

.... [1]

[Total: 5]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either / or and only one of the alternatives should be attempted.

B9 Transition metals occupy the middle portions of the long periods of the Periodic Table, between the groups on the left-hand side and the groups on the right-hand side.

Each transition metal may have several oxidation states, which shows the number of electrons that the transition metal would lose if it were to bond with other atoms. Table 9.1 shows the range of oxidation states of the first row of transition metals in their compounds. Some of the oxidation states are uncommon and unstable. The important ones are underlined.

Table 9.1

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
								+1	
	+2	+2	$\underline{+2}$	$\underline{+2}$	$\underline{+2}$	$\underline{+2}$	$\underline{+2}$	$\underline{+2}$	$\underline{+2}$
$\underline{+3}$	$\underline{+3}$	+3	$\underline{+3}$	+3	$\underline{+3}$	$\underline{+3}$	+3	+3	
	$\underline{+4}$	$\underline{+4}$	+4	$\underline{+4}$	+4	+4	+4		
		$\underline{+5}$	+5	+5					
			$\underline{+6}$	+6	+6				
				$\underline{+7}$					

Chromium is a hard bluish-white metal, whose name refers to its many colourful compounds. Chromium, like other transition metals, forms a few oxides. Table 9.2 gives some information of the common oxides of chromium.

Table 9.2

formula of oxide	melting point / °C	nature of oxide	colour of oxide
CrO	decomposes at 300 °C	basic	black
Cr_2O_3	2450	amphoteric	dark green
CrO_3	190	acidic	deep red

Transition metals are not as reactive as alkali metals, but they are hard and strong metals. Hence, transition metals are often used for making objects and machineries. An example is titanium which has high strength, is strong as steel but 45% lighter, and is resistant to corrosion. Hence, titanium is used in aircrafts, ships and hip replacement joints. However, titanium is more expensive than iron, and five times more expensive than stainless steel.

[Turn over

Most titanium is extracted from its ore, rutile, which contains titanium dioxide. Titanium cannot be extracted by using carbon as a reducing agent, as titanium forms a carbide, TiC. The presence of carbide makes the metal brittle and thus, titanium is extracted from its ore in two stages as shown in Fig. 9.1

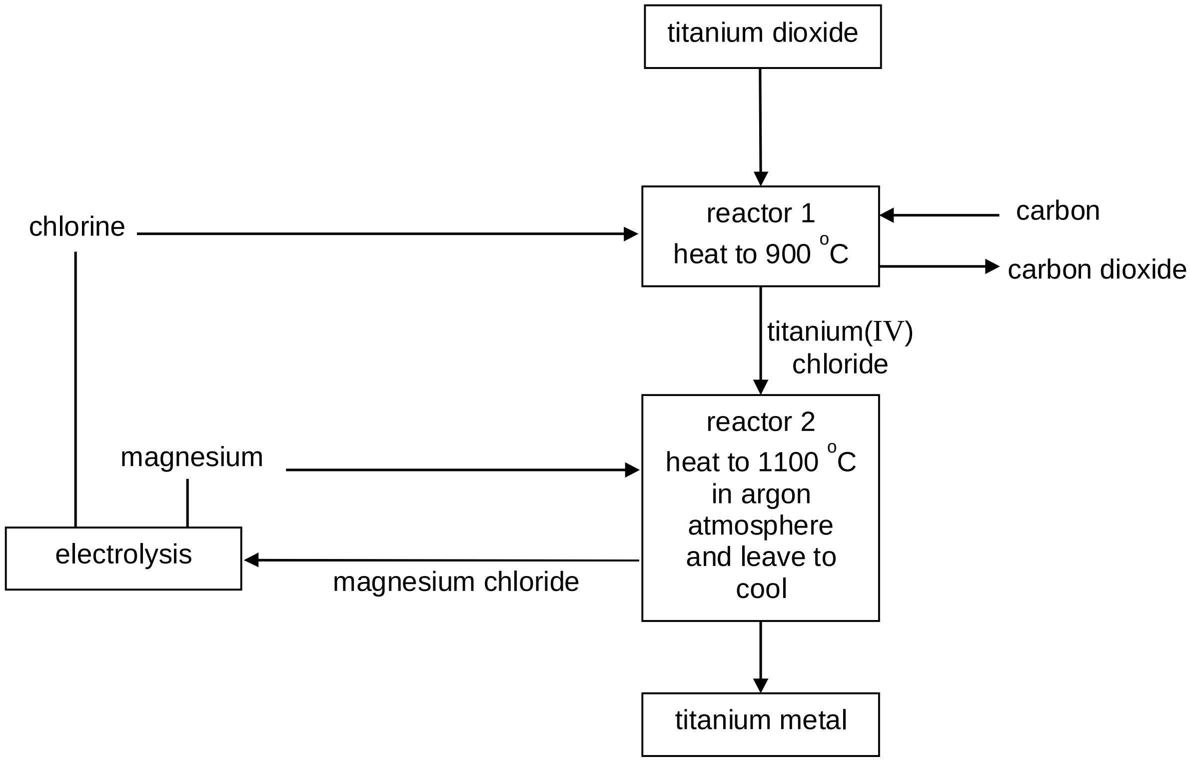


Fig. 9.1

Fig. 9.2 shows the mass of titanium metal produced from pure rutile ore and impure rutile ore. The difference between the two lines represents the amount of waste rock in the impure ore.

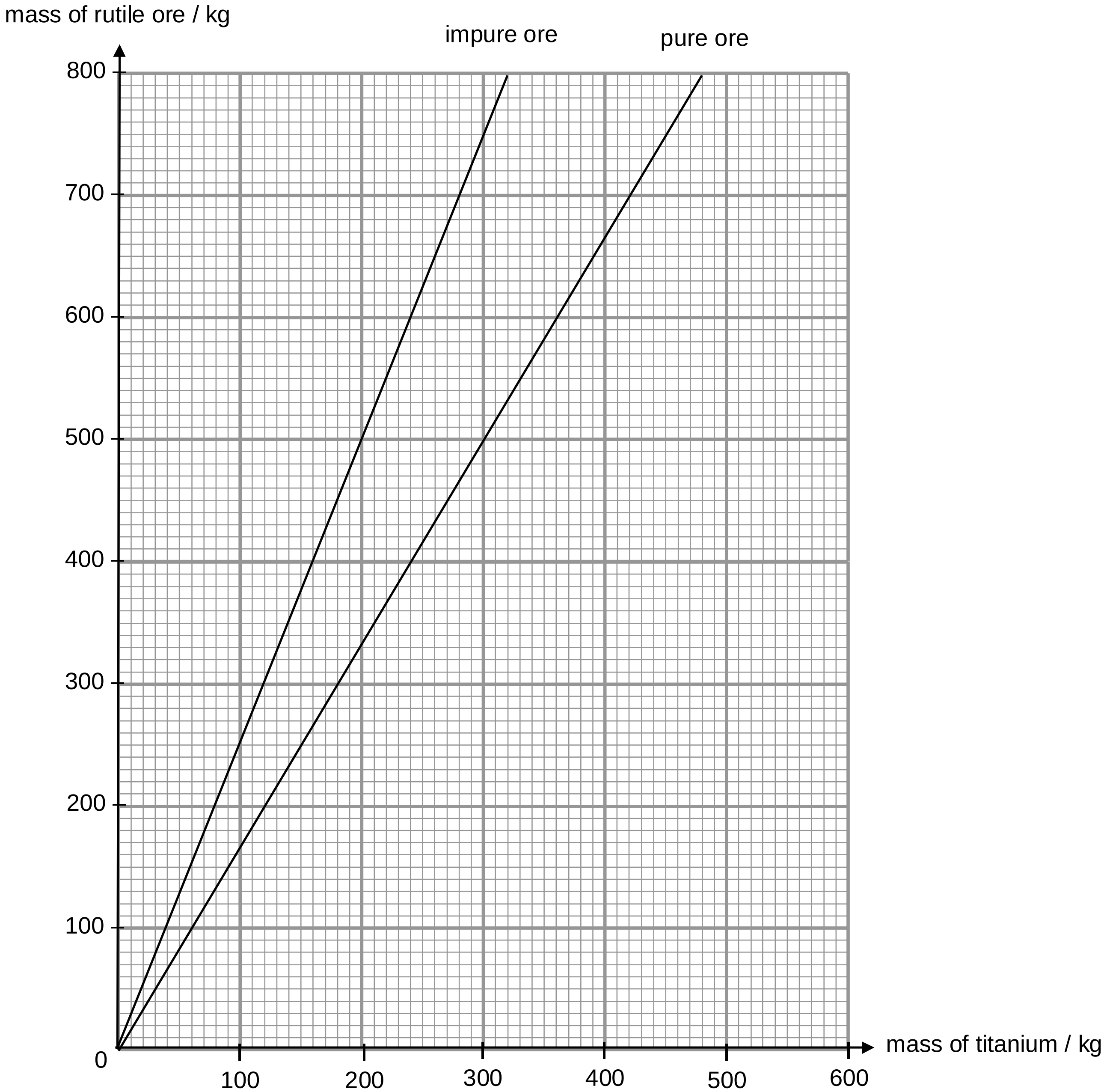


Fig. 9.2

(a) Explain why +2 oxidation state is the most common amongst the transition metals.

……………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

[Turn over

(b) State the relationship between the oxidation state of chromium oxides and the nature of the oxides.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(c) Similar to chromium, manganese also forms a few oxides. The chemistry of manganese resembles that of chromium. Predict the nature of the oxides.

name of oxide	nature of oxide
manganese(VII) oxide	
manganese(IV) oxide	
manganese(II) oxide	

[1]

(d) Describe how magnesium chloride was recycled in Fig. 9.1.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(e) **(i)** From Fig. 9.1, construct the equation to show the reaction which produces titanium metal.

…………………………………………………………………………………………… [1]

(ii) Besides high temperature, state one other condition for the reaction and explain why this condition is required.

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(f) From the impure ore, 300 kg of pure titanium was produced. Calculate the mass of waste rock in the impure ore.

mass …………………… kg [1]

(g) **(i)** State the reducing agents in the extraction of iron and titanium respectively.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(ii) Give two reasons why titanium is more costly than iron even through it is the ninth most abundant element in the Earth's crust.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

[Total: 12]

[Turn over

B10 A toilet detergent contains the acid salt sodium dihydrogen phosphate, NaH_2PO_4.

(a) Explain why sodium dihydrogen phosphate is both an acid and a salt.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(b) Sodium dihydrogen phosphate can be made by reacting sodium hydroxide solution with dilute phosphoric acid, H_3PO_4.

(i) Write the balanced chemical equation for the formation of sodium dihydrogen phosphate, including state symbols.

…………………………………………………………………………………………… [1]

(ii) Suggest the chemical formula of another possible salt formed from sodium hydroxide solution and dilute phosphoric acid.

…………………………………………………………………………………………… [1]

(c) Table 11.1 shows information about other acids.

Table 11.1

acid	pH
sodium dihydrogen phosphate	4.5
ethanoic acid	3.8
sulfuric acid	1.0

(i) Explain how sulfuric acid behaves as a strong acid, but ethanoic acid behaves like as a weak acid.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) Describe an experiment, other than measuring pH and using indicators, how you would carry out an experiment to show that sulfuric acid is a strong acid and ethanoic acid is a weak acid.

State the measurements you would make and expected results.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[Total: 8]

[Turn over

EITHER

B11 1,1-dichloroethene, $C_2H_2Cl_2$, undergoes polymerisation to form polyvinylidene chloride, PVDC.

The most well-known use of PVDC is as plastic food wraps. PVDC is non-biodegradable and the only way to dispose PVDC is to incinerate. But incinerating PVDC causes serious environmental issues.

(a) Describe one similarity and one difference in structure between 1,1-dichloroethene and polyvinylidene chloride.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) Draw the structure of PVDC polymer, showing three repeating units.

[2]

(c) Calculate the number of repeating units in a PVDC polymer if it has a relative molecular mass of 82 450.

number of repeating units ……………………….. [2]

(d) Describe a chemical test to distinguish between 1,1-dichloroethene and PVDC.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(e) Explain why being non-biodegradable is both an advantage and a disadvantage.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Total: 10]

OR

B11 Ethers are a group of compounds containing carbon, hydrogen and oxygen as shown in Table 12.1.

Table 12.1

name	molecular formula	boiling point / ^{o}C
methoxyethane	$CH_3 – O – CH_2CH_3$	7
ethoxyethane	$CH_3CH_2 – O – CH_2CH_3$	35
Z	$CH_3 – O – CH_2CH_2CH_3$	39
Propoxybutane	$CH_3CH_2CH_2 – O – CH_2CH_2CH_2CH_3$	117

(a) Name ether Z.

…………………………………………………………………………………………………… [1]

(b) With reference to Table 12.1, state and explain the trend observed in the boiling points of ether.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(c) Simple ethers are prepared commercially by the dehydration of alcohols using concentrated sulfuric acid.

Alcohol Y is used to prepare ethoxyethane, $C_2H_5 – O – C_2H_5$, as shown in the equation.

$$2Y \rightarrow C_2H_5 – O – C_2H_5 + H_2O$$

(i) Give the formula of alcohol Y used in the dehydration reaction.

…………………………………………………………………………………… [1]

[Turn over

(ii) Alcohol Y reacted with an organic compound W, CH_2O_2, to form a sweet smelling liquid X.

Give the name and full structural formula of the sweet smelling liquid X.

name: …………………………………………………………………………… [1]

structure:

[1]

(d) Epoxides also known as oxiranes, are three-membered ring structures in which one of the vertices is an oxygen and the other two are carbons.

The full structural formula for the first member, C_2H_4O, is shown in Fig. 12.1.

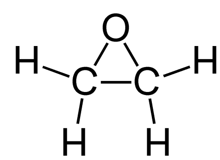


Fig. 12.1

(i) Epoxides can be produced by reacting an alkene with oxygen.

Name the alkene which could be used to produce the first member, C_2H_4O.

……………………………………………………………………………………… [1]

(ii) The second member of epoxides has a chemical formula, C_3H_6O, with three atoms in a ring, one of which is oxygen.

Draw the full structural formula of the epoxide, C_3H_6O.

[1]

(e) Epoxides are more reactive than simple ethers due to ring strain. Opening the ring relieves the ring strain and the products are 2 substituted alcohols.

Suggest a way to produce ethanol in the laboratory.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

[Total: 10]

End of Paper

THE PERIODIC TABLE OF ELEMENTS

Group

I	II											III	IV	V	VI	VII	0
							1 **H** hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) numbers atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium 209	85 At astatine 210	86 Rn radon 222
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 162	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinum –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

LOYANG VIEW SECONDARY SCHOOL
Preliminary Examination 2022
Secondary Four Express

CANDIDATE NAME : ……………………………………………………………………..........

CLASS : …………………. **INDEX NUMBER** : …………….

CHEMISTRY **6092/02**

Paper 2 Theory **29 August 2022**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 21.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

Setter: Mrs Lam-Tan Siok Hiang

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

1 Iron is extracted from iron ore in the blast furnace.

The equations **A, B, C, D** and **E** show some reactions that happen in the blast furnace.

A $C + O_2 \rightarrow CO_2$

B $CO_2 + C \rightarrow 2CO$

C $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

D $CaCO_3 \rightarrow CaO + CO_2$

E $SiO_2 + CaO \rightarrow CaSiO_3$

(a) Use the letters **A**, **B**, **C**, **D** and **E** to answer the following questions.

Each letter can be used once, more than once or not at all.

(i) Which equation shows neutralisation?

.... [1]

(ii) Which equation shows an element that undergoes both oxidation and reduction at the same time?

.... [1]

(iii) Which equation shows no change in the oxidation state of any element in the reactants?

.... [1]

(b) Blast furnace slag may contain impurities of Group IV and Group V oxides.

These impurities cause the slag to be less effective in removing acidity from the soil.

Explain why Group IV and Group V oxides are less effective in removing acidity.

....

.... [1]

[Total: 4]

2 Two students want to distinguish between two unlabelled test tubes each containing either aqueous sodium hydroxide or aqueous ammonia.

Student **A** suggests adding aqueous zinc nitrate while student **B** suggests adding aqueous lead(II) nitrate into both test tubes.

(a) Which student would be able to distinguish between the two unlabelled test tubes? Use the observations obtained by both students to support your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) Aqueous ammonia can be used to make fertilisers such as ammonium nitrate. Ammonium nitrate is slightly acidic.

Calcium carbonate can be added to the fertiliser so that soil does not become acidic, but calcium hydroxide should not be used.

Explain why calcium hydroxide should **not** be added to ammonium nitrate fertiliser.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Total: 4]

3 Some elements have many isotopes.

Table 3.1 shows information about three atoms of element **X**.

Table 3.1

atom	**1**	**2**	**3**
number of protons	7	7	7
number of electrons	7	7	7
number of neutrons	7	8	9
number of electrons in outer shell	5	5	5

(a) Use data from Table 3.1 to show that atoms 1, 2 and 3 are isotopes of the same element.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(b) Explain how the data suggests that the three isotopes undergo the same types of chemical reactions.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(c) Elements **Y** and **Z** also have isotopes**.**

Table 3.2 shows information about the isotopes of elements **Y** and **Z**.

Table 3.2

	isotope of element **Y**	isotope of element **Z**
number of protons	53	38
number of electrons	53	38
number of neutrons	66	50
number of electrons in outer shell	7	2

(i) Use the information in Table 3.1, Table 3.2 and the Periodic Table to identify the elements **X**, **Y** and **Z**.

X …………………………………………..

Y …………………………………………..

Z ………………………………………….. [1]

(ii) Suggest the trend in the melting points of elements **X**, **Y** and **Z**.

lowest melting point ……………

……………

highest melting point …………… [1]

Explain your reasoning.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

………………………………………………………………………………… [3]

(iii) Which of the elements, **X**, **Y** or **Z**, reacts with acids to form a salt?

Explain your reasoning.

…………………………………………………………………………………

………………………………………………………………………………… [1]

[Total: 8]

4 The reaction between dilute hydrochloric acid and aqueous sodium hydroxide releases 57.3 kJ of energy when one mole of water is formed.

(a) Write the ionic equation of the reaction.

………………………………………………………………………………………… [1]

(b) **(i)** 200 cm^3 of 0.200 mol/dm^3 dilute hydrochloric acid reacts with 100 cm^3 of 0.150 mol/dm^3 aqueous sodium hydroxide.

Calculate the overall enthalpy change of this reaction

overall enthalpy change = ……………kJ [2]

(ii) In a separate reaction, the same volume and concentration of dilute sulfuric acid is used instead of dilute hydrochloric acid.

State and explain whether this affects the overall enthalpy change of the reaction.

……………………………………………………………………………………….

……………………………………………………………………………………….

………………………………………………………………………………………. [2]

(c) Draw a labelled energy profile diagram for the reaction between dilute hydrochloric acid and aqueous sodium hydroxide.

Your diagram should include:

- the formulae of the reactants and products
- the enthalpy change
- the activation energy

[3]

[Total: 8]

5 Bromomethane, CH_3Br, is a poisonous organic compound.

It is used to kill pests such as rats and bugs.

(a) Draw a 'dot and cross' diagram to show the bonding in bromomethane.

Show the outer shell electrons only.

[2]

(b) Determine if the following statements about bromomethane are true or false.

Put a tick (✓) in one box for each statement.

	true	false
Bromomethane has a low boiling point.		
Bromomethane has good electrical conductivity when molten.		
Bromomethane could be obtained through the substitution reaction of methane and bromine.		

[3]

(c) Bromine reacts with sodium to form sodium bromide.

Draw a 'dot and cross' diagrams to show the arrangement of outer shell electrons in sodium bromide.

[2]

[Total: 7]

6 The table shows some information about a homologous series called ethers.

name	number of carbon atoms	formula	boiling point / °C
methoxymethane	2	CH_3OCH_3	−24.8
methoxyethane	3	$CH_3OC_2H_5$	7.0
methoxypropane	4	$CH_3OC_3H_7$	
	5		70.3

(a) Deduce the name and formula of the ether that contains 5 carbon atoms.

name ………………………………………..………..

formula ……………………………………………………. [2]

(b) **(i)** Suggest a value for the boiling point of methoxypropane.

…………………………………………………………………………………….. [1]

(ii) Account for the changes in boiling point down the group.

…………………………………………………………………………………….

…………………………………………………………………………………......

…………………………………………………………………………………….

……………………………………………………………………………………. [2]

(c) Besides boiling point, suggest how another physical property of this homologous series changes down the group.

……………………………………………………………………………………….. [1]

(d) How does the data in the table show that the compounds are from the same homologous series?

………………………………………………………………………………………..

……………………………………………………………………………………….. [1]

(e) Methoxymethane has an isomer which belongs to a homologous series that has the hydroxyl functional group.

Name this isomer and draw its structural formula.

name ……………………………………………………..…………

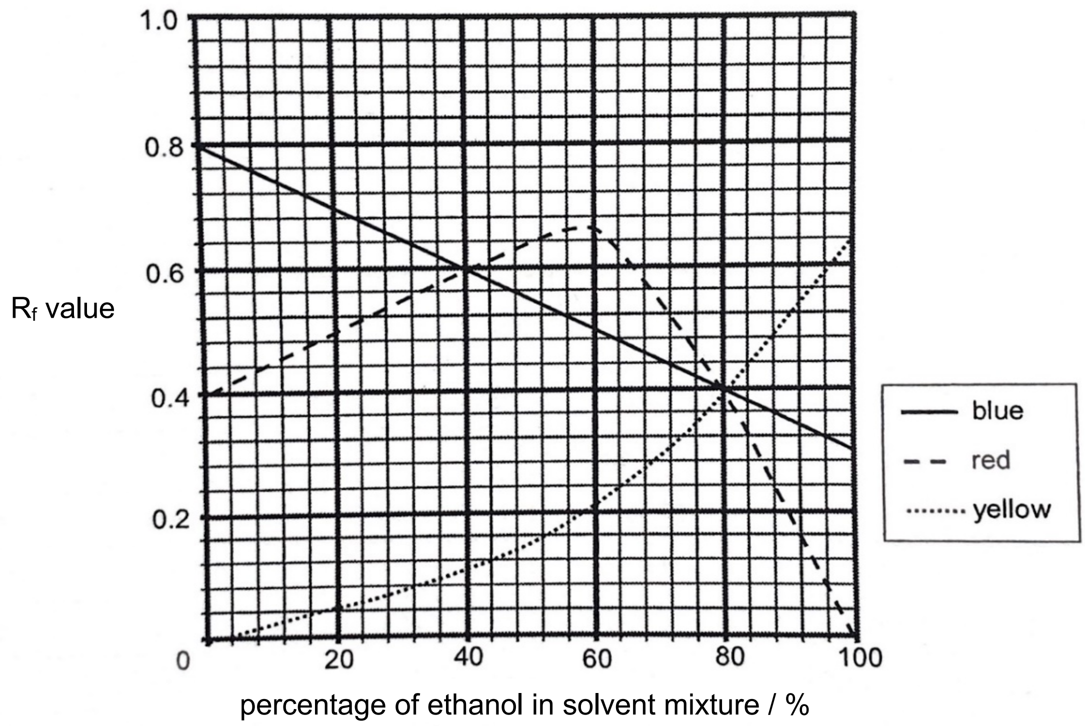
structural formula

[2]

[Total: 9]

7 A sample of black ink contains a mixture of red, blue, and yellow dyes. A common solvent used to separate the dyes in black ink is a mixture of ethanol and water. The coloured dyes have different R_f values in solvents with different composition of ethanol as shown in Fig. 7.1

Fig. 7.1



(a) **(i)** How many spots will be shown on the chromatogram when the solvent used consists of 40% ethanol in the solvent mixture?

…………………………………………………………………………………….. [1]

(ii) With reference to Fig 7.1, explain why 40% ethanol in the solvent mixture is not suitable for the separation of black ink.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(b) **(i)** Calculate the percentage of ethanol in a solvent mixture of 32 cm^3 of ethanol and 168 cm^3 of water.

percentage of ethanol = ……........% [1]

(ii) Hence state the R_f value of the blue dye on the chromatogram in the percentage of ethanol calculated in **(b)(i)**.

…………………………………………………………………………………….. [1]

[Total: 4]

8 Smartphones are pocket-sized vaults of precious metal and rare earth elements.

A mobile phone is estimated to house around 0.034 g of gold, 0.34 g of silver, 0.015 g of palladium and less than one-thousandth of a gram of platinum. It also contains the less valuable but still significant aluminium (25 g) and copper (about 15 g).

Table 8.1 shows the top few metals used in the manufacturing of mobile phones and their extraction methods.

Table 8.1

metal	uses	extraction method	electrical conductivity/ s/m
Gold, Au	to make circuit boards	leaching using cyanide	42.6×10^6
Tin, Sn	acts as a solder to join parts in phones and camera modules	metal ores are smelted with carbon	9.1×10^6
Lithium, Li	to produce lithium batteries	electrolysis of concentrated lithium chloride	11.1×10^6
Aluminium, A*l*	to make mobile phone casings and components	electrolysis of molten bauxite (aluminium oxide)	37.7×10^6
Cobalt, Co	to make rechargeable batteries in mobile phones	metal ore are smelted with carbon	11.7×10^6
Copper, Cu	to make circuit boards	metal ore are smelted with carbon	59.8×10^6
Nickel, Ni	used in electrical connections, capacitors and batteries	metal ore are smelted with carbon	14.6×10^6
Silver, Ag	to make circuit boards	heating the ore	62.9×10^6
Zinc, Zn	to make circuit boards and added to aluminium to strengthen mobile phone casings	metal ore are smelted with carbon	16.9×10^6

(a) Explain what is meant by an 'element.'

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [1]

(b) A student reported that the electrical conductivity of a metal is linked to the reactivity of the metal.

Do you agree? Explain your answer using the information in Table 8.1.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) Based on the information given in Table 8.1, suggest a reason why aluminium is not used in the circuit even though it has a high electrical conductivity.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(d) Explain how the addition of zinc strengthens the aluminium casings for mobile phones.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Total: 6]

Section B

Answer all three questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

9 **The Processing of Crude oil**

The relative demand for fuel far outstrips the supply from the primary distillation of crude oil. Consequently, methods have been developed to convert the higher boiling, and more abundant, fractions into petrol by cracking through two alternative processes. The difference between these can be illustrated using dodecane as an example.

Thermal Cracking

Thermal cracking involves heating the alkane mixture to about 800 °C and at moderate pressure, in the absence of air but in the presence of steam. After only a fraction of a second at this temperature, the mixture is rapidly cooled. By this means, dodecane will typically be broken to form hexane and ethene:

$$CH_3(CH_2)_{10}CH_3 \rightarrow CH_3(CH_2)_4CH_3 + 3CH_2CH_2$$

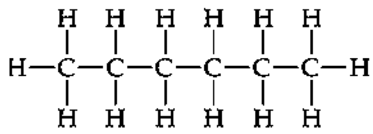
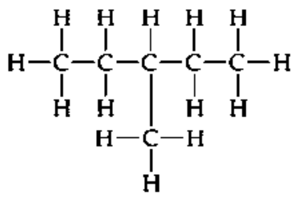
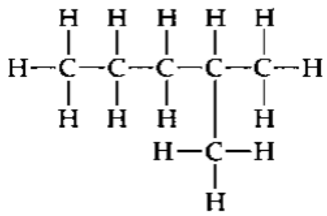
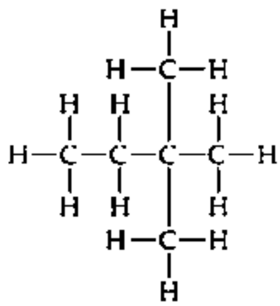
Catalytic Cracking

Catalytic cracking involves heating the alkane mixture to a temperature of 500 °C and passing it under slight pressure over a catalyst made from a porous mixture of aluminium and silicon oxides (called zeolites). By this means, isomers of hexane and ethene are produced:

$$2CH_3(CH_2)_{10}CH_3 \rightarrow (CH_3)_2CHCH_2CH_2CH_3 + (CH_3)_2CHCH(CH_3)_2 + 6CH_2CH_2$$

Table 9.1 shows melting points and boiling points of some isomers of hexane.

Table 9.1

compound	structural formula	boiling point / °C
hexane		68
3-methylpentane		63
2-methylpentane		60
2,3-dimethylbutane		58

(a) There is a large demand for the molecules in crude oil that can be used to make petrol. Both cracking processes are important to make sure that supply meets demand.

(i) Explain how cracking helps to meet the demand for petrol.

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(ii) Explain an advantage that catalytic cracking has over thermal cracking.

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(b) Ethene can undergo addition polymerisation to form a polymer.

(i) Draw two repeating units of the polymer formed by ethene.

[1]

(ii) Suggest a use of the polymer you have drawn in part **(b)(i)**.

……………………………………………………………………………….. [1]

(c) How is the boiling point of alkanes affected by isomerisation?

Use evidence from the information to explain your reasoning.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

……………………………………………………………………………………….. [3]

(d) Describe a test to distinguish between hexane and ethene. Include the results that would be obtained.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

……………………………………………………………………………………….. [2]

(e) Carbon is formed during catalytic cracking and this can coat the surface of the solid catalyst used.

Explain how a coating of carbon affects the efficiency of the catalyst used.

………………………………………………………………………………………..

……………………………………………………………………………………… [1]

(f) Other than petrol, ethanol can be used as a car fuel.

In some countries, it is produced from the sugars in sugar cane.

An environmentalist claims that ethanol as a fuel is 'carbon neutral' because using it does not add to the amount of carbon dioxide in the atmosphere.

Explain why this is true.

....

....

....

.... [2]

[Total: 12]

10 Mendeleev devised the modern Periodic Table, where he placed the elements in the same group if their properties were similar. When each Group VII element is allowed to react with vanadium under similar conditions of high temperature and pressure, the following results are obtained.

element	main product formed	colour of product
fluorine	VF_5	colourless
chlorine	VCl_4	bright red
bromine	VBr_3	red brown
iodine	VI_2	red violet

(a) Vanadium is a transition metal because it is able to exhibit variable valencies.

Use the data above to explain why vanadium is a transition metal.

....

.... [1]

(b) Do the formulae of the products in the table show clearly that all the elements belong to the same group?

Explain your reasoning.

....

.... [1]

(c) Group VII elements behave as oxidising agents in their reactions with vanadium.

(i) Explain, using ideas of oxidation states, how the given information shows that the oxidising strength of the halogens decreases down the group.

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………….. [2]

(ii) Based on your knowledge of the trend in the reactivity of Group VII, suggest a possible reason for the decreasing oxidising strength of halogens down the group.

…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………….. [1]

(d) Vanadium is transition metal that can exhibit a total of four different valencies.

Suggest the formula of a product formed when vanadium reacts with astatine.

……………………………………………………………………………………… [1]

(e) Zinc is a special transition metal.

(i) State one property of zinc which is not typical of a transition metal.

………………………………………………………………………………… [1]

(ii) Zinc forms an oxide which is said to be amphoteric.

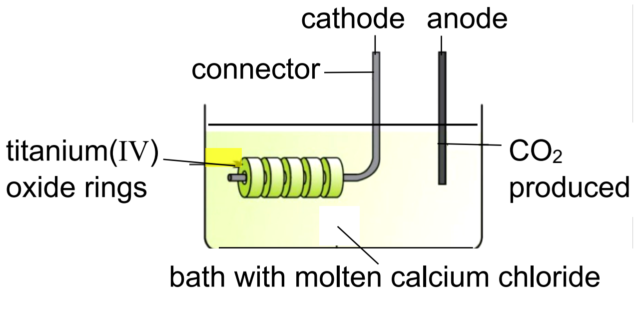
Explain why zinc oxide is classed as an amphoteric oxide.

………………………………………………………………………………….. [1]

[Total: 8]

Either

11 The diagram below shows a new process that uses electrolysis for the direct reduction of solid titanium(IV) oxide (TiO_2) to extract titanium metal. Titanium has many desirable properties. It is light, strong and corrosion-resistant. Its use has been restructured because of the high processing cost of current extraction methods.



A voltage is set up between the cathode and anode. The titanium(IV) oxide gains electrons and releases oxide ions, which dissolve into the molten calcium chloride bath leaving pure solid titanium metal at the cathode. At the same time, oxide ions are discharged at the anode to form oxygen gas which then reacts with the carbon anode to form carbon dioxide. The process takes place between 900 °C and 1100 °C.

(a) Write the ionic equation, with state symbols, for the reaction occurring at the cathode.

.... [2]

(b) Suggest why the electrolysis cell needs to be operated at a temperature of between 900 °C to 1100 °C?

....

.... [1]

(c) What is the purpose of the molten calcium chloride bath?

....

.... [1]

(d) Write the ionic equation, with state symbols, for the formation of oxygen gas at the anode.

.... [2]

(e) In an industrial process, 4.8 tonnes of the titanium(IV) oxide rings was used.

Calculate the maximum mass of titanium metal that can be extracted.

maximum mass of titanium metal = ... tonnes [2]

(f) At the start of the electrolysis, it was noticed that the gas formed was not colourless.

Name this gas and explain why it was formed initially.

....

....

.... [2]

[Total: 10]

OR

12 Coal-burning power stations produce sulfur dioxide and oxides of nitrogen. The two gases cause acid rain.

(a) Nitric oxide, NO, is formed in a power station when nitrogen and oxygen react.

Write the equation for this reaction.

………………………………………………………………………………………… [1]

(b) Many coal burning power stations are now fitted with a flue gas desulfurisation plant which removes sulfur dioxide and nitrogen dioxide from the gaseous emissions.

In a flue gas desulfurisation plant, powdered calcium carbonate reacts with sulfur dioxide as shown below.

$$SO_2(g) + CaCO_3(s) \rightarrow CaSO_3(s) + CO_2(g)$$

(i) State the nature of calcium carbonate which enables it to react with sulfur dioxide.

…………………………………………………………………………………….. [1]

(ii) Explain why the calcium carbonate used is in powdered form.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(iii) Calculate the volume of sulfur dioxide that can be removed with 20 kg of calcium carbonate which contains 10% impurities.

volume of sulfur dioxide = …………….. dm^3 [2]

(iv) State a chemical test for sulfur dioxide.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(c) In the air, sulfur dioxide reacts with nitrogen dioxide forming sulfur trioxide.

The reaction that takes place are shown in the equation.

reaction 1 $SO_2 + NO_2 \rightarrow SO_3 + NO$

reaction 2 $2NO + O_2 \rightarrow 2NO_2$

(i) In which reaction, 1 or 2, is nitrogen reduced?

Explain your answer in terms of oxidation states.

....

....

....

.... [2]

(ii) Nitrogen monoxide is also an atmospheric pollutant. It is found in car exhaust. It is removed from car emissions by the catalytic converter in the car. Nitrogen monoxide reacts with carbon monoxide to produce a mixture of two gases.

Write a chemical equation for this reaction.

.... [1]

(iii) While the catalytic converter can help to remove nitrogen monoxide and carbon monoxide from the car exhaust, explain why the gases released by the converter could still harm the environment.

....

[1]

....

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Class/ Index Number	Centre Number/ 'O' Level Index Number	Name
/	/	

新加坡海星中学

MARIS STELLA HIGH SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

CHEMISTRY **6092/02**

Paper 2

17 August 2022
1 hour 45 minutes
(Total duration for both section A and B)

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number, Centre number, O level index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

This is Section A of the paper.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper (sections A and B) is 80.
The use of an approved scientific calculator is expected, where appropriate.
A copy of the Periodic Table is printed on the last page of Section B.

At the end of the examination, hand in the following separately:
(1) Section A
(2) Section B

For Examiner's Use	
Section A	50
Section B	30
Total	80

This document consists of 13 printed pages.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Select substances from the list to answer the following questions.

ammonia

calcium hydroxide

barium chloride

copper(II) oxide

carbon

silicon dioxide

zinc

You may use each substance once, more than once or not at all.

(a) Which substance is added to soil to increase the pH?

.... [1]

(b) Which substance reacts with aqueous copper(II) sulfate to form copper?

.... [1]

(c) Which substance is used as a catalyst in cracking?

.... [1]

(d) Which substance is displaced from its salts in alkaline conditions?

.... [1]

(e) Which substance produces a precipitate on mixing with dilute sulfuric acid?

.... [1]

(f) Which substance turns from black to red brown when reacted with hydrogen gas?

.... [1]

[Total: 6]

A2 **(a)** The table shows the information about preparation of different solid salts.

Complete the table by filling in the missing information. Include state symbols with any formulae.

formula of salt	formulae of reagents used	key steps involved
$CuCl_2$(s)	……………………………… HCl(aq)	1. addition of excess solid to acid 2. …………………………………… 3. evaporation and crystallization
………………	NH_3(aq) HNO_3(aq)	1. …………………………………... 2. evaporation and crystallization
$CaCO_3$(s)	……………………………. ……………………………	1. …………………………………….. 2. ……………………………………..

[4]

(b) An unlabelled bottle of a colourless solution was found. Johnny was told that the bottle contains either sodium carbonate or sodium sulfate.

To determine the identity of the solution, Johnny added 2 cm^3 of aqueous barium nitrate to a sample of the solution. A white precipitate was observed.
Johnny concluded that the bottle contains sodium sulfate.

Do you agree with Johnny? Explain your reasoning.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………… [2]

[Total: 6]

A3 Underground steel pipes are used to transport crude oil over long distances.

The pipes rust easily because they contain iron and are surrounded by water in the soil.

(a) Fig. 3.1 shows one method of protecting an underground steel pipe from rusting.

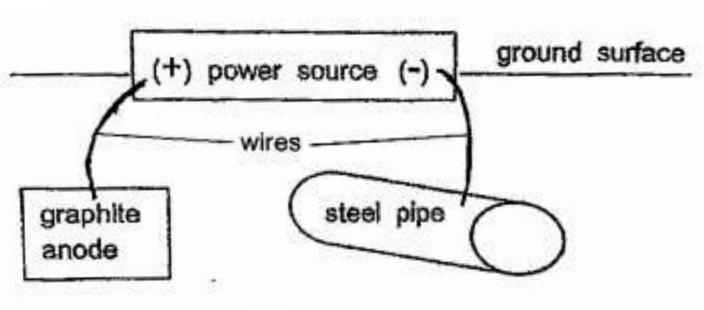


Fig. 3.1

(i) With reference to the diagram, explain briefly how the steel pipe is prevented from rusting.

………………………………………………………………………………………..

……………………………………………………………………………………... [1]

(ii) An alternative method of rust prevention is to attach a magnesium block to the steel pipe. Explain how the alternative method works.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

……………………………………………………………………………………... [2]

(iii) Write the ionic half equation to show what happens to magnesium in your answer to **a(ii)**.

……………………………………………………………………………………... [1]

(b) Samples of iron were placed in an aqueous solution having different pH values. Table 3.1 shows how the speed of rusting of iron varies with the pH of the solutions.

Table 3.1

speed of rusting (cm per year)	0.043	0.029	0.012	0.010	0.010	0.010	0.009	0.006
pH	2	3	4	5	6	8	10	12

Use the information from the table, describe how the pH affects the speed of rusting of iron.

....

....

....

.... [2]

[Total: 6]

A4 Vanadium (V) oxide, V_2O_5, undergoes various types of chemical reactions. Three of such reactions are represented in the following chemical equations.

equation 1 $V_2O_5\,(s) + 2HNO_3\,(aq) \rightarrow 2VO_2NO_3\,(aq) + H_2O\,(l)$

equation 2 $V_2O_5\,(s) + SO_2\,(g) \rightarrow V_2O_4\,(s) + SO_3\,(g)$

equation 3 $V_2O_5\,(s) + 6NaOH\,(aq) \rightarrow 2Na_3VO_4\,(aq) + 3H_2O\,(l)$

The following statements are based on reaction 1, 2 and 3.

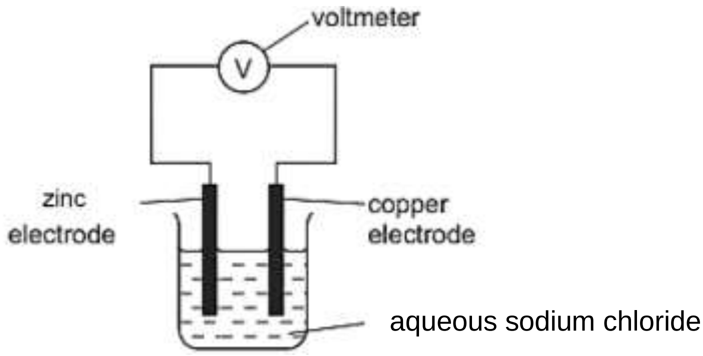
Put a tick (✓) in **one** box in each row to show which statements are **true** and which are **false.**

	true	**false**
vanadium (V) oxide is an amphoteric oxide.		
the reaction shown in equation 2 is a redox reaction.		

[2]

[Total: 2]

A5 The diagram shows a simple cell.



(a) Write the ionic half equations at

(i) the positive electrode: ………………………..……………………………… [1]

(ii) the negative electrode: ………………………………………………………… [1]

(b) The order of reactivity of a few metals can be established by measuring the voltage of the following simple cell.

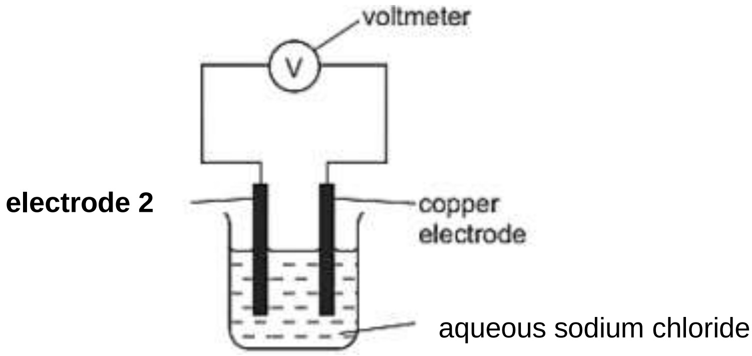


Table 5.1 shows the voltages of the simple cell when the following metals were used as electrode 2.

Table 5.1

cell	electrode 2	Voltage / V
1	cadmium	0.74
2	iron	0.78
3	tin	0.48
4	zinc	1.10
5	metal X	- 0.52

(i) Use the information in Table 5.1 to deduce the descending order of reactivity of the five metals (cadmium, iron, tin, zinc and copper).

…………………………………………………………………………………………

……………………………………………………………………………………..… [1]

(ii) Explain your answer to **b(i)**.

....

.... [1]

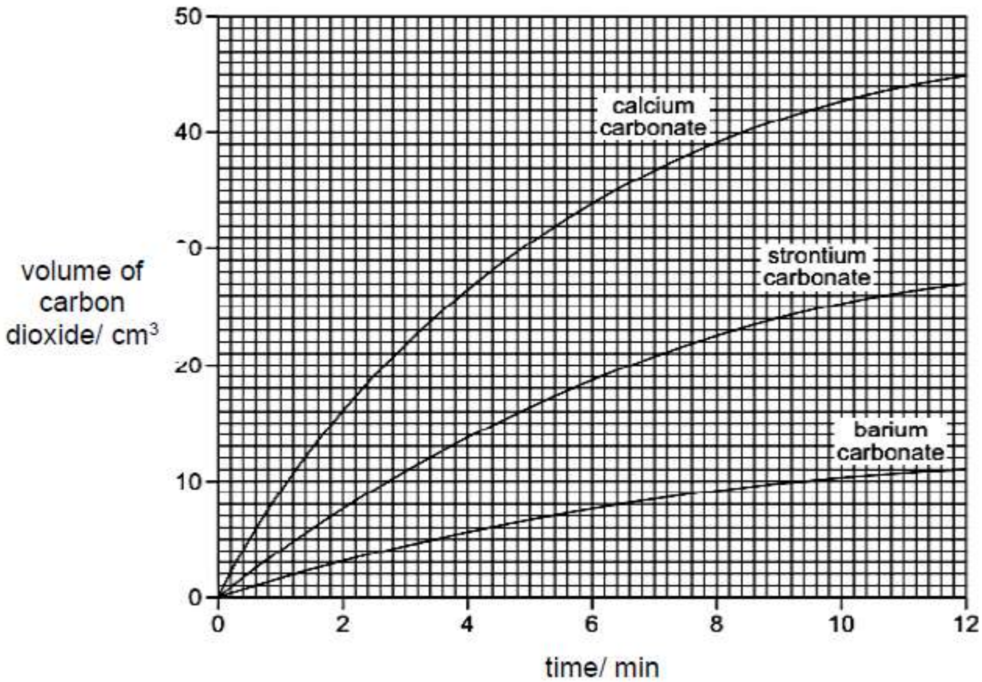
(iii) Suggest a reason to explain why the voltage of cell 5 is a negative value.

....

.... [1]

(c) The order of reactivity of Group II metals can also be established using thermal decomposition of metal carbonates.

The graph shows the volume of carbon dioxide released when equal number of moles of three Group II metal carbonates were heated.



(i) Use the information from the graph to deduce the order of reactivity of the three metals, calcium, strontium and barium. Explain your reasoning.

....

....

....

....

....

....

.... [3]

(ii) Calculate the mass of strontium oxide produced when 50 tonnes of strontium carbonate is completely decomposed.
(1 tonne = 1000 kg)

mass of strontium oxide produced = ………………. tonnes [3]

[Total: 11]

A6 Two main pollutant gases are carbon monoxide and oxides of nitrogen.

(a) State **one** harmful effect of **one** of these pollutant gases.

……………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(b) Scientists have found out that nitrogen monoxide is involved in the formation of sulfur trioxide in two-steps.

step 1: $2NO + O_2 \rightarrow 2NO_2$

step 2: $NO_2 + SO_2 \rightarrow NO + SO_3$

(i) Use the equations to write the overall equation for the formation of sulfur trioxide. Show your working.

[2]

(ii) Explain how the reactions above suggest that nitrogen monoxide is acting as a catalyst.

……………………………………………………………………………………………

………………………………………………………………………………………….. [1]

(c) In an attempt to cut down carbon dioxide emissions during the burning of fossil fuels to produce electricity, a city decided to build more power stations burning natural gas instead of coal.

Table 6.1 shows some information about each type of power station.

Table 6.1

type of power station	energy change of combustion (kJ / mol)	amount of by-product produced per MJ of electrical energy / g (1 MJ = 10^6 J)	
		SO_2	NO_2
coal	−890	0.31	0.64
natural gas	−394	0.0015	0.11

Use the information in Table 6.1 to suggest **one** advantage and **one** disadvantage of using a natural gas power.

advantage: ……….…………………..…………………………………….……………………..

…..…………………………………………………………………………………………….

disadvantage: …………..………………………………………………….…………………..

…...…………………………………………………………………………………….. [2]

(d) Although hydrogen releases less than half the energy than methane per unit volume, many people believe that hydrogen is a better alternative fuel compared to methane.

Suggest why this is so.

…..…………………………………………………………………………….……………….

…..…………………………………………………………………………………………….

…..…………………………………………………………………………………………….

…..…………………………………………………………………………….……………….

…..…………………………………………………………………………………….. [2]

[Total: 8]

A7 **(a)** Nickel and nickel(II) nitrate conduct electricity differently.

(i) Describe **two differences** in the electrical conductivity between nickel and nickel(II) nitrate.

…………………………………………………………………………………………....

…………………………………………………………………………………………....

…………………………………………………………………………………………....

…………………………………………………………………………………………....

……………………………………………………………………………………….. [2]

(ii) Conduction of electricity has a different effect on nickel and nickel(II) nitrate. Describe this difference.

…………………………………………………………………………………………....

……………………………………………………………………………………….. [1]

(b) Nickel can be used as a catalyst in chemical reactions.
Explain, in terms of collision theory, how nickel acts as a catalyst.

…………………………………………………………………………………………....

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…………………………………………………………………………………………

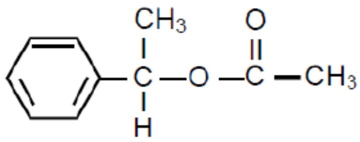
…………………………………………………………………………………………

……………………………………………………………………………………….. [2]

[Total: 5]

A8 Perfumes usually contain three groups of compounds called the top note, the middle note and the base note.

(a) Top note consists of small, light molecules that evaporate quickly.
An example of a top note compound is shown below:



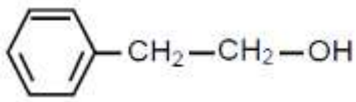
Draw the structural formula of the alcohol and carboxylic acid used to make the top note compound.

alcohol	carboxylic acid

[2]

(b) The middle note compounds vaporise less rapidly than the top note compounds.
A typical compound of the middle note is 2-phenylethanol.

The structure of 2-phenylethanol is shown below:



Describe a chemical test which would distinguish the top note compound from the middle note compound.

....

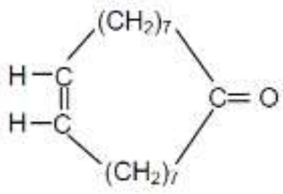
....

....

....

.... [2]

(c) The base note compound of a perfume has a long-lasting odour which stays with the user. An example of a base note compound is shown below.



Iodine reacts similarly as bromine with unsaturated compounds.

The iodine value is a measure of how unsaturated a compound is. It is based on the mass, in grams, of iodine that reacts with 100 g of the compound.

Given that the relative molecular mass of the base note compound and iodine are 250 and 254 respectively, calculate the iodine value for the base note compound.

[2]

[Total: 6]

END OF SECTION A

Class/ Index Number	Centre Number/ 'O' Level Index Number	Name
/	/	

新加坡海星中学

MARIS STELLA HIGH SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

CHEMISTRY **6092/02**

Paper 2

17 August 2022

1 hour 45 minutes

(Total duration for both section A and B)

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number, Centre number, O level index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

This is Section B of the paper.
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.
For Question B11, circle your choice of question ('either' or 'or').

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 12.
The total number of marks for this paper (sections A and B) is 80.
The use of an approved scientific calculator is expected, where appropriate.

At the end of the examination, hand in the following separately:
(1) Section A
(2) Section B

For Examiner's Use	
Question B9	12
Question B10	8
Question B11 Either / Or	10
Total	30

This document consists of 12 printed pages.

Section B

Answer **three** questions.

The last question is in the form of an **either/or** and only one of the alternatives should be attempted.

B9 Electronegativity and chemical bonding

Electronegativity

Electronegativity is the strength an atom has to attract a bonding pair of electrons to itself. Electronegativity gives information about what will happen to the bonding pair of electrons when two atoms bond.

When a chlorine atom covalently bonds to another chlorine atom, the bonding pair of electrons is shared equally between the two atoms as they have the same electronegativity. The electrons that comprises the covalent bond is located halfway between the two atoms.

However, when two atoms of different elements are involved in a bond, the two positively charged nuclei will attract the bonding pair of electrons to different degrees. The end result is that the electron pair is shifted toward one atom. The larger the value of the electronegativity, the greater the atom's strength to attract a bonding pair of electrons.

Fig. 9.1 shows the electronegativity values of the various elements.

1 H 2.1																
3 Li 1.0	4 Be 1.5											5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0
11 Na 0.9	12 Mg 1.2											13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0
19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.9	28 Ni 1.9	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br
37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5
55 Cs 0.7	56 Ba 0.9	57 La 1.1	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.9	83 Bi 1.9	84 Po 2.0	85 At 2.2
87 Fr 0.7	88 Ra 0.9	89 Ac 1.1														

Fig. 9.1

Electronegativity difference

The electronegativity difference, ΔX, between two atoms can be calculated as follows:

$$\Delta X = X_A - X_B$$

where

X_A = electronegativity value of atom with the larger electronegativity value

X_B = electronegativity value of atom with the smaller electronegativity value

The electronegativity difference provides another way of predicting the type of bond that will form between two elements, as indicated in Table 9.1.

Table 9.1

electronegativity difference	type of bond formed
0.0 to 0.2	nonpolar covalent
0.3 to 1.4	polar covalent
>1.5	ionic

A bond in which the electron pair is equally shared is called a nonpolar covalent bond. This occurs when the two atoms involved in the bond are the same or having very small difference in the electronegativities of the atoms involved in the bond.

A bond in which the electron pair is shifted toward one atom is called a polar covalent bond. The atom that attracts the bonding pair of electrons more strongly takes on a slight (partial) negative charge due to the electron pair located nearer to it, while the other atom taking on a partial positive charge due to the electron pair being shifted further away from it.

The larger the difference in the electronegativities, the more negative and positive the atoms become. When this difference reaches an extreme, such as in the case of sodium chloride (NaC*l*), then ionic bonding will occur.

References: https://www.dummies.com/education/science/chemistry/electronegativity-and-polar-covalent-bonding/

(a) Using the information from Fig. 9.1, describe the general trend in the electronegativity values **across a Period** and **down a Group**.

....

....

....

.... [2]

(b) Suggest an explanation for the trend **down a Group** described in **(a)**.

....

....

.... [1]

(c) Using the information from Fig. 9.1, predict the electronegativity value for bromine.

.... [1]

(d) Using the information from Fig. 9.1 and Table 9.1, explain

(i) why carbon monoxide molecule contains polar covalent bond;

....

....

.... [1]

(ii) which atom in the carbon monoxide molecule takes on a slightly negative charge.

....

....

....

....

....

....

....

.... [3]

(e) Suggest one compound, other than sodium chloride, that contains ionic bond. Explain your reasoning in terms of electronegativity values of the atoms in the compound.

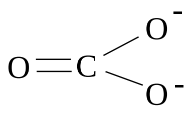
....

....

....

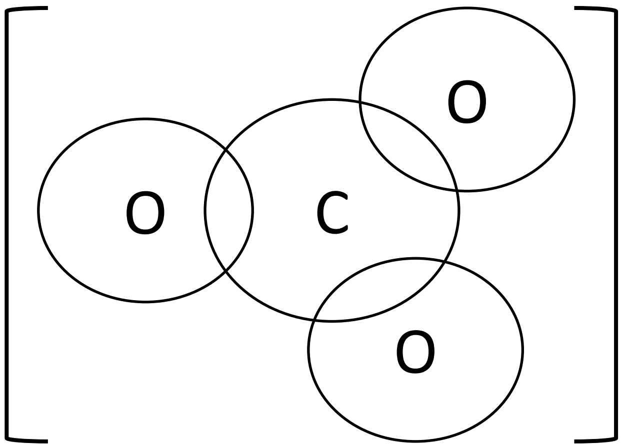
.... [2]

(f) A polyatomic ion is an ion composed of more than one atom covalently bonded. One example of a polyatomic ion is carbonate ion. The carbonate ion has the structural formula as shown.



The negative charge on each single-bonded oxygen atom shows that an electron has been gained by the oxygen atom.

Hence, complete the dot-and-cross diagram for the carbonate ion, CO_3^{2-}, below showing only the valence electrons.



[2]

[Total: 12]

B10 An oxyacid is an acid that contains an oxygen atom bonded to a hydrogen atom and at least one other element. Sulfuric acid (H_2SO_4), phosphoric acid (H_3PO_4) and nitric acid (HNO_3) are all oxyacids.

Chlorine forms several types of oxyacids. Table 10.1 shows some properties of oxyacids of chlorine that have the same concentration.

Table 10.1

name of acid	chemical formula	reaction with magnesium
perchloric acid	$HClO_4$	very vigorous
hypochlorous acid	$HOCl$	only a few bubbles seen
chloric acid	$HClO_3$	vigorous
chlorous acid	$HClO_2$	reacts readily

(a) **(i)** Write the formulae of the ions in perchloric acid.

.... [1]

(ii) Arrange, in ascending order, the strength of these acids.

....

.... [1]

(b) Iodine also form an oxyacid known as iodic acid, with the formula HIO_3.
Iodic acid is produced when iodine is mixed with water and chlorine, as shown in the equation below.

$$I_2 + 6H_2O + 5Cl_2 \rightarrow 2HIO_3 + 10HCl$$

What is the oxidising agent in this reaction? Explain your answer.

....

....

....

.... [2]

(c) Carboxylic acids are also a type of oxyacid.

In an experiment, a solution containing 15.4 g of an unknown carboxylic acid, $C_xH_yCO_2H$ is reacted with 8.75 g of magnesium carbonate.

$$2C_xH_yCO_2H + MgCO_3 \rightarrow (C_xH_yCO_2)_2Mg + H_2O + CO_2$$

Calculate the relative formula mass of the carboxylic acid and deduce its identity.

[4]

[Total: 8]

EITHER

B11 A student carried out an experiment to investigate the reaction between bromide ions and chlorine gas.

She bubbled excess chlorine gas through dilute aqueous potassium bromide. She took samples of the reaction mixture every 30s, measured the colour intensity of each sample using a colorimeter until there was no change in the reading.

A colorimeter measures the intensity of light that is absorbed by a coloured solution. The darker the colour of the solution, the more light is absorbed and the higher the absorbance reading on the colorimeter.

(a) Write an ionic equation, with state symbols, for the reaction between chlorine gas and bromide ions.

.... [1]

(b) Explain why the absorbance reading increases as the reaction takes place.

....

....

....

....

.... [2]

(c) The student carried out three more experiments to determine the time taken for each reaction to finish. She used the same volume of aqueous potassium bromide each time. She recorded the time taken and the absorbance reading at the end of each reaction in a table.

Table 11.1

experiment	time taken for the reaction to complete / min	absorbance reading at the end of reaction
1	5.00	0.8
2	2.50	0.9
3	6.00	0.5
4	6.00	0.9

(i) Which experiment used aqueous potassium bromide of a lower concentration than in experiment 1?

.... [1]

(ii) Which two experiments used aqueous potassium bromide of the same concentration but at different temperatures?

.... [1]

(iii) Describe and explain, in terms of collision theory, the effect of temperature on rate of reaction.

....

....

....

....

....

.... [3]

(d) The student repeated the experiment using chlorine and aqueous potassium iodide of the same concentration. He compared the absorbance reading with that in experiment 1.

Predict the change in the absorbance reading (*increase, remain the same or decrease*).
Explain your reasoning.

....

....

....

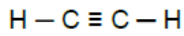
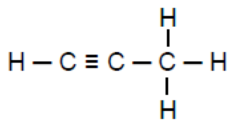
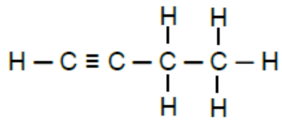
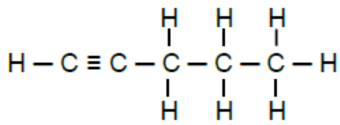
.... [2]

[Total: 10]

OR

B11 **(a)** Alkynes are a homologous series of organic compounds.
Table 11.2 shows the names and structures of the first four members of alkynes.

Table 11.2

n	name of alkyne	structure of alkyne
2	ethyne	
3	propyne	
4	butyne	
5	pentyne	

(i) Use the information in the table to state the general formula and functional group of alkynes.

general formula

…………………………………………………………………………………………… [1]

functional group

…………………………………………………………………………………………… [1]

(ii) Explain, in terms of bonding and structure, the trend in the boiling points of the alkynes down the series.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(iii) Alkynes undergo addition reaction. Explain why.

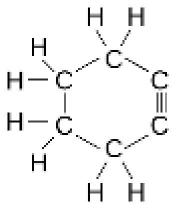
……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

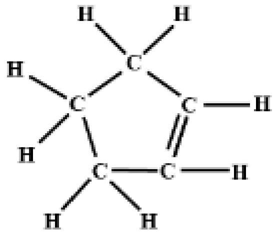
(iv) Predict the name of the product formed by the catalytic reaction between butyne and excess hydrogen.

……..……………………………………………………………………………….… [1]

(v) The structure of two organic compounds (**X** and **Y**) are shown below.



compound **X**



compound **Y**

Are these compounds isomers of pentyne? Explain your reasoning.

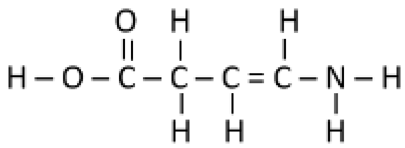
…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……..…...…..…………………………………………………………………….… [2]

(b) The organic compound, trans-4-aminocrotonic acid (TACA) is currently used in pharmacology studies. The structure of TACA is shown below.



TACA undergoes condensation polymerisation to form polymer **Z**.

(i) Draw the full structural formula of the repeat unit of **Z**.

[1]

(ii) Name another polymer that contains the same linkage as **Z**.

……………………………………………………………………………………….. [1]

[Total: 10]

Reference: OR B11(a)(v), https://www.toppr.com/ask/question/number-of-carbon-and-hydrogen-in-cyclopentene-are/

END OF SECTION B

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Section A

Answer **all** questions in this section in the spaces provided.

A1 The equations **A**, **B**, **C**, **D**, **E** and **F** show some reactions.

A $CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$

B $F_2\ (g) + 2NaI\ (aq) \rightarrow 2NaF\ (aq) + I_2\ (aq)$

C $H_2O\ (g) \rightarrow 2H\ (g) + O\ (g)$

D $NH_3\ (aq) + HCOOH\ (aq) \rightarrow HCOONH_4\ (aq)$

E $Pb(NO_3)_2\ (aq) + 2HCl\ (aq) \rightarrow PbCl_2\ (s) + 2HNO_3\ (aq)$

F $SiO_2\ (s) + CaO\ (s) \rightarrow CaSiO_3\ (l)$

Use the letters **A**, **B**, **C**, **D**, **E** and **F** to answer the questions.

Each letter may be used once, more than once or not at all.

(a) Which equation shows a precipitation reaction?

.... [1]

(b) Which equation shows a displacement reaction?

.... [1]

(c) Which **two** equations show endothermic reactions?

.... [1]

(d) Which **two** equations remove acidic impurities in the Blast furnace?

.... [1]

[Total: 4]

A2 The model of the nuclear atom was first proposed by Ernest Rutherford. He developed this model based on results obtained from an experiment using gold foil.

(a) Complete the table with information for the two particles in an atom of ^{197}Au.

particle	relative mass	relative charge	location within atom	total number in an atom of ^{197}Au
electron	approx. 0.0005	1-		79
neutron			nucleus	

[2]

(b) A sample of gold found in the earth consists of only one isotope.

(i) State what is meant by the term *isotope*.

………………………………………………………………………………………….

……………………………………………………………………………………..….. [1]

(ii) A different sample of gold contains more than one isotope.

Explain why this different sample of gold has the same chemical properties as the sample found in the earth.

………………………………………………………………………………………….

……………………………………………………………………………………..….. [1]

(c) Tumbaga is an alloy obtained by adding gold to copper. It is harder than copper.

Explain why tumbaga is harder than copper.

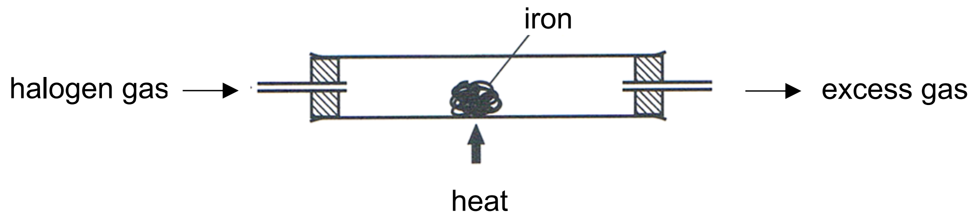
…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………...…………………………………………………………………… [2]

[Total: 6]

A3 The set-up below is used during the reaction between iron and excess halogens, X, Y and Z.



The observations of the experiments are shown in the table below.

halogen	observation
X	Iron wool glows less brightly. Brown solids are formed in the reacting tube.
Y	Iron wool burns brightly and vigorously. Brown solids are formed in the reacting tube.
Z	Iron wool glows brightly and less vigorously. Brown solids are formed in the reacting tube.

(a) Arrange the halogens, X, Y and Z, in order of increasing reactivity.

.... [1]

(b) Brown solids are halides of iron(III).

What is the chemical formula of the brown solid when halogen Y reacts with iron?

.... [1]

(c) Halogen Z is a liquid at room temperature.

In which period is halogen Z most likely found in the Periodic Table?

.... [1]

(d) When a halogen reacts with iron, the halogen acts as an oxidising agent.

Explain, in terms of electrons, the trend in oxidising power down Group VII.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………..… [2]

[Total: 5]

A4 **(a)** Household bleach contains sodium chlorate(I), NaC*l*O, as its active ingredient.

The chlorate ion has an overall charge of 1-. It contains a covalent bond between the oxygen and chlorine atoms. Both atoms in the ion have a stable octet electron configuration.

Draw a 'dot-and-cross' diagram to show the arrangement of outer shell electrons in sodium chlorate(I), NaC*l*O.

[3]

(b) A metallic element, M, has the following properties.

- less dense than water
- soft
- occurs naturally as its chloride, formula MCl
- the oxide of M reacts with water to form a soluble hydroxide

(i) Suggest how metal M can be extracted from its compounds.

Explain your answer.

…………………………………………………………………………………………..

………………………………………………………………………………….… [2]

(ii) 6.72 g of MCl contains 1.42 g of chlorine.

Calculate the number of moles of chlorine atoms in the sample, and hence suggest a value for the relative atomic mass, A_r, of M.

[3]

[Total: 8]

A5 A student prepares equal volumes of three acid solutions in small beakers. He then measures the electrical conductivity of each solution with a circuit containing an ammeter. The results are shown in the table below.

beaker	solution	ammeter reading / mA
I	0.100 mol/dm^3 nitric acid	270
II	0.100 mol/dm^3 ethanoic acid	4
III	0.100 mol/dm^3 sulfuric acid	?

(a) Given the same concentration, explain why the conductivity of the solution in beaker I is higher than that of the solution in beaker II.

....

....

.... [2]

(b) Predict the ammeter reading for the solution in beaker III.

Explain your answer.

....

....

.... [2]

(c) The student added aqueous calcium hydroxide to beaker III and the reading on the ammeter decreases.

Explain why.

....

....

.... [2]

[Total: 6]

A6 **(a)** One of the first buses to use hydrogen as a fuel was operated in Germany in 1996.

(i) Describe **one** advantage and **one** disadvantage of using hydrogen as a fuel rather than petrol.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(ii) Some buses use hydrogen to generate electrical energy from a fuel cell. The diagram of a typical fuel cell is shown in Fig. 6.1.

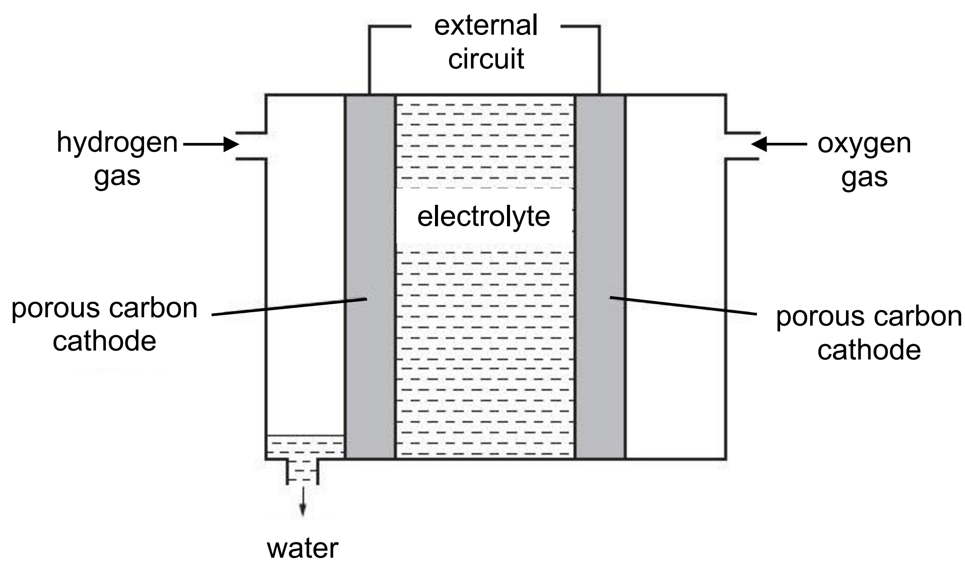


Fig. 6.1

The equation for the reaction at the anode is shown below.

$H_2 (g) + 2OH^- (aq) \rightarrow 2H_2O (l) + 2e^-$

What type of reaction is this? Explain your answer.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(iii) In some fuel cells, an acidic electrolyte is used. The ionic half-equations at the respective electrodes are given below:

anode: $H_2(g) \rightarrow 2H^+(aq) + 2e^-$

cathode: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

Write an overall equation, with state symbols, for the reaction occurring in this fuel cell.

……………………………………………………………………………………….…. [1]

(b) An electric current can also be generated by a simple electrochemical cell such as the one shown in Fig. 6.2.

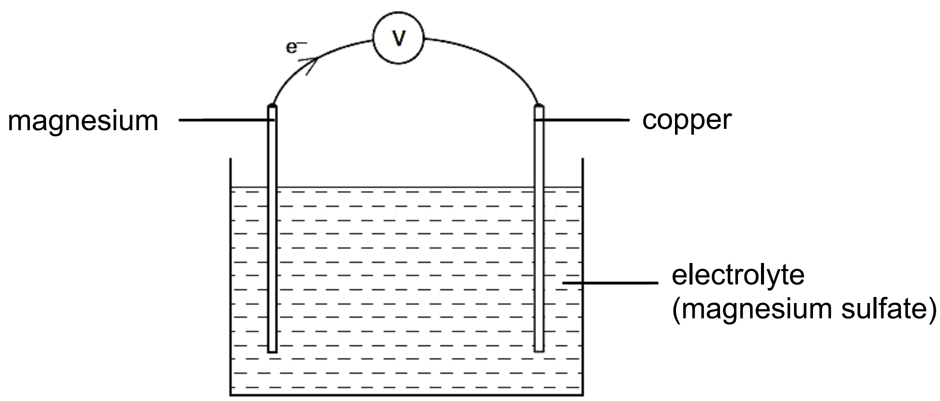


Fig. 6.2

(i) Explain why the flow of electrons is in the direction shown in Fig. 6.2.

……………………………………………………………………………………….

……………………………………………………………………………………….…. [1]

(ii) Suggest why aqueous silver nitrate would **not** be a good electrolyte to be used in this cell.

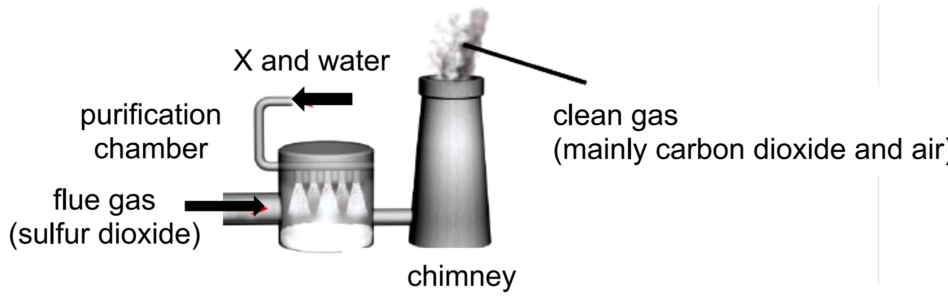
……………………………………………………………………………………….

……………………………………………………………………………………….…. [2]

[Total: 8]

A7 **(a)** Flue gas produced from coal-burning power stations contains sulfur dioxide and oxides of nitrogen. These two gases cause acid rain.

Sulfur dioxide can be removed from the flue gases by several methods. One method uses a 'scrubber' that contains wet compound X.



(i) Name compound X that is added to the purification chamber to remove sulfur dioxide.

………………………………………………………………………………………… [1]

(ii) Write a balanced chemical equation to show how compound X named in **(a)(i)** removes sulfur dioxide.

………………………………………………………………………………………… [1]

(iii) In flue gas, nitrogen monoxide is the main component in the oxides of nitrogen produced.

Suggest how nitrogen monoxide can cause acid rain even though it is a neutral oxide.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(iv) In order to remove the effects of acid rain, a farmer has been advised to treat the soil with calcium compounds to reduce the acidity. The table below gives the solubility of some calcium compounds.

calcium compound	calcium hydroxide	calcium oxide	calcium carbonate
solubility in water (g per 100 cm^3 of water)	0.173	immediately reacts with water to form an alkaline solution	6.17×10^{-4}

Using the information in the table, suggest which calcium compound is **least** effective at reducing acidity in soil.

……………………………………………………………………………………… [1]

(b) Ozone, O_3, acts as a shield to filter out harmful ultraviolet radiation from the sun. Chlorofluorocarbons (CFCs) release chlorine atoms at the upper atmosphere. The chlorine atoms damage the ozone layer in a two-step reaction.

step 1: $Cl + O_3 \rightarrow ClO + O_2$

step 2: $ClO + O_3 \rightarrow Cl + 2O_2$

Use the above equations to explain why small amounts of CFCs can destroy large amounts of ozone molecules.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

[Total: 7]

A8 Table 8.1 summarises some features of the two methods that can be used to produce ethanol.

Table 8.1

	fermentation	hydration
raw material	glucose from plants	ethene from crude oil
conditions used	1. ………………………....... 2. ………………………....... 3. ……………………….......	temperature of 300°C, pressure of 60 – 70 atm catalyst of phosphoric acid
atom economy	**w %**	100 %

(a) Complete Table 8.1 on the conditions used for fermentation. [1]

(b) Write the chemical equation for the fermentation of glucose.

……………………………………………………………………………………...… [1]

(c) State how ethanol produced from fermentation can be obtained from the liquid mixture.

……………………………………………………………………………………...… [1]

(d) The atom economy of a chemical reaction can be defined as a measure of the amount of starting materials that become useful products.

A method of calculation is shown below.

$$\text{Atom economy} = \frac{M_r \text{ of useful product}}{\text{total } M_r \text{ of all products}} \times 100\ \%$$

Calculate the atom economy of fermentation, **w %**.

[1]

(e) Chemist X strongly encourages the method of hydration over fermentation.

Chemist Y, however, argues that fermentation is better than hydration.

Explain why **both** views of Chemists X and Y are correct.

Chemist X: ……………………………………………………………………………………

……………………………………………………………………………………………………

Chemist Y: ……………………………………………………………………………………

…………………………………………………………………………………………………… [2]

[Total: 6]

Section B

Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 The rate of a reaction can be determined experimentally using an initial rate method.

Initial rate method

The initial rate is used to measure the rate of reaction before any of the reactants is used up. This is done by measuring the gradient of tangent at time = 0 on a graph of concentration against time. Fig. 8.1 shows how an initial rate can be obtained.

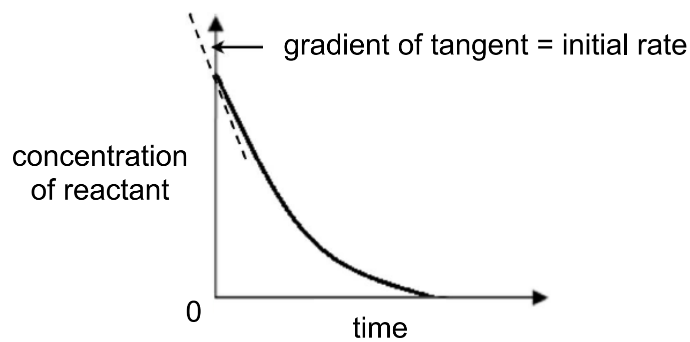


Fig. 8.1

Once the initial rate of reaction is determined, a graph of rate of reaction against concentration of reactant can be plotted. This would give the order of reaction with respect to a particular reactant.

Order of reaction

The order of reaction with respect to a particular reactant shows the relationship between its concentration and the initial rate of the reaction. Fig. 8.2 shows how the graphs look like depending on its order.

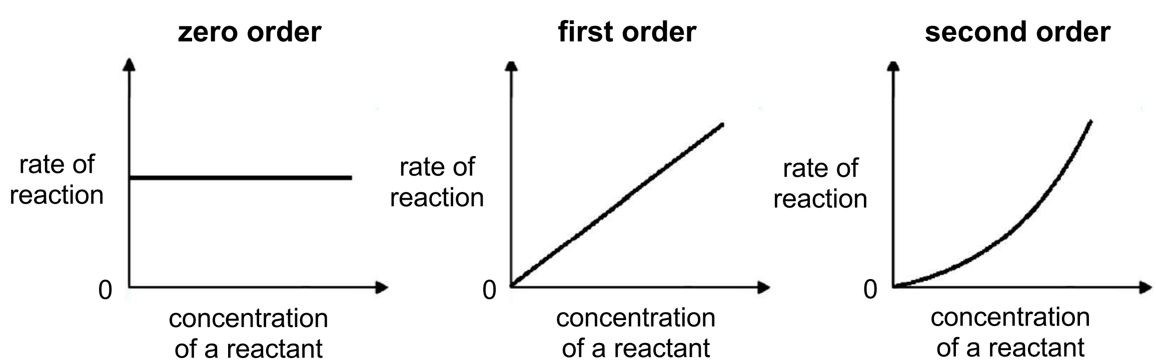


Fig. 8.2

Reaction of propanone with aqueous iodine

Propanone, CH_3COCH_3, and aqueous iodine react together in the presence of sulfuric acid, to form iodopropanone, ICH_2COCH_3. Both propanone and iodopropanone are colourless liquids at room temperature and pressure.

The reaction can be represented by the following equation:

$$CH_3COCH_3(aq) + I_2(aq) \xrightarrow{H^+} ICH_2COCH_3(aq) + H^+(aq) + I^-(aq)$$

The rate of reaction was followed by measuring the concentration of propanone when 0.002 mol/dm^3 of aqueous iodine was used. The results are shown in Fig. 8.3.

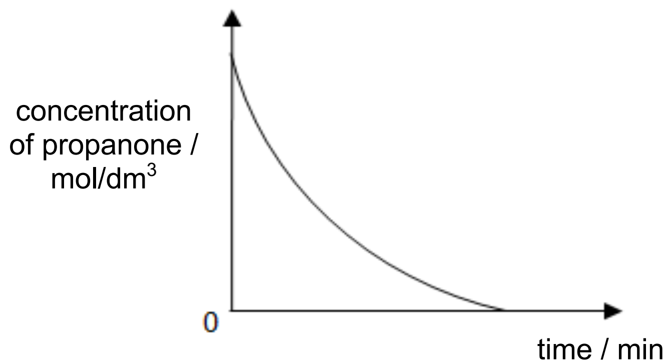


Fig. 8.3

Two sets of experiments were carried out to determine how the concentration of reactants affects the initial rate of reaction.

In **experiment 1**, different concentrations of propanone were reacted with a fixed concentration of aqueous iodine. The results are shown in Table 8.4.

Table 8.4

concentration of CH_3COCH_3 / mol/dm^3	concentration of I_2 / mol/dm^3	initial rate / mol/dm^{3}s
0.4	0.002	1.39×10^{-6}
0.8	0.002	2.78×10^{-6}
1.2	0.002	4.17 x 10–^{6}

In **experiment 2**, different concentrations of aqueous iodine were reacted with a fixed concentration of propanone. The results are shown in Fig. 8.5.

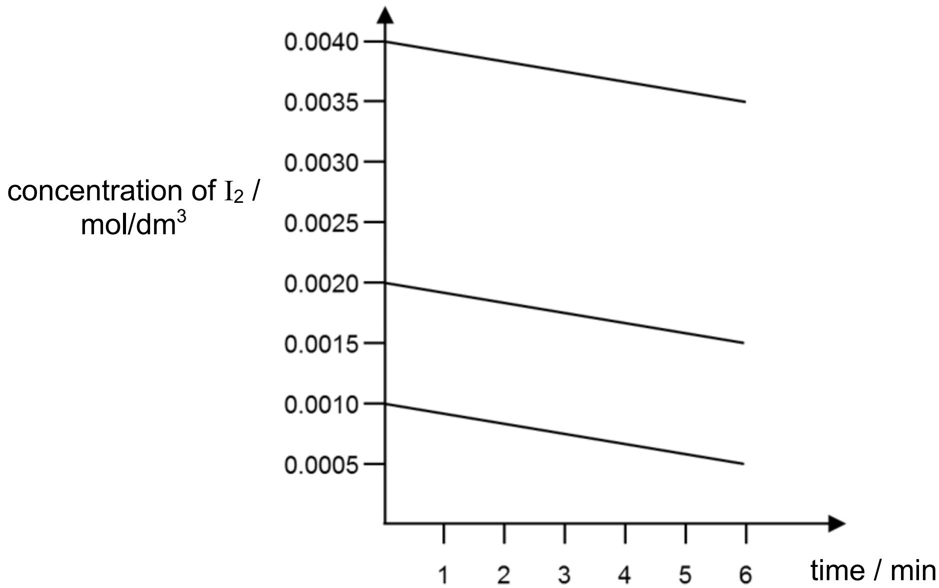


Fig. 8.5

(a) (i) With reference to Fig. 8.3, identify the reactant which is in excess.

Explain your answer.

……………………………………………………………………………………………...

……………………………………………………………………………….………… [2]

(ii) Sketch on Fig. 8.3, the graph you would expect when 0.0040 mol/dm^3 of aqueous iodine is used.
[1]

(b) Describe the change you would expect to see when propanone reacts with aqueous iodine.

……………………………………………………………………………………………….

………………………………………………………………………………………… [1]

(c) (i) Sulfuric acid acts as a catalyst for the reaction between propanone and iodine.

Explain, in terms of collisions and energy, how the addition of sulfuric acid catalyses the reaction between propanone and iodine.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………….………… [3]

(ii) With reference to the given chemical equation, suggest why **only** a small volume of sulfuric acid is required for the reaction between propanone and iodine.

……………………………………………………………………………………...

……………………………………………………………………….………… [1]

(d) Using information in Table 8.4, predict the initial rate when 1.6 mol/dm^3 of propanone, is used in experiment 1.

initial rate ……………………………… mol/dm^{3}s [1]

(e) The following statements were written by a student.

Statement 1: The order of reaction with respect to propanone is zero.
Statement 2: The order of reaction with respect to iodine is also zero.

Do you agree with the statements? Support your answer with relevant evidence.

………………………………………………………………………………………

………………………………………………………………………………………

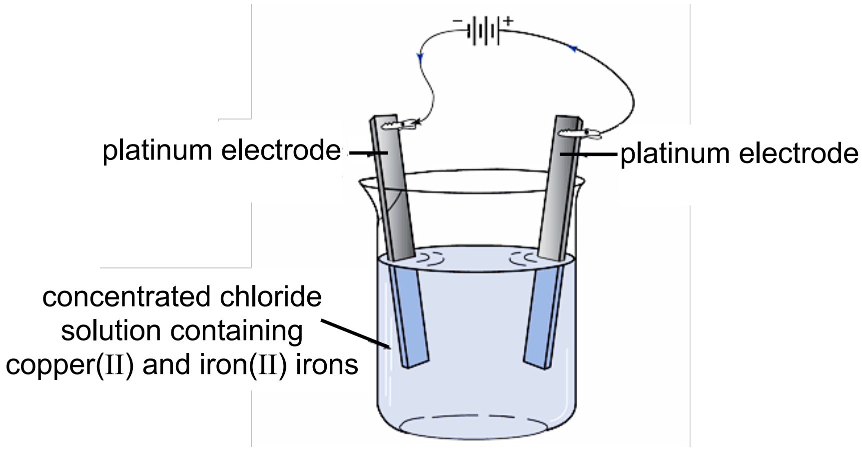
………………………………………………………………………………………

………………………………………………………………………………………

…………………………………………………………………………………..… [3]

[Total: 12]

B10 A concentrated chloride solution containing two metal ions, copper(II) and iron(II), was electrolysed using platinum electrodes.



The observations at different stages were recorded in the table.

stage	observations
1 (after 10 mins)	Bubbles of yellowish-green gas are observed at one of the electrodes while a reddish-brown solid is deposited at the other electrode. The electrolyte remained blue-green in colour.
2 (after 1 hour)	A yellowish-green gas is observed at one of the electrodes while a reddish-brown solid is deposited at the other electrode. The electrolyte became pale green in colour.
3 (after 2 hours)	Bubbles are observed at both electrodes. The gases produced at both electrodes are colourless. The electrolyte became darker green in colour.

(a) Write ionic equations to show the reactions that happen at the anode and cathode in stage 1.

anode

………………………………………………………………………………………………

cathode

…………………………………………………………………………………….... [2]

(b) Explain why the electrolyte became pale green in stage 2.

……………………………………………………………………………………………

…………………………………………………………………………………….… [1]

(c) Identify the two gases that are produced at the two electrodes in stage 3 and state the volume ratio in which they are produced.

	at cathode	at anode
name of gas produced		
volume ratio		

[2]

(d) Explain why the electrolyte became darker green in stage 3.

……………………………………………………………………………………………

…………………………………………………………………………………….… [1]

(e) A few drops of Universal Indicator were added near the **cathode** in stage 3.

State, with a reason, the change in observations that would be made.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………….… [2]

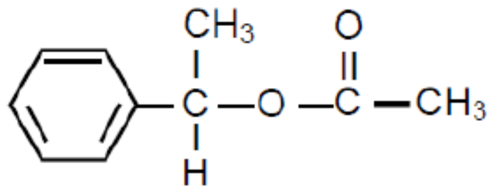
[Total: 8]

EITHER

B11 Perfumes usually contain three groups of compounds called the top note, the middle note and the end note.

(a) Top notes consist of small, light molecules that evaporate quickly. An example of a top note compound is styrallyl acetate as shown below.

Top note:



(i) With reference to the structure of the compound, explain why it is likely to have a pleasant smell.

……………………………………………………………………………………………..

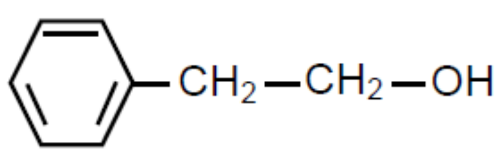
……………………………………………………..………………………………….. [1]

(ii) Draw the structural formula of the alcohol and carboxylic acid used to make styrallyl acetate.

alcohol carboxylic acid [2]

(b) The middle note compounds form vapours less rapidly than the top note compounds. A typical compound of the middle note is 2-phenylethanol. The structure of 2-phenylethanol is shown below.

Middle note:



(i) Describe a chemical test to distinguish between the top note and the middle note compounds.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………..……………………………….. [2]

(ii) Draw the full structural formula and suggest the name of the molecule formed from 2-phenylethanol in the positive test described in **(b)(i)**.

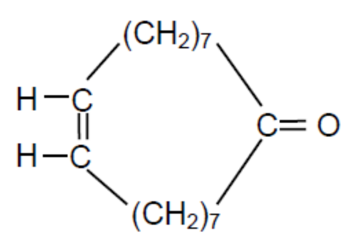
name ………………………………………….

full structural formula

[2]

(c) The end note compound of a perfume has a long lasting odour which stays with the user. An example of an end note compound is shown below.

End note:



The iodine value is a measure of how unsaturated a compound is. It is based on the mass, in grams, of iodine that reacts with 100 g of the compound.

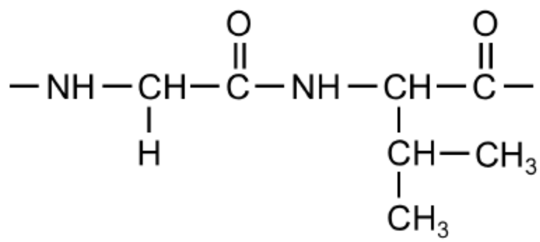
If the relative molecular mass of the end note compound is 250, calculate the iodine value for the end note compound.

[3]

[Total: 10]

OR

B11 **(a)** Proteins are large biomolecules, or macromolecules, consisting of one or more long chains of amino acid monomers. One section of protein is shown below.



Draw the full structural formula of the monomers that make up this section of the protein.

[2]

(b) When a surgeon repairs a wound, a mesh can be inserted to minimise the wound from opening. Poly(propene) is the recommended material for the mesh.

(i) Draw a section of poly(propene) showing 2 repeating units.

[1]

(ii) Describe **two** differences between the type of polymerisation for poly(propene) and the protein in **(a)**.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………… [2]

(iii) A polymer of propene was manufactured and have an average relative molecular mass in the range of 5000 to 10200.

Calculate the minimum number of repeating units in the polymer.

[2]

(iv) Suggest **one** reason why poly(propene) is used rather than a natural fibre such as cotton.

…………………………………………………………………………………………..

…………………………………………………………………………………………… [1]

(v) Propene is obtained from the cracking of long chain hydrocarbons such as hexadecane, $C_{16}H_{34}$, which are less useful.

When 1 mole of hexadecane is cracked, it produces 4 moles of propene and one other product.

Write the chemical equation and state the conditions for this cracking process.

equation ………………………………………………………………………………..

conditions ……………………………………………………………………………...

…………………………………………………………………………………………… [2]

[Total: 10]

End of Paper 2

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

O

NORTHBROOKS SECONDARY SCHOOL
Preliminary Examination 2022
Secondary 4 Express

NORTHBROOKS

CANDIDATE NAME	

CLASS		INDEX NUMBER		

CHEMISTRY **6092/02**

Paper 2

12 September 2022

1 hour 45 mins

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 19.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
Paper 1	40
Paper 2 Section A	50
Paper 2 Section B	30
Paper 3	40
Total	160

DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO DO SO.

This document consists of 19 printed pages.

Section A (50 marks)

Answer **all** the questions in the spaces provided.

1 An experiment was set up at room temperature as shown in Fig. 1.1.

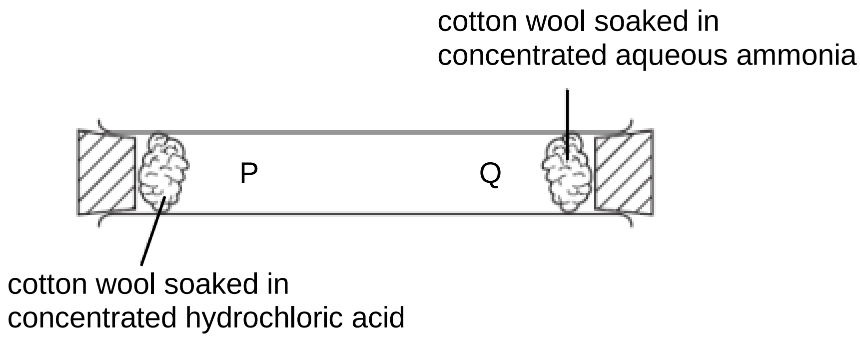


Fig. 1.1

(a) After a few seconds, white fumes were seen at point P in the tube.

Name the compound formed at point P.

.... [1]

(b) Explain the observation in **(a)**.

....

....

....

.... [2]

(c) The student repeated the experiment at a temperature of 18 ºC.

Predict the time taken to observe the white fumes at point P. Explain your answer.

....

....

....

.... [2]

[Total: 5]

2 Table 2.1 shows the number of sub-atomic particles found in particles, L to S. The letters are **not** the symbols of the elements.

Table 2.1

particle	electrons	protons	neutrons
L	6	6	6
M	10	8	8
N	8	8	10
O	12	12	12
P	10	12	12
Q	13	13	13
R	1	1	1
S	13	13	14

Use the letter(s) L to S to answer the following questions.

(a) Which particle is an atom of oxygen?

.... [1]

(b) Which particle will combine with oxygen atoms to form a compound that does **not** react with both alkali and acid?

.... [1]

(c) Which pair of particles are isotopes?

.... [1]

(d) **(i)** Which pair of particles are found in a compound that can conduct electricity in aqueous and molten states?

.... [1]

(ii) Draw a 'dot-and-cross' diagram to show the bonding for the compound in **(d)(i)**. Show outer shell electrons only.

[2]

(e) Which particle is an atom of an element that can have oxidation states +1, 0 and -1? Explain your answer.

....

....

....

.... [3]

[Total: 9]

3 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid was added in excess to a known mass of calcium carbonate placed in a conical flask. The reaction produced carbon dioxide according to the following equation.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

The apparatus used is shown in Fig. 3.1.

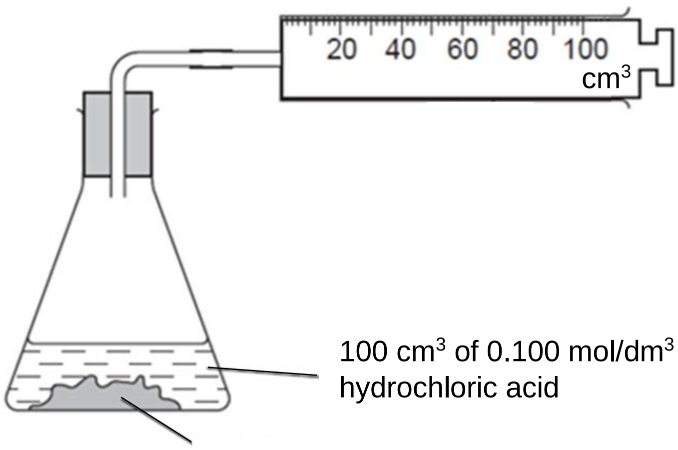
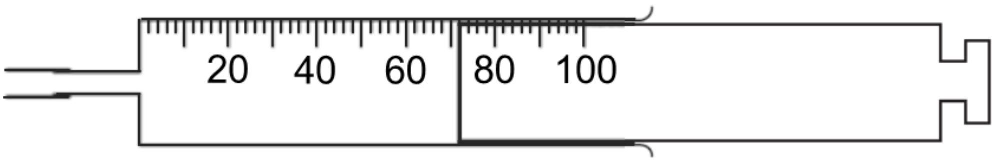


Fig. 3.1

(a) The diagram below shows the gas syringe at the end of the reaction.



State the volume of carbon dioxide collected.

.... [1]

(b) **(i)** Using your answer in part **(a)**, calculate the number of moles of carbon dioxide produced in the reaction.

number of moles = ……………………… [1]

(ii) Hence, calculate the mass of calcium carbonate that reacted with 0.100 mol/dm^3 hydrochloric acid.

mass = ……………………… g [2]

(c) The experiment was repeated using 100 cm^3 of 0.050 mol/dm^3 sulfuric acid instead of hydrochloric acid. It was observed that the reaction stopped quickly and the volume of carbon dioxide produced was much less than expected.

Explain why this was observed.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(d) The collection of gas produced over time can be used to compare the rate of reaction.

Describe another method that can be used to compare the rate of reaction of hydrochloric acid with calcium carbonate to that of ethanoic acid with calcium carbonate.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(e) The rate of some reactions can be increased by adding suitable catalysts.

Explain how the catalysts speed up these reactions.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

[Total: 8]

4 A reaction scheme involving nickel is given in Fig. 4.1.

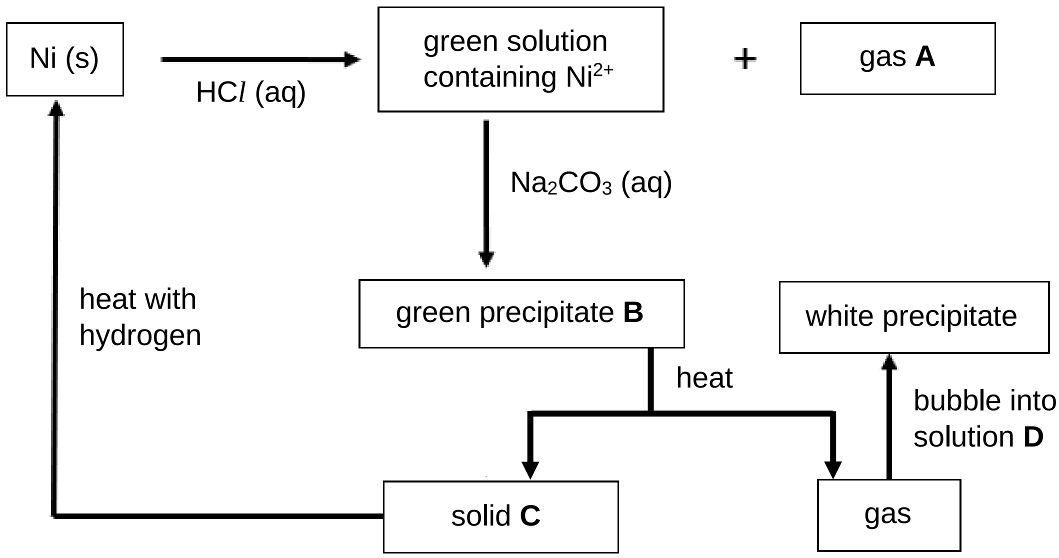


Fig. 4.1

(a) Identify substances **A** to **D**.

A: ……………………………………………………………

B: ……………………………………………………………

C: ……………………………………………………………

D: …………………………………………………………… [4]

(b) Write the ionic equation, with state symbols, for the formation of **B**.

…………………………………………………………………………………………………… [2]

(c) **(i)** State the role of hydrogen in its reaction with solid **C**.

…………………………………………………………………………………………………… [1]

(ii) Explain your answer in **(c)(i)**.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(d) Excess nickel powder is placed in aqueous copper(II) chloride and a pink deposit is obtained.

State the colour change of the solution.

…………………………………………………………………………………………………… [1]

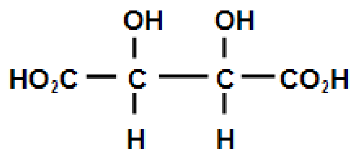
[Total: 9]

467

5 Both phosphoric acid and tartaric acid are weak acids. The formulae of both acids are given below.

H_3PO_4

phosphoric acid



tartaric acid

(a) Describe a simple test that can be used to show that tartaric acid and phosphoric acid are weak acids.

....

.... [2]

(b) Describe a chemical test to distinguish phosphoric acid from tartaric acid.

....

....

....

.... [2]

(c) Complete the energy profile diagram for the reaction between magnesium ribbon and phosphoric acid.

Your diagram should show and label the

- formulae of the reactants and the products,
- activation energy (Ea) and enthalpy change (ΔH) of the reaction.

[3]

[Total: 7]

6 Elements in the same group in the Periodic Table can show different physical properties. For example, Group VII elements chlorine and bromine exist in different physical states.

In another example shown in Table 6.1, the melting points of Group IV elements show a marked change after germanium.

Table 6.1

element	C	Si	Ge	Sn	Pb
melting point (°C)	3550	1410	937	232	327

(a) State the melting point trend of the Group VII elements from chlorine to iodine.

.... [1]

(b) Carbon, silicon and germanium each form a solid with the same type of structure.

(i) Name the structure present in carbon, silicon and germanium.

.... [1]

(ii) Suggest why the melting point of these elements decreases from carbon to germanium.

....

.... [1]

(iii) State the physical states of chlorine and silicon at room temperature.

Explain, in terms of bonding, why the physical states of chlorine and silicon are different.

....

....

....

....

....

.... [3]

(c) Carbon can react with chlorine to form a colourless liquid.

Draw a 'dot-and-cross' diagram to show the bonding in the colourless liquid.

Show outer electrons only.

[2]

(d) Vitamin C (ascorbic acid) contains 40.92% carbon, 4.58% hydrogen and 54.50% oxygen by mass. The experimentally determined molar mass is 176.0 g/mol.

Determine the empirical formula and molecular formula of ascorbic acid.

empirical formula = ………………………

molecular formula = ……………………… [4]

[Total: 12]

----------------- END OF SECTION A ------------------

Section B (30 marks)

Answer all **three** questions in the spaces provided.
The last question is in the form of an either/or and only one alternative should be attempted.

7 <u>The Electrochemical Series</u>

When electrodes of metallic and non-metallic elements in contact with their ions are arranged on the basis of the values of their standard reduction potentials, E°, the resulting series is called the electrochemical series of the elements.

The standard reduction potential of an element is the measure of the tendency of the element to get reduced by gaining electrons. All reduction potentials are measured against the standard hydrogen electrode which is the reference electrode.

The standard potential of any metal or non-metal is measured when in contact with aqueous solutions of their ions at a concentration of 1 mol/dm^3 and temperature of 25 °C. Any gases involved are maintained at a pressure of 1 atmosphere.

Fig. 7.1 shows the setup to measure the standard reduction potential of copper. The Cu/Cu^{2+} half-cell is connected to the hydrogen half-cell.

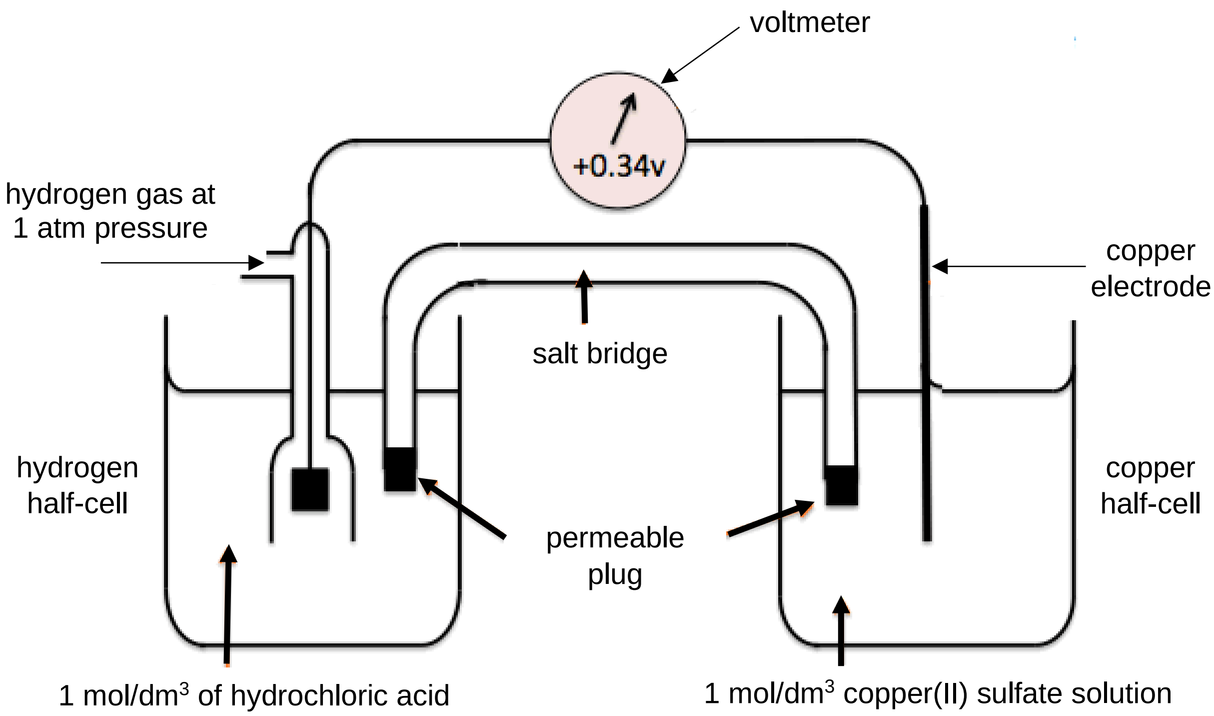


Fig. 7.1

By international convention, the standard potentials of electrodes are tabulated for reduction half reactions. Electrodes with positive E° values indicate the tendencies of the electrodes to gain electrons more readily and behave as cathodes.

Table 7.1 gives the standard reduction potential, E° of some elements.

Table 7.1

element	electrode reaction	standard reduction potential, E° (V)
Li	$Li^+ + e^- \rightarrow Li$	-3.05
K	$K^+ + e^- \rightarrow K$	-2.93
Na	---	-2.71
Zn	---	-0.76
Cr	$Cr^{3+} + 3e^- \rightarrow Cr$	-0.74
Fe	$Fe^{2+} + 2e^- \rightarrow Fe$	-0.44
Ni	$Ni^{2+} + 2e^- \rightarrow Ni$	-0.25
Sn	$Sn^{2+} + 2e^- \rightarrow Sn$	-0.14
H_2	$2H^+ + 2e^- \rightarrow H_2$	0.00
Cu	---	+0.34
I_2	---	+0.54
Ag	---	+0.80
Cl_2	---	+1.36
F_2	---	+2.87

Predicting Displacement Reactions

The electrochemical series help us to predict whether displacement reactions can occur.

Metallic elements having lower reduction potential will lose electrons more readily and will displace elements having higher reduction potential from its salt solution. For example, zinc will displace copper from its salt solution because it has E° value of -0.76V while copper has E° value of +0.34V.

On the contrary, non-metallic elements with higher reduction potential will displace other non-metallic elements with lower reduction potential.

For displacement of hydrogen from dilute acids by metals, the metal which can provide electrons to H^+ ions present in dilute acids for reduction, evolve hydrogen from dilute acids. Metals having negative values of reduction potential possess the property of losing electron(s).

Determining the Products of Electrolysis

In the event that two or more positive ions are present in the solution during electrolysis, the ion which is the stronger oxidising agent or has the higher value of standard reduction potential is discharged first at the cathode. For example, in a solution containing potassium and silver ions, silver ions are discharged first.

(a) It is difficult to set up the Na/Na$^+$ and K/K$^+$ half cells to measure their E° value and hence sometimes scientists have to conduct indirect experimental methods and perform calculations to estimate these values.

Explain why it is difficult to set up these half cells.

……………………………………………………………………………………………….

………………………………………………………………………………………………. [1]

(b) **(i)** With reference to Table 7.1, construct the electrode equation for I_2.

………………………………………………………………………………………… [1]

(ii) Using the reaction between chlorine and aqueous solution containing iodide ions as an example, explain what does it mean by '*non-metallic elements with higher reduction potential displace other non-metallic elements with lower reduction potential*'.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(c) Which of the following setups is displacement reaction likely to occur?

Put a tick (√) if a reaction is likely to occur.

	chromium	tin
aqueous solution of nickel(II) ions		
aqueous solution of iron(II) ions		
dilute nitric acid		

[2]

(d) Describe and explain how the trend in reactivity of Group I and Group VII elements compare to their trends in standard reduction potentials as shown in Table 7.1.

	reactivity	standard reduction potentials
Group I		
Group VII		

[3]

(e) Complete Table 7.2 for the electrolysis of different aqueous solutions using platinum electrodes.

Table 7.2

solutions	name of products of electrolysis that would be produced first		ionic equation with state symbols for the reaction at each electrode
concentrated magnesium chloride	at negative electrode		
	at positive electrode		
mixture of aqueous silver nitrate and aqueous copper(II) chloride	at negative electrode		
	at positive electrode		

[4]

[Total: 12]

8 Fig. 8.1 shows the extraction of iron using a blast furnace.

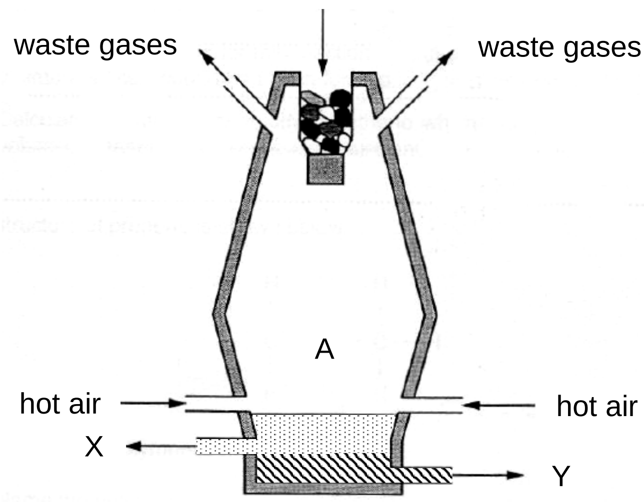


Fig. 8.1

(a) **(i)** The reaction at region A results in the formation of molten iron from haematite. Write down an equation with state symbols for the above reaction.

.... [2]

(ii) Explain why the reaction in **(a)(i)** is a redox reaction.

....

....

....

.... [2]

(b) Explain how substance X is produced from the raw materials in the blast furnace.

....

....

....

.... [2]

(c) A company decided to use iron pyrite, FeS_2, as the ore for the extraction of iron instead. Explain why this decision may lead to environmental problem.

....

....

....

.... [2]

[Total: 8]

9 EITHER

(a) The carbon cycle involves the processes of combustion, respiration and photosynthesis. Describe how the carbon cycle can maintain the amount of carbon dioxide in the atmosphere.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(b) Alcohols can be used as fuels in internal combustion engines of cars. The term *fuel economy* is used to describe the distance a car can travel on a fixed volume of fuel. It depends on two factors – energy density and octane number.

Energy density is the amount of energy stored per unit volume of the fuel. Octane number indicates how quickly a fuel burns. In general, the slower a fuel burn, the more efficient it is to extract energy from it. A high octane number means that a fuel burns slowly and thus more energy efficient.

Table 9.1 shows the data of two fuels.

Table 9.1

fuel	energy density (megajoules per litre)	octane number
gasoline (petrol)	33	90 to 105
propanol	24	118

(1 megajoule is equal to 1 million joules of energy.)

In 2016, scientists in Singapore developed a method to reduce carbon dioxide emissions by converting the gas into propanol using copper catalyst and electricity.

The suitability of a fuel depends on the *fuel economy* and how cleanly the fuel burns in air. The chemical composition of the fuel determines whether it burns cleanly in air.

Comment on the suitability of propanol as a fuel compared to gasoline.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [4]

(c) In 2017, scientists in Singapore developed a prototype device to produce ethene from carbon dioxide and water using copper catalyst and solar energy. Ethene is widely used in the chemical industry and is said to have the highest global production quantities compared to other organic compounds. Much of ethene is used to make poly(ethene).

(i) Poly(ethene) is an addition polymer. Explain what the terms *addition* and *polymer* mean.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

....

………………………………………………………………………………………….. [2]

(ii) Draw the structural formula of poly(ethene), showing three repeat units.

[1]

[Total: 10]

9 OR

Chlorine is a Group VII element that is commonly used in reactions. It can react to form many useful chlorine-containing compounds.

(a) When chlorine gas is passed into aqueous iron(II) bromide, the colour of the solution changes to orange-red.

When the orange-red solution is heated, it gives off a reddish-brown gas, leaving a yellow solution, **S**. A reddish-brown precipitate is formed when aqueous sodium hydroxide is added to **S**.

The reddish-brown gas forms a dark red liquid, **T** on cooling. When propane is passed through **T** under ultraviolet light, the dark red colour disappears.

(i) Name solution **S**.

Hence, write a balanced equation when chlorine gas is passed into aqueous iron(II) bromide.

....

.... [3]

(ii) Write a balanced equation when propane is passed through **T**.

.... [1]

(b) Hydrogen chloride gas can react with oxygen to produce chlorine gas.

$$4HCl(g) + O_2(g) \rightarrow 2Cl_2(g) + 2H_2O(g) \qquad \Delta H = -108 \text{ kJ/mol}$$

This reaction is carried out in the presence of copper(II) chloride catalyst at 400 – 450 °C.

Some bond energies are given in Table 9.2.

Table 9.2

bond	bond energy (kJ/mol)
O=O	496
H-C*l*	431
O-H	460

(i) Using the information in Table 9.2, calculate the bond energy of C*l*–C*l*.

bond energy = ……………………… kJ/mol [2]

(ii) When liquid hydrogen chloride is used, the enthalpy change of reaction to produce chlorine gas becomes greater. Explain why this is so.

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [1]

(iii) Hydrochloric acid can be used to produce the copper(II) chloride catalyst required for the reaction.

Describe how pure copper(II) chloride crystals can be obtained from hydrochloric acid.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

……………………………………………………………………………………………. [3]

[Total: 10]

--------------------- END OF PAPER ---------------

The Periodic Table of Elements

Group

I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is $24\,dm^3$ at room temperature and pressure (r.t.p.).

NAME:		INDEX NO:		CLASS:	

NORTHLAND SECONDARY SCHOOL
PRELIMINARY EXAMINATION
Secondary Four Express

CHEMISTRY **6092**

Paper 2 **30 August 2022**

Candidates answer on the Question Paper. **1 hour 45 minutes**
No Additional Materials are required.

READ THESE INSTRUCTIONS

Write your name and index number on the work you hand in.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either/ or.
Answer all questions in the space provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 20.

The use of an approved scientific calculator is expected, where appropriate.
The total marks for this paper is **80**.

SECTION		FOR EXAMINER'S USE
A		50
B	8	12
	9	8
	10	10
TOTAL		80

Setter: Mdm Kumari **Vetter: Mdm Nilasari**

Section A

Answer **all** questions in this section in the spaces provided.
The total marks for this section is 50.

A1 The position of eight elements, **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** are shown in the outline of part of the Periodic Table.

							C										**H**
													F			**G**	
	B											**E**					
A					**D**												

Use the letters **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** to answer the following questions. You may use the letter once, more than once, or not at all.

(a) Which element has atoms with no neutrons?

………………………………………………………………………………………….............. [1]

(b) Which element(s) form(s) ions with +1 charge?

………………………………………………………………………………………….............. [1]

(c) Which element has similar chemical properties to barium?

………………………………………………………………………………………….............. [1]

(d) Which element forms an oxide that reacts with both an acid and a base?

………………………………………………………………………………………….............. [1]

(e) Which element forms coloured compounds?

………………………………………………………………………………………….............. [1]

(f) Which element is the strongest oxidising agent?

………………………………………………………………………………………….............. [1]

[Total: 6]

A2 Fig. 2.1 shows a strip of moist Universal Indicator paper pasted in a hollow cylindrical tube.

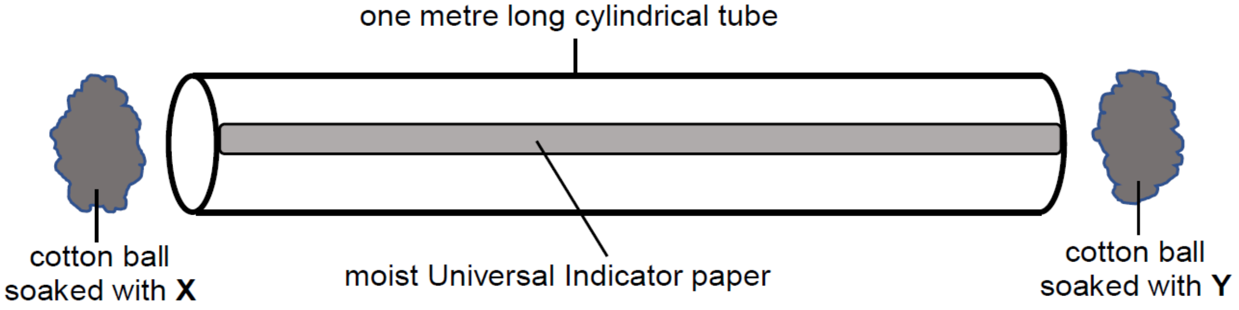


Fig. 2.1

One cotton ball is soaked with concentrated hydrochloric acid which will produce hydrogen chloride gas. The other cotton ball is soaked with concentrated aqueous ammonia which will produce ammonia gas.

Both cotton balls are inserted at both ends of the cylindrical tube simultaneously. When no more changes are observed on the Universal Indicator paper, the cotton balls are removed, and the Universal Indicator paper is taken out.

The results are shown in Fig. 2.2.

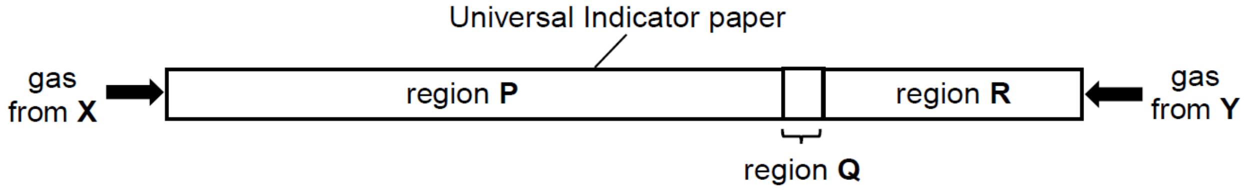


Fig. 2.2

Region **P** is uniformly of one colour and region **R** of another colour.

(a) What are **X** and **Y**?

Explain your answer.

....

....

....

....

.... [3]

(b) State the colours of region **P** and region **R**.

region **P**: ....

region **R**: .... [2]

(c) Region **Q** remains green throughout the experiment.

Explain why.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

[Total: 6]

A3 Table 3.1 gives some properties of the elements in Group VII.

The properties of astatine are missing in the table.

Table 3.1

element	electronic structure	melting point/ ^oC	boiling point/ ^oC	atomic radius/ pm
fluorine	2.7	-220	-188	64
chlorine	2.8.7	-101	-35	99
bromine	2.8.18.7	-7	59	114
iodine	2.8.18.18.7	113	183	133
astatine	-	-	-	

(a) Describe the trend in atomic radius of halogens.

Hence, predict the atomic radius of astatine.

....

....

.... [2]

(b) Using information from the table, suggest which halogen contains particles that are sliding about freely at room temperature and pressure.

.... [1]

(c) State and explain what you would see when chlorine gas reacts with a sample of potassium iodide solution. Include a chemical equation with state symbols.

....

....

.... [3]

[Total: 6]

A4 Fig. 4.1 shows the Haber process for making ammonia.

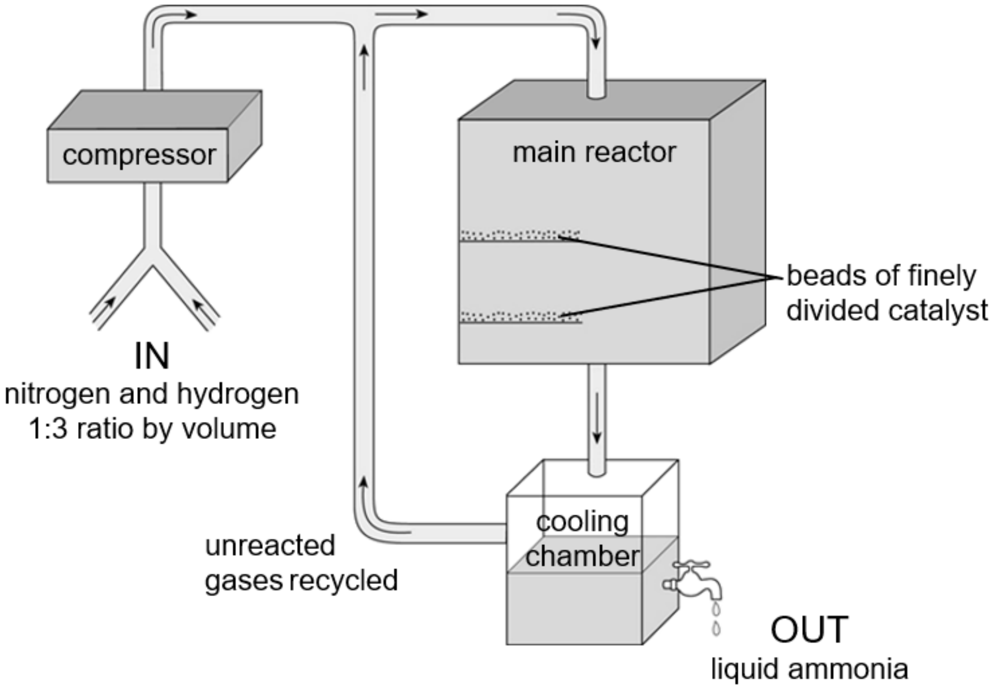


Fig. 4.1

(a) Explain, with the help of an equation, why nitrogen and hydrogen are mixed in a 1:3 ratio by volume.

....

....

....

.... [2]

(b) When the mixture of hydrogen, nitrogen and ammonia gases enters the cooling chamber, ammonia turns to a liquid but the other gases do not.

What does this information suggest about the physical properties of the three gases?

....

.... [1]

(c) Other than cost, suggest why unreacted hydrogen is recycled.

....

.... [1]

(d) Ammonia is used to manufacture nitric acid by a two-stage process.

Stage 1: Ammonia is converted to nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$$

Stage 2: Nitrogen monoxide is converted to nitric acid.

$$4NO(g) + 2H_2O(g) + 3O_2(g) \rightarrow 4HNO_3(aq)$$

(i) It is possible to find out whether stage 1 has finished by following pH changes during the reaction. Samples of gas are taken from the reaction vessel at intervals and bubbled through water to form a solution. The pH of each solution is measured.

Explain why the measured pH changes during the reaction in stage 1.

....

....

....

.... [2]

(ii) Calculate the maximum volume of 5 mol / dm^3 nitric acid which can be made from 720 dm^3 of nitrogen monoxide at room temperature and pressure.

[3]

[Total: 9]

A5 Small pieces of a silvery metal, **V**, were added to concentrated nitric acid. A brown gas, **W**, and a colourless solution containing salt **X** were formed.

Analysis of a sample of gas **W** showed it contained 1.07 g of nitrogen and 2.43 g of oxygen.

The small sample of the colourless solution of **X** was diluted with water and then divided into two portions.

To one portion, aqueous sodium hydroxide was added drop by drop until it was in excess. A white precipitate **U** was formed that did not dissolve in excess sodium hydroxide.

To the other portion, aqueous ammonia was added drop by drop until it was in excess. There was no observable change.

(a) Name the following:

precipitate **U** : ………………………………………………

metal **V** : ………………………………………………

solution **X** : ……………………………………………… [3]

(b) Write the chemical equation, with state symbols, for the formation of white precipitate **U** when sodium hydroxide was added to solution **X.**

………………………………………………………………………………………… [2]

(c) Given the information above, determine the empirical formula of gas **W**.

[2]

[Total: 7]

A6 The rate of reaction of iron with aqueous bromine is determined using the apparatus in Fig. 6.1.

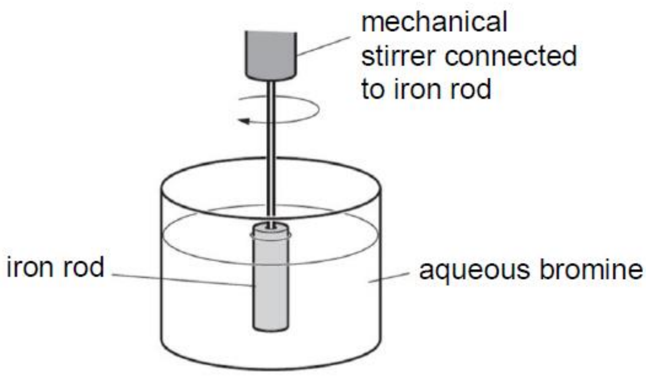
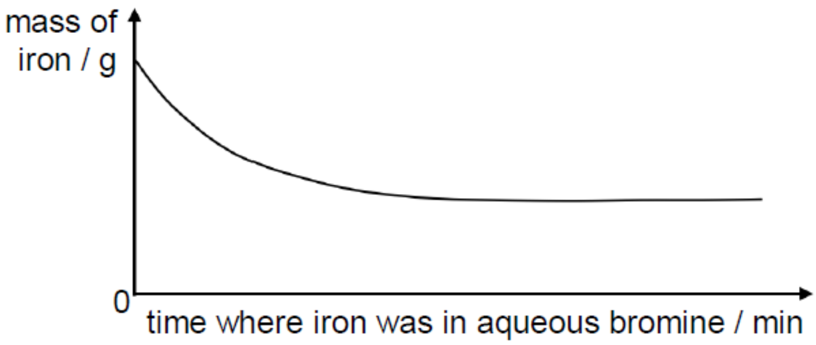


Fig. 6.1

The iron is removed at regular intervals. It is washed, dried and then weighed. The iron is then replaced in the solution.

(a) The mass of iron was plotted against time. The graph shows the results obtained.



Which reactant, iron or aqueous bromine, was in excess?
Use the graph to explain your answer.

....

.... [1]

(b) The experiment is repeated twice, each time with a different concentration of aqueous bromine at room temperature.

The results are shown in Table 6.2.

Table 6.2

concentration of aqueous bromine (mol/dm^3)	speed of reaction (gram of iron reacted/min)
0.0050	9.2
0.10	18.1
0.15	27.2

(i) Using the information in the table, describe how and explain why the speed of this reaction changes with the concentration of aqueous bromine.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(ii) Describe and explain, in terms of reacting particles, how the speed of reaction will change when aqueous bromine is cooled to 20 ^oC.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [3]

[Total: 6]

A7 Propene undergoes complete combustion.

$$2\ C_3H_6 + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

Table 7.1 lists the bond breaking energies of the following substances.

Table 7.1

bond	bond energy / kJ mol^{-1}
C – C	346
C – H	411
C = C	602
O = O	498
C = O	799
H – O	459

(a) Calculate the enthalpy change for the reaction.

enthalpy change = ……………………… [3]

(b) Explain, in terms of bond breaking and bond making, why this reaction is exothermic.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

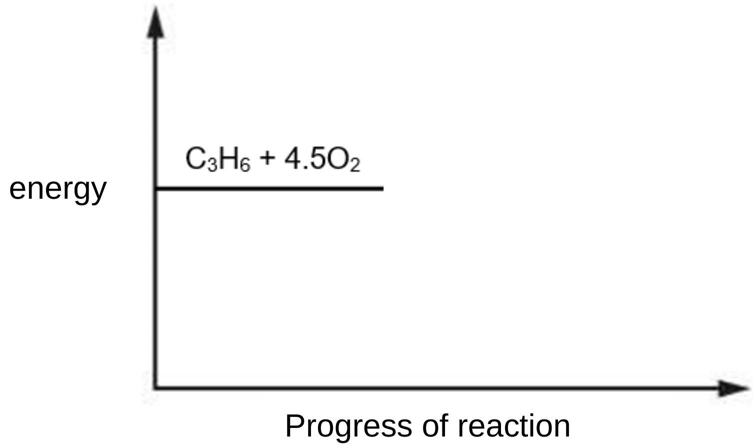
…………………………………………………………………………………… [3]

(c) Complete the energy profile diagram for the combustion of propene.

Your diagram should include a label for:

(i) **enthalpy change of reaction**

(ii) **activation energy**



[2]

(d) Draw a 'dot and cross' diagram to show the arrangement of outermost shell electrons in a propene molecule.

[2]

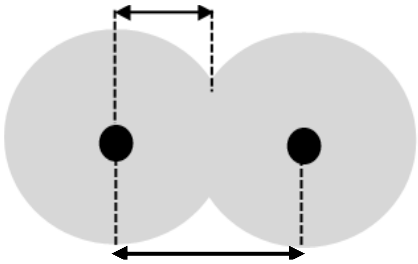
[Total: 10]

SECTION B

Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Atomic radii

The actual size of an atom cannot be measured exactly. However, it is possible to measure the distance between the nuclei of two atoms.



For example, the 'covalent radius' of a chlorine atom is assumed to be half of the distance between the nuclei in a chlorine molecule. Similarly, the 'metallic radius' is half of the distance between two metal atoms in the giant lattice of a metal.

These two types of radius are generally known as 'atomic radii'.

Table 8.1 shows the resulting atomic radii and electronic configuration for the elements of period three of the Periodic Table, from Na to C*l*.

Table 8.1

element	Na	Mg	A*l*	Si	P	S	C*l*
electronic configuration	2.8.1	2.8.2	2.8.3	2.8.4	2.8.5	2.8.6	2.8.7
atomic radius / nm	0.186	0.160	0.143	0.117	0.110	0.104	0.099

Ionic radii

An atom could form a negative ion or a positive ion when it gains or loses electron(s). Table 8.2 shows the resulting ions, ionic radii and electronic configuration for the elements of period three of the Periodic Table, from Na to C*l*.

Table 8.2

Ion	Na^{+}	Mg^{2+}	Al^{3+}	P^{3-}	S^{2-}	Cl^{-}
electronic configuration	2.8	2.8	2.8	2.8.8	2.8.8	2.8.8
ionic radius / nm	0.095	0.065	0.050	0.212	0.184	0.181

(a) Describe the relationship between the atomic radii and electronic configuration of elements in period 3.

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(b) Describe the trend observed in the ionic radii of elements in period 3.

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(c) Describe how the ionic radii differ from the atomic radii for the elements in period 3.

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(d) Two students made the following statements about the data.

Student 1: 'I think that the ionic radius is linked to the charge of the ions.'

Student 2: 'I think the ionic radius is linked to the electronic configuration of the ions.'

Does the information in the table support the statements made by the students? Explain your reasoning.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [4]

(e) Suggest why it is **not** possible to use the same type of measurement for argon atom, Ar, which is also an element in period 3.

....

.... [1]

(f) Suggest why there is **no** ionic radius for silicon in the table.

....

.... [1]

[Total: 12]

B9 Zinc is used to make alloys and in the construction of dry cells (batteries). Under special conditions, zinc can be obtained from zinc oxide in a two-step process.

Step 1: aqueous zinc sulfate is made from zinc oxide
Step 2: aqueous zinc sulfate is electrolysed with carbon electrodes to obtain zinc.

(a) Name the reagent which reacts with zinc oxide to form zinc sulfate.

reagent: .... [1]

(b) Complete the following for the electrolysis of aqueous zinc sulfate.

(i) Write the ionic equation happening at the anode.

.... [1]

(ii) What is the resulting electrolyte formed?

.... [1]

(iii) Besides electrolysis, suggest another method to extract zinc from zinc oxide.

.... [1]

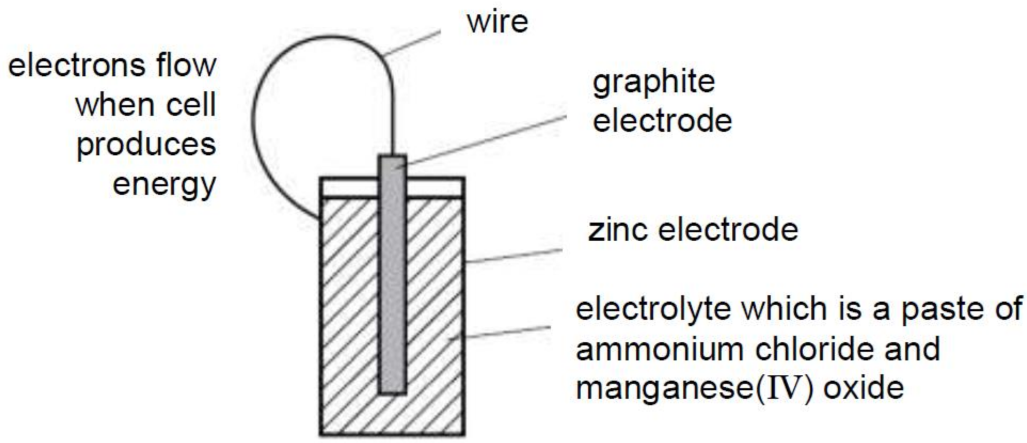
(c) A dry cell (battery) has a central rod, usually made of graphite.

The diagram shows the positive electrode which is surrounded by the electrolyte, typically a paste of ammonium chloride and manganese(IV) oxide, all of which are in a zinc container which is the negative electrode.

The following ionic equations occur at the electrodes in a dry cell.

positive electrode: $2NH_4^+(aq) + 2MnO_2(s) + 2e^- \rightarrow Mn_2O_3(s) + 2NH_3(g) + H_2O(l)$

negative electrode: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$



(i) Draw an arrow on the diagram to indicate the direction of electron flow. [1]

(ii) Suggest why the electrolyte is a paste instead of solid.

………………………………………………………………………………………… [1]

(iii) Suggest why there is no gas built up in the dry cell.

………………………………………………………………………………………… [1]

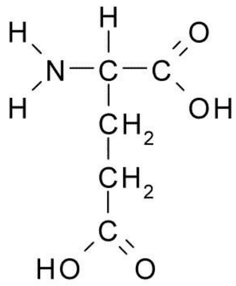
(iv) Give the overall equation for the reaction.

………………………………………………………………………………………… [1]

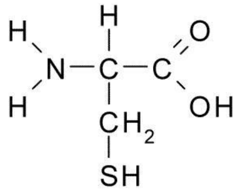
[Total: 8]

Either

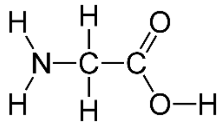
B10 Glutathione is a naturally-occurring anti-oxidant in the body. It is a tripeptide, which means that it is made up of three amino acids bonded together. The structure of the amino acids are shown below, together with their short forms.



glutamic acid (glu)



cysteine (cys)



glycine (gly)

(a) With reference to the three amino acid structures, explain whether they can be considered to be in the same homologous series.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

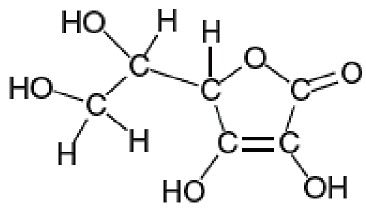
(b) State the type of linkage that would be found in a molecule of glutathione.

…………………………………………………………………………………………… [1]

(c) Given that glutathione is made up of the three amino acids in the sequence glu–cys–gly, draw the structure of glutathione.

[1]

Another anti-oxidant, taken as a supplement, is vitamin-C. Its structure is shown below.



vitamin-C

(d) Vitamin-C can react with hydrogen gas under suitable conditions.

(i) Draw the structure of the product and state the conditions required.

Conditions: ………………………………………………………………… [2]

(ii) Hydrogen gas can be obtained from the cracking of alkanes. Octane, an alkane with 8 carbon atoms, is cracked to obtain hydrogen gas and an alkene.

Write the balanced chemical equation for the cracking reaction.

………………………………………………………………………………… [1]

(e) Vitamin-C can also react with acidified potassium manganate(VII).

(i) State the functional group in vitamin-C that is involved in the reaction.

………………………………………………………………………………… [1]

(ii) With the help of a simpler molecule with the same functional group in **(e)(i)**, describe what usually occurs in such a reaction, and explain why it is not always possible to react with **all** of the functional groups in **(e)(i)**, found in vitamin-C**.**

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

………………………………………………………………………………… [2]

[Total: 10]

OR

B10 Fig. 10.1 shows the types of fuel used in 1990 and 2002**.**

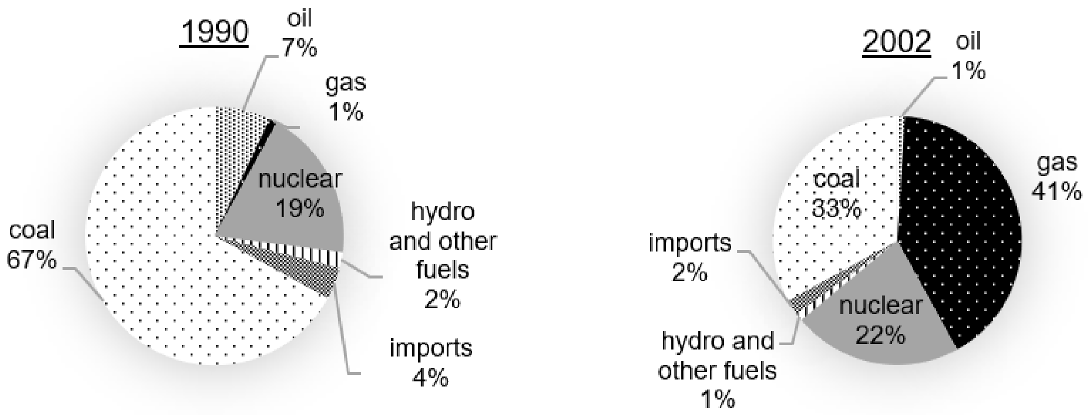


Fig 10.1

Fig. 10.2 shows the relationship between the air : fuel ratio and the production of pollutants in vehicle engines.

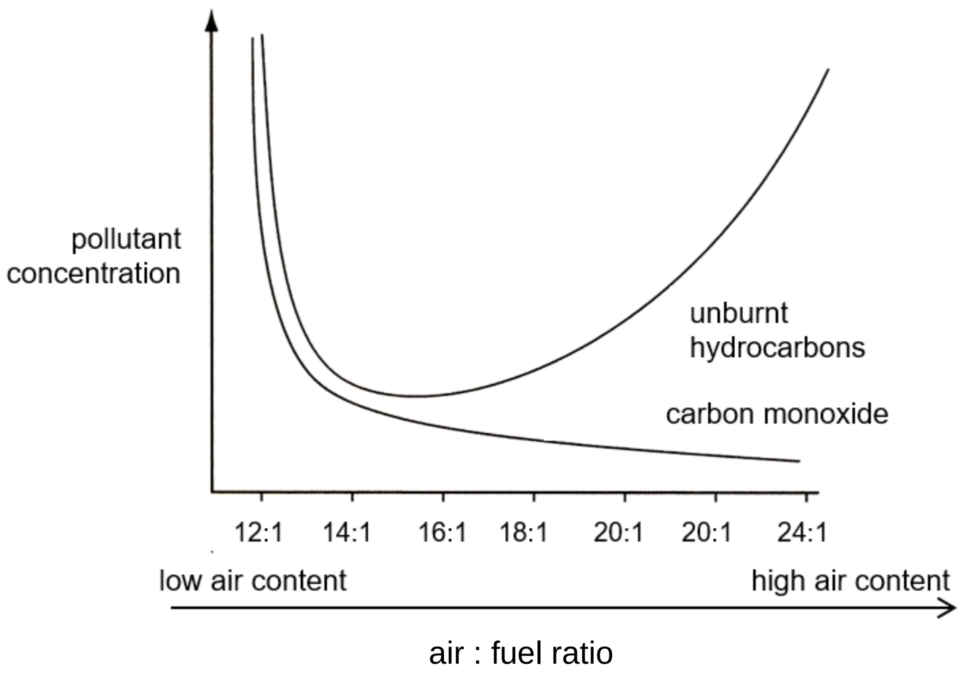


Fig 10.2

(a) Use the information in Fig. 10.1 to describe the changes in the main type of fuel used from 1990 to 2002.

....

....

....

.... [2]

(b) Describe and explain the trend for carbon monoxide production in Fig. 10.2.

....

....

....

.... [2]

(c) Apart from carbon monoxide and unburnt hydrocarbons, oxides of nitrogen are also air pollutants produced by vehicle engines.

(i) Explain how oxides of nitrogen are formed in vehicle engines.

....

....

....

.... [2]

(ii) Predict the air : fuel ratio where the concentration of oxides of nitrogen is the highest. Explain your answer.

....

....

....

....

....

.... [3]

(d) It was observed that crops do not grow well in areas near coal-burning power stations.

Suggest an explanation for this observation.

....

.... [1]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

Class	Centre/Index Number	Name

南洋女子中學校

Nanyang Girls' High School

Preliminary Examination 2022
Secondary 4

CHEMISTRY

6092/02

Paper 2

1 hour 45 minutes

Friday 26 August

0845 – 1030

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid / tape.

Section A (50 marks)
Answer **all** questions in the spaces provided.

Section B (30 marks)
Answer all **three** questions, the last question is in the form either/or.
Indicate in the box to the right your choice of the either/or question.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 23.

The use of an approved scientific calculator is expected, where appropriate.

Examiner's Use	
Paper 1	
Paper 2	
Indicate the question attempted for **B9** with a tick (✓). **Either** ☐ **Or** ☐	
Total	

This document consists of **23** printed pages and **1** blank page.

Section A

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

A1 Choose from the following substances to answer the questions below.
Each of these substances can be used once, more than once or not at all.

Al_2O_3	Ar
CaO	CH_4
CO_2	$Ba(NO_3)_2$
TiO_2	$Pb(NO_3)_2$

(a) Which substance forms approximately 1 % of clean, dry air?

.... [1]

(b) Which substance is the main constituent of natural gas?

.... [1]

(c) Which substance dissolves in water to form an aqueous solution which gives a white precipitate on addition of aqueous sodium chloride?

.... [1]

(d) Which substance reacts with both acids and alkalis?

.... [1]

(e) Which substance is most likely to be coloured and can be used as a catalyst?

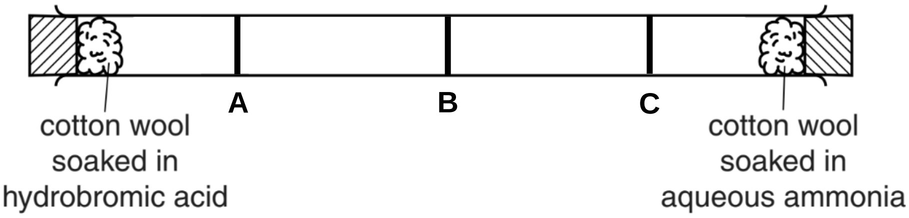
.... [1]

(f) Which two substances are the products of thermal decomposition of limestone?

.... [1]

[Total: 6]

A2 A student sets up a tube as shown in the diagram.



Concentrated hydrobromic acid produces fumes of hydrogen bromide.
Concentrated aqueous ammonia produces fumes of ammonia.

After sometime, solid ammonium bromide appeared on the walls of the tubes.

(a) **(i)** Calculate the relative molecular mass of hydrogen bromide and ammonia.

[1]

(ii) Hence, state the position (**A**, **B** or **C**) of where the solid ammonium bromide may appear in the tube above.

.... [1]

(iii) Explain your answer to **(a)(ii)**.

....

....

.... [2]

(b) Draw a 'dot-and-cross' diagram for ammonia.
Show only the outer electrons.

[2]

[Turn over

(c) Explain why ammonium bromide exists as a solid at room temperature and pressure.

....

....

....

....

....

....

.... [3]

[Total: 9]

A3 The analysis of compound **Y** shows that it has the following composition.

element	percentage by mass (%)
nitrogen	11.1
hydrogen	3.2
chromium	41.3
oxygen	44.4

(a) Show that **Y** has the empirical formula $N_2H_8Cr_2O_7$.

[3]

(b) An aqueous solution of **Y** is orange.

Deduce, with a simple reason, which element in **Y** is responsible for the orange colour.

.... [1]

(c) An acidified aqueous solution of **Y** reacts with aqueous potassium iodide to form aqueous iodine.

(i) Write an ionic half-equation to show the formation of iodine from iodide ion.

.... [1]

(ii) Using your answer in **(i)**, state and explain what you can conclude about the chemical nature of **Y**.

....

....

.... [2]

[Turn over

(d) When aqueous sodium hydroxide is added to solid **Y** and warmed, ammonia gas is evolved.

Suggest the cation present in **Y** that gave the above observation.

.... [1]

(e) Solid **Y** is a compound with the molecular formula, $N_2H_8Cr_2O_7$.

When solid **Y** is heated strongly, it decomposes to only chromium(III) oxide, water and nitrogen gas.

Write a balanced chemical equation to show this decomposition.
State symbols are not required.

.... [2]

[Total: 10]

A4 Iron(II) sulfide is a compound that can be made by heating iron filings with sulfur powder.

(a) For each of the statements below, put a tick (✓) in one box in each row that corresponds with a **mixture** of iron and sulfur or a **compound** of iron and sulfur.

	statement	mixture	compound
(i)	Chemical properties are the same as those of its components.		
(ii)	During its formation, energy change is involved.		
(iii)	Has fixed composition.		
(iv)	Components can be separated by magnetism.		

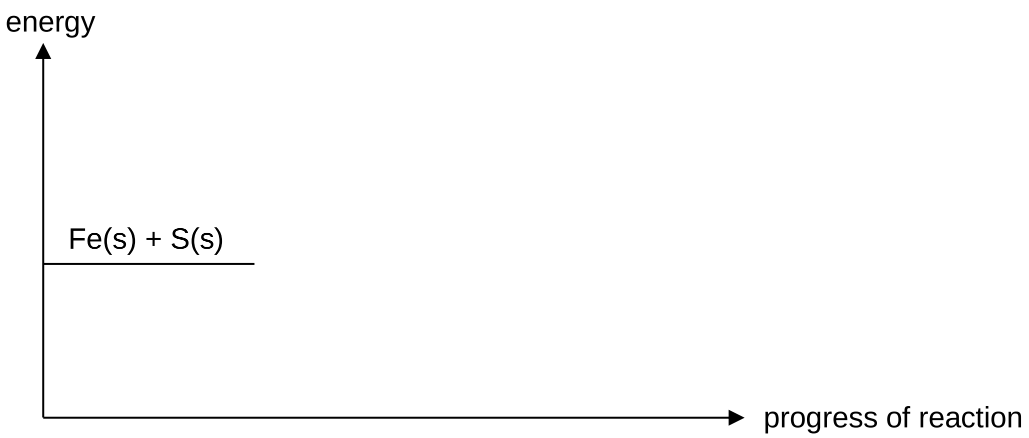
[2]

(b) The enthalpy change of the reaction between iron and sulfur to form iron(II) sulfide is -100 kJ/mol.

Complete the energy profile diagram for this reaction.

You should include

- the formula of the product,
- a label for the activation energy,
- a label for the enthalpy change of reaction.



[3]

(c) Iron(II) sulfide reacts with hydrochloric acid to form hydrogen sulfide.
An aqueous solution of hydrogen sulfide behaves as a weak acid.

Explain what is meant by the term *weak acid*.

....

.... [1]

[Turn over

(d) Iron(II) sulfate can be prepared by reacting iron with dilute sulfuric acid.

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

(i) Write an ionic equation for this reaction.

.... [2]

(ii) A student claimed that she could obtain pure, dry iron(II) sulfate by adding an equal volume of aqueous sodium hydroxide into iron(II) sulfate solution before filtering to obtain its residue.

State the observation upon addition of aqueous sodium hydroxide and explain why the student is incorrect.

....

....

.... [2]

(iii) Describe how you would obtain crystals of pure, dry iron(II) sulfate from iron(II) sulfate solution.

....

....

....

.... [2]

[Total: 12]

A5 The table below shows some information about the extraction of metals from molten electrolytes using electrolysis.

metal extracted	electrolyte	amount of electrons needed to extract 10 g of the metal/ mol
sodium	molten sodium chloride	0.435
calcium	molten calcium chloride	
magnesium	molten magnesium chloride	0.833

(a) In the space below, construct a simple diagram to represent the set up for an electrolytic cell using molten sodium chloride as the electrolyte.

Include on the diagram suitable electrodes that can be used for this cell, as well as the direction of electron flow.

[2]

[Turn over

(b) **(i)** State the electrode where calcium metal is formed at.

.... [1]

(ii) With the help of a suitable ionic half-equation, calculate the amount of electrons needed to form 10 g of calcium metal.

amount of electrons = ... [2]

(c) A student suggested using aqueous magnesium chloride as an electrolyte to extract magnesium metal.

With reference to the ions present, explain why the student would not be able to obtain any magnesium metal.

....

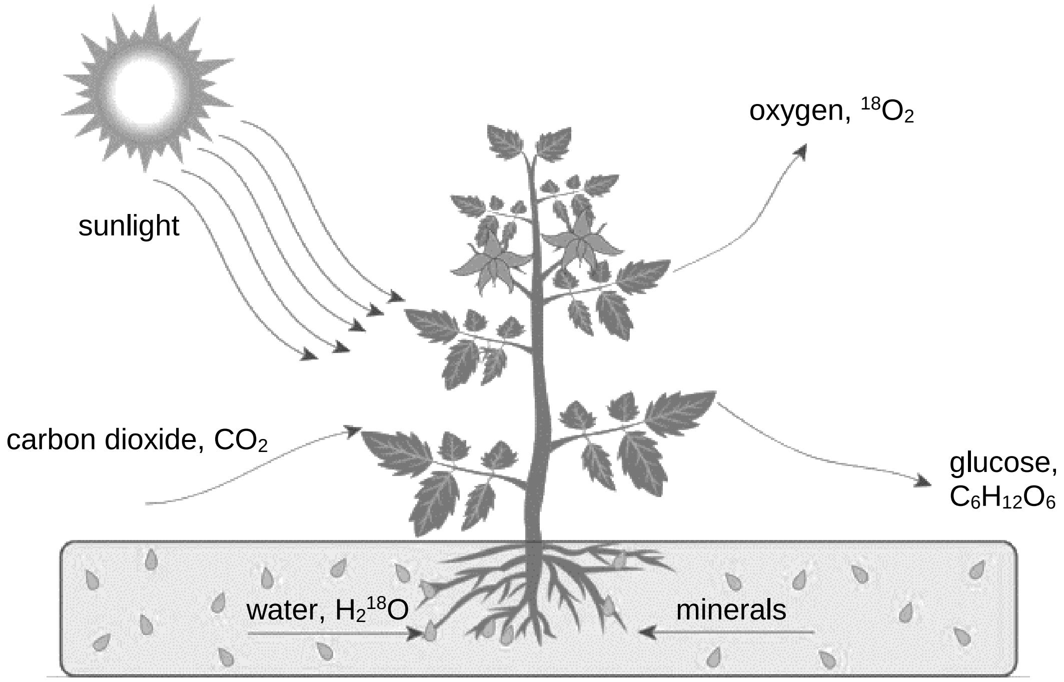
....

....

.... [2]

[Total: 7]

A6 The diagram below shows how plants undergo photosynthesis, one of the main processes in the carbon cycle. Water containing the radioactive isotope ^{18}O is fed to a plant.



(a) Define *isotope*.

....

.... [1]

(b) The resulting radioactivity in the products of photosynthesis is shown in the equation below.

$$6CO_2 + 6H_2{}^{18}O \rightarrow C_6H_{12}O_6 + 6{}^{18}O_2$$

Complete the table below to state the source of the oxygen in each of the products.

products	source
glucose, $C_6H_{12}O_6$	
oxygen, $^{18}O_2$	

[1]

(c) Which other process in the carbon cycle is not shown above?

.... [1]

[Turn over

(d) *Land cover class* is a term that classifies land according to the amount of trees covering the area.

A comparison of surface temperatures for each land cover class is shown in the table below.

land cover class	surface temperature / °C
bare earth	29.1 to 32.4
moderately-densed forests	25.2 to 25.5
highly-densed forests	24.5 to 24.9

(i) Describe the trend shown in the data above.

.... [1]

....

(ii) Suggest how planting more trees on Earth could potentially reduce the effects of global warming.

....

....

....

.... [2]

[Total: 6]

Section B

Answer all **three** questions in this section.
The last question is in the form of either/or and only one of the alternatives should be attempted.

B7 The Nature of a Chemical Bond

The formulae and the type of bonding of the oxides and chlorides of the elements across Period 3 are shown in **Table 7.1** below.

Table 7.1

element	metal/non-metal	formula of main oxide	bonding in oxide	formula in chloride	bonding in chloride
Na	metal	Na_2O	ionic	$NaCl$	ionic
Mg	metal	MgO	ionic	$MgCl_2$	ionic
Al	metal	Al_2O_3	ionic	$AlCl_3$	covalent
Si	non-metal	SiO_2	covalent	$SiCl_4$	covalent
P	non-metal	P_4O_{10}	covalent	PCl_3	covalent
S	non-metal	SO_3	covalent	S_2Cl_2	covalent
Cl	non-metal	Cl_2O_7	covalent	Cl_2	covalent

Electronegativity is a measurement of the tendency of an atom to attract a bonding pair of electrons. A bonding pair of electrons is the pair of electrons shared in a chemical bond. The higher the electronegativity, the greater the tendency of an atom to attract the bonding pairs of electrons towards itself.

The Pauling scale is used to measure the electronegativity of elements. It ranges from 0.7 to 4.0, with a higher value representing greater electronegativity. **Table 7.2** shows the electronegativity values of some elements in the Periodic Table.

Table 7.2

proton number	element	Pauling Scale of electronegativity
8	O	3.4
9	F	4.0
10	Ne	undefined
11	Na	0.9
12	Mg	1.3
13	Al	1.6
14	Si	1.9
15	P	2.2
16	S	2.6
17	Cl	3.2
18	Ar	undefined

[Turn over

The difference in electronegativity between two elements involved in a chemical bond, X, can be calculated by the following equation:

$$X = \text{larger electronegativity value} - \text{smaller electronegativity value}$$

For example, the electronegativity between sodium and oxygen in Na_2O is calculated as

$$X = 3.4 - 0.9 = 2.5$$

X gives an indication of whether a chemical bond formed between two elements is ionic or covalent. It is said that if the X is greater than 2.0, the chemical bond formed between two elements is ionic.

The Pauling scale is also closely related to the strength of a bond, which can be measured by its bond energy. Bond energy is the amount of energy needed to break a mole of a particular bond. It is a measure of the strength of a chemical bond. Bond lengths are the distances between the nuclei of bonded atoms.

Table 7.3 shows the bond lengths and bond energies of some bonds.

Table 7.3

bond	bond length (pm)	bond energy (kJ / mol)
C–C	154	348
C=C	134	614
C≡C	120	839
Si–C*l*	202	381
P–C*l*	203	326
S–C*l*	207	253
C*l*–C*l*	199	243

Note: pm = picometers (10^{-12} m)

Source: http://www.science.uwaterloo.ca/~cchieh/cact/c120/bondel.html

(a) Use the data to describe the trend in the electronegativity values of the Period 3 elements.

....

.... [1]

(b) Suggest a reason why the electronegativity values of argon and neon are 'undefined'.

....

.... [2]

(c) The following statement is extracted from the information given.

"It is said that if the X is greater than 2.0, the chemical bond formed between two elements is ionic."

A student commented that this statement is true for most oxides and chlorides but there are exceptions to the statement.

Use data from **Table 7.1 and 7.2** to support your ideas for the following questions.

(i) Select one oxide or chloride that supports that the statement is true.

Calculate the value of X for this compound and use it to explain your answer. Show your working clearly.

....

.... [2]

(ii) Select one oxide or chloride that is an exception to the statement.

Calculate the value of X for this compound and use it to explain your answer. Show your working clearly.

....

.... [2]

(d) Describe the general relationship between bond length and bond energy.

....

.... [1]

(e) How is the strength of a bond affected by the number of bonds between atoms?

Use data from **Table 7.3** to explain your answer.

....

.... [2]

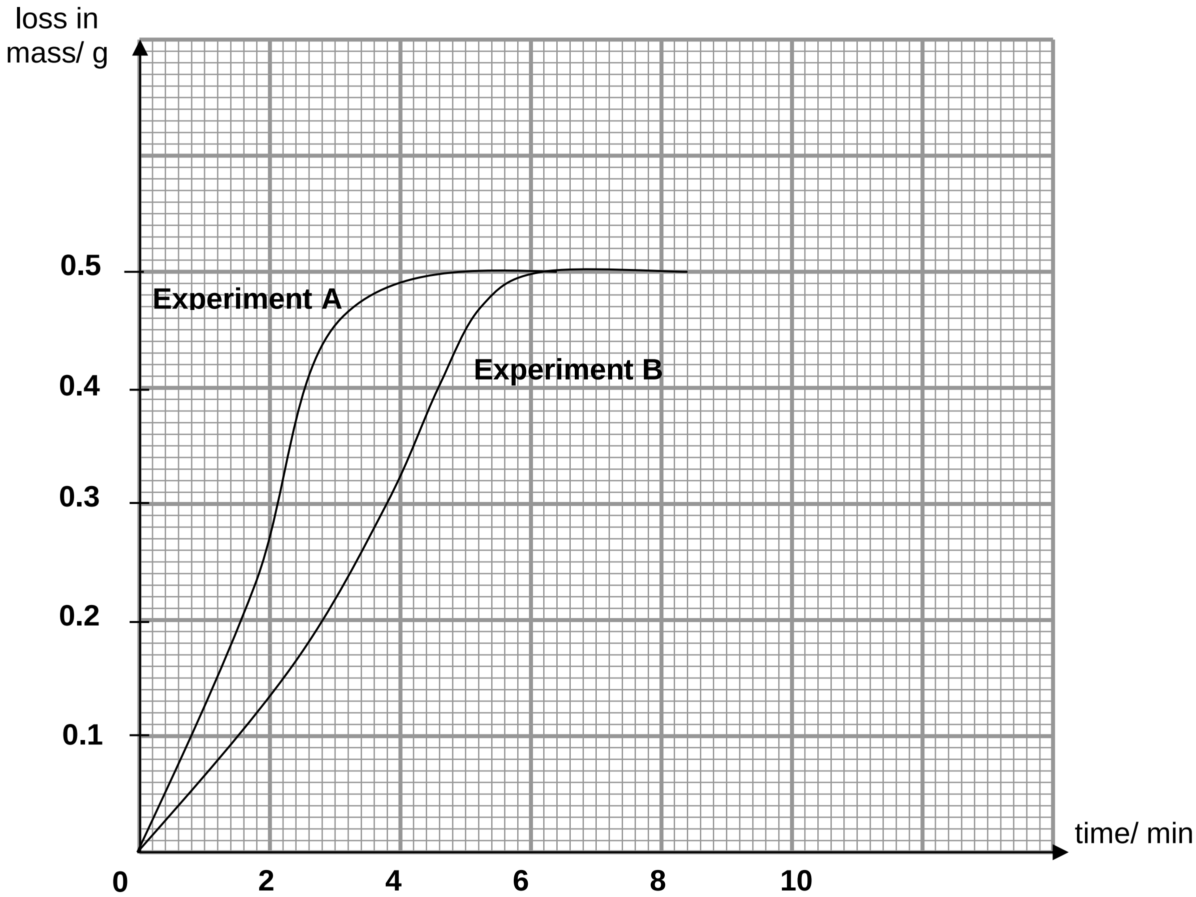
[Total: 10]

[Turn over

B8 Lead(II) carbonate reacts with dilute nitric acid as shown by the equation below:

$$PbCO_3(s) + 2HNO_3(aq) \rightarrow CO_2(g) + Pb(NO_3)_2(aq) + H_2O(l)$$

Two experiments are carried out at 30 °C and 40 °C using excess dilute nitric acid. All other experimental conditions were kept constant. The results are shown in the graphs below.



(a) With reference to the shape of the graph, state which experiment was carried out at 40 °C. Explain your answer in terms of collisions between particles.

....

....

....

....

....

.... [4]

(b) Explain why there was a loss in mass over time.

.... [1]

(c) Calculate the mass of lead(II) carbonate used in each experiment.

mass of lead(II) carbonate = ... [3]

(d) If temperature was kept constant at 30 °C for both experiments **A** and **B**, what other conditions could have resulted in the results shown in the graphs?

....

.... [1]

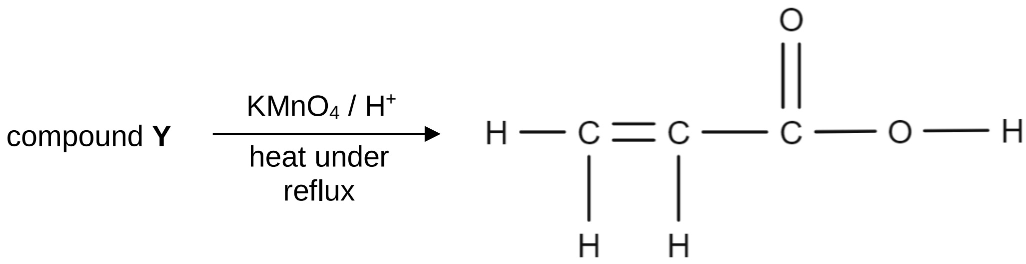
(e) Experiment **B** is repeated using half the mass of lead(II) carbonate. All other conditions are kept constant.

On the graph, draw a graph to show the results you would expect to obtain. Label this graph as Experiment **C**. [1]

[Total: 10]

[Turn over

B9 Either Organic compound **Y** was heated under reflux with acidified potassium manganate(VII) solution to form compound **Z**. The reaction is show below.



compound **Z**

(a) **(i)** Name the reaction above.

....

Describe the observation seen.

....

.... [2]

(ii) Hence, draw the full structural formula of compound **Y**.

[1]

(b) A few drops of liquid bromine were added to compound **Z**.

(i) Name the reaction and describe the observation seen.

....

.... [2]

(ii) Hence, draw the full structural formula of the product formed.

[1]

(c) On warming **Z** with ethanol and a few drops of concentrated sulfuric acid, a sweet smelling substance was formed.

Draw the full structural formula and circle the functional group that gave the compound the sweet smell.

[2]

(d) Under suitable conditions, compound **Z** undergoes addition polymerisation.

(i) State the conditions necessary for compound **Z** to undergo addition polymerisation.

.... [1]

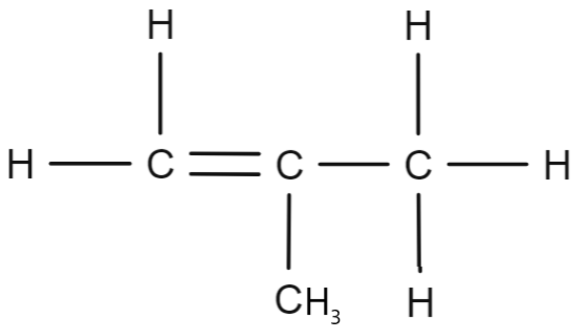
(ii) Draw the structural formula of the polymer formed, showing three repeating units.

[1]

[Total: 10]

[Turn over

B9 Or The World Cup soccer ball's innermost layer is a spherical bladder formed from butyl rubber. Butyl rubber is composed mostly of isobutylene. The structure of isobutylene is shown below.



isobutylene

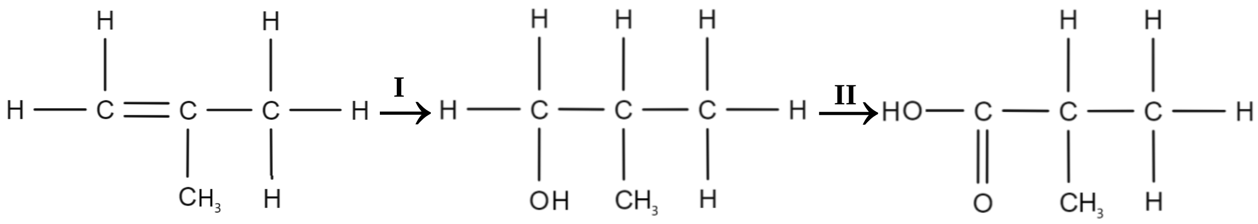
(a) **(i)** Name the homologous series that isobutylene belongs to and state its general formula.

.... [2]

(ii) Draw an isomer of isobutylene.

[1]

(b) The following shows a reaction scheme to obtain the final product, compound **X**.



isobutylene

compound **X**

(i) State the reagent and conditions necessary for reaction **I**.

....

.... [2]

(ii) Describe a test to differentiate between isobutylene and compound **X**.

....

.... [2]

[Turn over

(c) Once the bladder has been formed into a sphere, it is wound with several thousand metres of nylon thread.

(i) Draw the structural formula of the linkage present in nylon in the space below and state its name.

[2]

(ii) Describe one environmental problem associated with using plastics like nylon.

....

.... [1]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

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	Class	Register Number
Candidate Name ____________________		

PEIRCE SECONDARY SCHOOL

Department of Science

GCE 'O' Level Preliminary Examination I for Secondary Four Express

CHEMISTRY **6092 / 2**

Wednesday **2 May 2018** **0900 -1045**

Duration **1 hr 45 mins**

INSTRUCTIONS TO CANDIDATES

Write your name, class and register number in the spaces provided at the top of this page.

Section A (50 marks)
Answer all questions. Write your answers in the spaces provided on the question paper

Section B (30 marks)
Answer all questions. Write your answers in the spaces provided on the question paper

PARENT'S SIGNATURE

For Examiner's Use		
Section A		
Section B	**B9**	
	B10	
	B11	
Total		

This paper consists of **26** printed pages.
Setter: Mr Ashwin Selvarajan

Section A (50 marks)

Answer **all** questions in the spaces provided.

A1 Select, from the following list, one method / apparatus by which each of the following may be used for the stated purpose / separation.

You may use the method / apparatus once, more than once, or not at all.

Separating funnel	Electrolysis	Chromatography
Sublimation	Filtration	Simple distillation
Crystallisation	Combustion	Fractional distillation
Evaporation to dryness		

(a) To test for banned drugs in athletes' urine samples. **[1]**

....

(b) To obtain hydrated copper(II) sulfate salt from its solution. **[1]**

....

(c) To obtain dilute sulfuric acid from a mixture containing sulfuric acid and liquid hexane. **[1]**

....

(d) To obtain oxygen gas from dilute sulfuric acid. **[1]**

....

(e) **(i)** To obtain oxygen gas from the atmosphere. **[1]**

....

(ii) Explain why oxygen gas can be obtained using the method stated in **(e)(i)**. **[1]**

....

[Total: 6 marks]

A2 Table 2.1 shows the properties of the different types of oxides formed by the Group IV elements.

Table 2.1

Element	Formula of oxides formed	Stability of oxides	Nature of oxide
Carbon	CO	Readily oxidised to dioxide	Neutral
	CO_2	Stable at high temperatures	Acidic
Silicon	SiO	Readily oxidised to dioxide	Neutral
	SiO_2	Stable at high temperatures	Acidic
Germanium	GeO	Readily oxidised to dioxide	Amphoteric
	GeO_2	Stable at high temperatures	Amphoteric
Lead	PbO	Readily oxidised to dioxide	Amphoteric
	PbO_2	Decomposes to PbO on warming	Amphoteric

(a) Using the data given in Table 2.1, describe one similarity in how the Group IV elements form oxides. **[2]**

....

....

....

(b) What does the trend in the nature of the oxides suggest about the metallic character of the elements in Group IV? **[1]**

....

(c) Both SiO_2 and GeO_2 are stable at high temperatures. Explain, in terms of bonding and structure, for the different reasons which contribute to the thermal stability of SiO_2 and GeO_2. **[2]**

....

....

....

....

[Total: 5 marks]

A3 Different salts were made by reacting an excess of a carbonate **X** with an acid **Y**. Unreacted solids were separated by filtration and the salt was recovered from the filtrate by evaporation to dryness.

Fig 3.1 shows the first three steps used to prepare these salts.

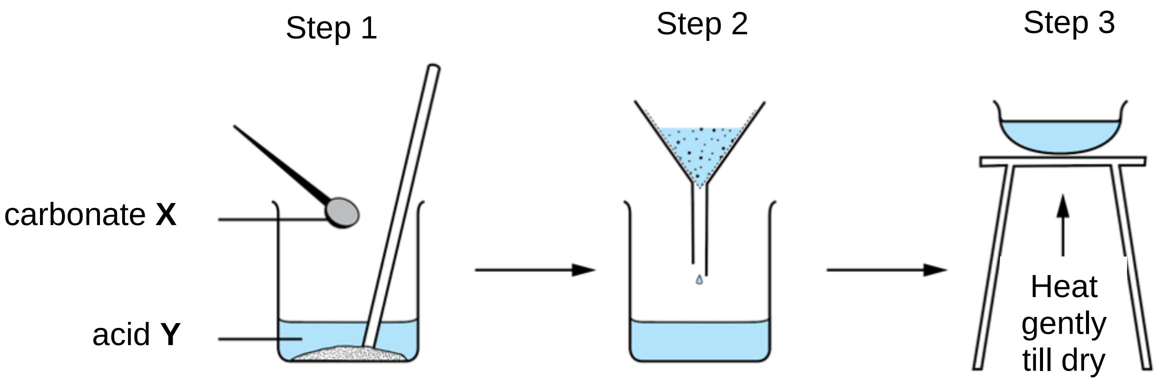

Fig 3.1

Four experiments were carried out using different combinations of **X** and **Y** to prepare salts. The percentage yield of each experiment is given in Table 3.1.

Table 3.1

Experiment	**X**	**Y**	**Salt prepared**	**Percentage yield of salt / %**
1	$CuCO_3$	H_2SO_4	$CuSO_4$	95
2	$ZnCO_3$	HNO_3	$Zn(NO_3)_2$	92
3	$CaCO_3$	H_2SO_4	$CaSO_4$	18
4	Ag_2CO_3	HCl	$AgCl$	< 1

(a) The copper(II) sulfate obtained in experiment 1 was white in colour. **[1]**

When experiment 1 was modified in the last step by recovering copper(II) sulfate by crystallisation instead of by evaporation to dryness, the percentage yield became 140%.

Explain why the percentage yield increased when the salt was recovered by crystallisation.

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(b) Explain why the yields were low in experiments 3 and 4. **[2]**

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[Total: 3 marks]

A4 Table 4.1 shows the ease at which different metal oxides can be reduced using carbon powder.

Table 4.1

metal oxide	ease of reduction
calcium oxide	Not reduced by carbon at 1800 ^{0}C
iron(III) oxide	Reduced by carbon at 650 ^{0}C
silver oxide	Reduced by heating without carbon
titanium(IV) oxide	Reduced by carbon at 1800 ^{0}C but not at 650 ^{0}C

(a) Use the information in Table 4.1 to place the metals in order of reactivity, starting from the least reactive metal. **[1]**

....

(b) Iron(III) oxide can also be reduced by hydrogen gas to form iron metal. The reaction can be represented by the following chemical equation.

$$Fe_2O_3\,(s) + 3H_2\,(g) \longrightarrow 2Fe\,(s) + 3H_2O\,(g)$$

Fig 4.2 shows the process where a continuous stream of dry hydrogen gas was supplied.

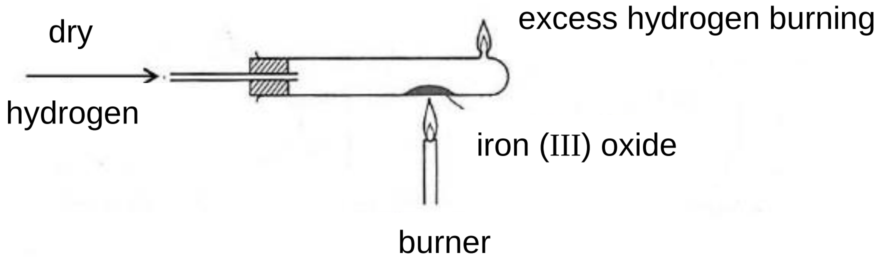

Fig 4.2

(i) Explain why dry hydrogen gas is necessary for this process. **[1]**

....

(ii) Besides checking the melting point, the purity of iron can also be determined by the measurement of mass. Describe briefly how iron obtained at the end of the experiment can be determined to be pure. **[2]**

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(iii) 14.4 g of iron(III) oxide is reduced by an excess volume of hydrogen gas. Calculate the maximum volume of steam, in dm^3, produced by this reaction at room temperature and pressure. **[2]**

Show your working as clearly as possible.

(iv) The use of hydrogen gas to obtain metals from metal oxides is not environmentally friendly. **[1]**

Explain why this statement is true.

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[Total: 7 marks]

A5 Peroxodisulfate(VII) ions, $S_2O_8^{2-}$, react with iodide ions in aqueous solution.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

Table 5.1 shows how the relative rate of this reaction changes when different concentrations of peroxodisulfate ions and iodide ions are used.

Table 5.1

experiment	concentration of $S_2O_8^{2-}$ in mol/dm^3	concentration of I^- in mol/dm^3	relative rate of reaction
1	0.008	0.02	1.7
2	0.016	0.02	3.3
3	0.032	0.02	6.8
4	0.008	0.04	3.4
5	0.008	0.08	6.9

If a small amount of Fe^{2+} ions are added to the reaction mixture, they will react with the peroxodisulfate(VII) ions, forming Fe^{3+} ions, which will then react with the iodide ions via the following two stages:

Stage 1: $2Fe^{2+}(aq) + S_2O_8^{2-}(aq) \longrightarrow 2Fe^{3+}(aq) + 2SO_4^{2-}(aq)$

Stage 2: $2Fe^{3+}(aq) + 2I^-(aq) \longrightarrow 2Fe^{2+}(aq) + I_2(aq)$

Use the information given above to answer the following questions.

(a) Using collision theory, state and explain the effect of the concentration of peroxodisulfate(VII) ions on the relative rate of reaction. **[2]**

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(b) State the role of Fe^{2+} ions in this chemical reaction. **[1]**

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(c) Explain why stage 2 is a redox reaction, in terms of electrons. **[3]**

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(d) One drop of sodium astatide solution was added to the solution after the Fe^{2+} ions were removed at the end of Stage 2 leaving behind iodine. State all observations and explain. **[2]**

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[Total: 8 marks]

A6 A student investigated the electrolysis of aqueous copper(II) sulfate using the apparatus shown in Fig 6.1.

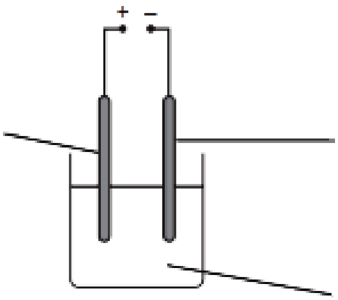

Fig 6.1

The student carried out three experiments and weighed the copper cathode before and after electrolysis.

Table 6.2

Experiment number	Current used / A	Time taken / s	Mass of cathode	
			Before electrolysis / g	After electrolysis / g
1	2.0	180	1.24	1.36
2	4.0	180	1.20	1.44
3	2.0	360	1.34	1.58

(a) In experiment 2, the student measured the mass of the anode before and after electrolysis. **[1]**

The mass of the anode at the start was 1.45 g. Determine the mass of the anode after electrolysis.

(b) The student carries out a fourth experiment, this time using a current of 8.0 A for 90 seconds. **[1]**

The mass of the cathode at the start was 1.51 g. Predict the mass of the cathode after electrolysis.

(c) The student carried out a fifth experiment. **[4]**

Carbon electrodes are now used instead of copper electrodes, with all other conditions kept the same as experiment 1.

Describe and explain the difference in observations at the electrode(s) and in the electrolyte.

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[Total: 6 marks]

A7 Solid **P** is a metal carbonate.

Fig 7.1 shows how the mass of the solid in a boiling tube changes as the experiment progresses.

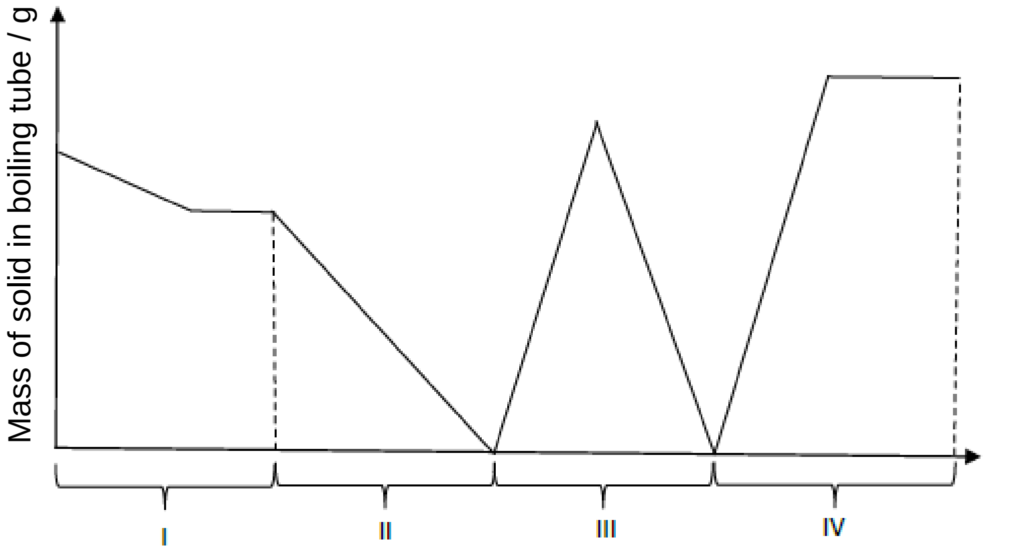

Fig 7.1

There are four stages of the experiment.

stages	Description
I	Solid **P** is heated strongly with a non – luminous flame to form Solid **Q.**
II	Excess dilute hydrochloric acid is added to Solid **Q**.
III	Aqueous ammonia is added to the reaction mixture from stage II.
IV	Aqueous silver nitrate is added to the reaction mixture from stage III.

(a) Suggest the identity of the cation present in Solid **P** using stage III. **[3]**

Explain your answer.

....

....

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....

(b) Write the ionic equation for the formation of the solid in stage IV. **[2]**

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[Total: 5 marks]

A8 Sulfur dioxide is used to manufacture sulfuric acid, by a three-stage process called the Contact Process. The first stage is to convert sulfur dioxide to sulfur trioxide. During this process, sulfur dioxide gas and sulfur trioxide gas are released to the environment.

$$2\ SO_2\,(g) + O_2\,(g) \rightleftharpoons 2\ SO_3\,(g) \qquad \Delta H = -\ 197\ \text{kJ/mol}$$

(a) The above reaction takes place at a moderate temperature of 450 °C. Suggest why this temperature is used in the Contact Process instead of a lower or higher temperature. **[2]**

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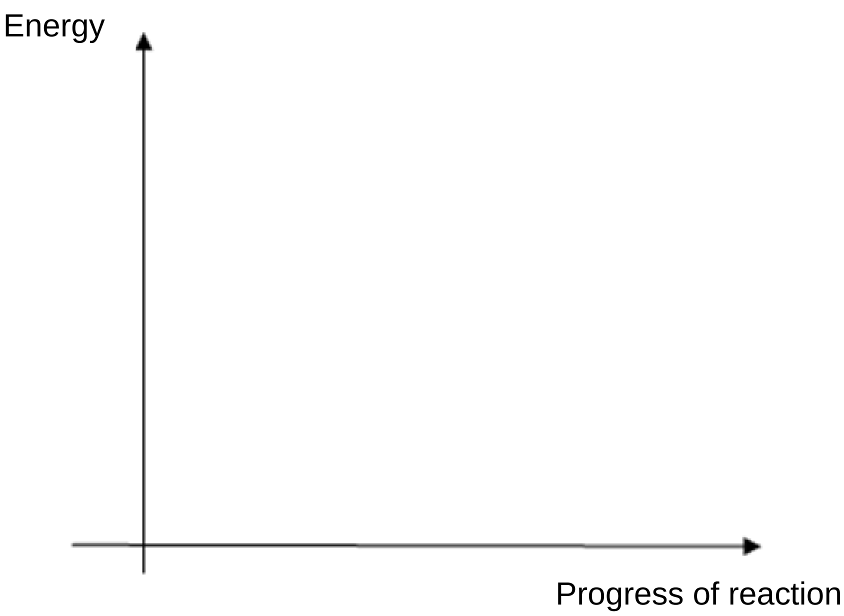
(b) Complete the energy profile diagram for the forward reaction in the production of sulfur trioxide. **[3]**

Your diagram should include

- the **formulae of the reactants and products** of the reaction,
- a label for **the activation energy of reaction**,
- a label for **the enthalpy change of reaction**.



(c) Using ideas about colliding particles, state and explain how the rate changes when the pressure is increased. **[2]**

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(d) The product of the Contact Process is concentrated sulfuric acid (98%) with only 2% of the mass being water. **[2]**

Explain why it is possible to transport sulfuric acid of such high concentration using steel tanks but not for dilute sulfuric acid.

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(e) Suggest a possible metal that can be used as a catalyst for this reaction, stating your reason clearly. **[1]**

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[Total: 10 marks]

Section B (30 marks)
Answer all **three** questions from this section

The last question is in the form **EITHER/OR** and only **one** alternative should be attempted.

B9 An atom gains or loses electron(s) to form an ion.

The energy required to remove 1 mole of electron from 1 mole of gaseous atoms is called the first ionisation energy.

The energy change on addition of 1 mole of electron to 1 mole of gaseous atoms or ions is called the electron affinity.

Table 9.1 shows the first ionization energy of some common elements.

Table 9.1

Elements	First Ionisation energy / kJ/mol	Elements	First Ionisation energy / kJ/mol
H	1310	Ne	2080
He	2370	Na	494
Li	519	A*l*	577
Be	900	Si	786
C	1090	S	1000
O	1310	C*l*	1200

Table 9.2 shows the electron affinity and melting points of three halogens.

Table 9.2

Halogens	Electron Affinity / kJ/mol	Melting Point / ^{0} C
Chlorine	-349	-101
Bromine	**Y**	-7
Iodine	-295	114

(a) Predict which element in Period 3 will have the highest first ionisation energy. Explain your answer. **[2]**

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(b) "The first ionisation energy of elements generally decreases down a group." **[3]**

Do you agree with the above statement? Explain your answers based on the data given as well as the atomic size of an element.

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(c) Calculate the energy required to remove the outermost electrons from 2.5 g of lithium atoms. **[2]**

(d) Predict the electron affinity of bromine. **[1]**

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(e) Explain why chlorine has a lower melting point than iodine. **[2]**

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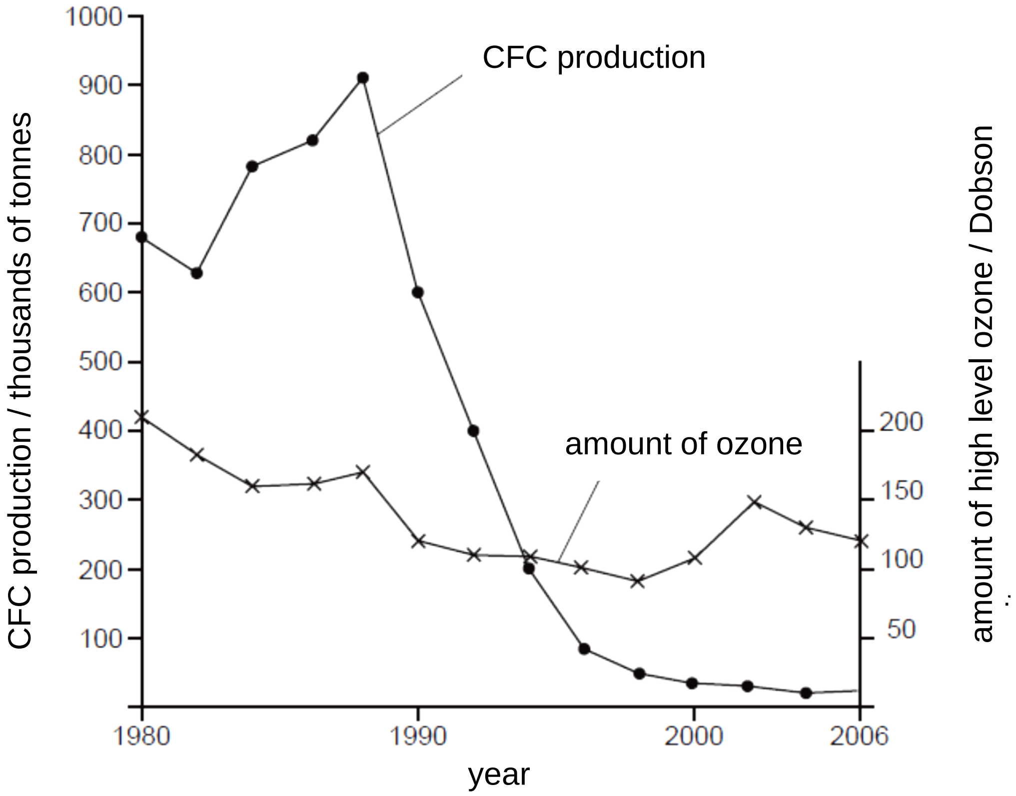
[Total: 10 marks]

B10 A thin layer of ozone, O_3, is present high in the Earth's atmosphere.
The graph shows how both the world chlorofluorocarbon (CFC) production and the amount of high level ozone at the South Pole have changed from 1980 to 2006.



(a) Explain why the ozone layer is important in terms of human health. **[1]**

....

....

(b) Chlorofluorocarbons, CFCs, catalyse the conversion of ozone to oxygen. Write the equation for this reaction. **[1]**

....

(c) Describe how the world production of CFCs has changed from 1980 to 2006. **[2]**

....

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(d) Using the graph, what is the relationship between the world CFC production and the amount of high-level ozone in the atmosphere at the South Pole? Explain your answer. **[3]**

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(e) **Ozone-depleting substances (ODS)** are substances containing chlorine or bromine, which destroy the stratospheric ozone layer that absorbs most of the biologically damaging ultraviolet radiation. The phasing out of ODS, and their substitution by less harmful substances or new processes, are aimed at the recovery of the ozone layer. The indicators signify progress made towards meeting the commitments to phase out the use of ODS in countries which have ratified the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer and its Amendments of London (1990), Copenhagen (1992), Montreal (1997) and Beijing (1999). Substances controlled by the Montreal Protocol include chlorofluorocarbons (**CFCs**), halons, methyl bromide, among others. In the table, **All ODS** refers to the aggregate consumption, in tonnes, for the controlled substance categories that have data available.

	Consumption of CFCs in tonnes			**Consumption of all ODS in tonnes**		
	Baseline	**2008**	**Reduction from Baseline**	**2002**	**2008**	**Reduction from 2002**
Japan	118134.0	-0.343	100.0	2466.8	1050.0	57.4
Singapore	2718.2	0.0	100.0	146.7	149.5	-1.9
Thailand	6082.1	190.3	96.9	3612.5	1197.5	66.9

(Adapted from: https://unstats.un.org/unsd/environment/ODS_Consumption.htm)

(i) Suggest one chemical property of chlorine or bromine that results in it destroying the stratospheric ozone layer. **[1]**

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(ii) Using values from the table, suggest a reason for the difference in Singapore's consumption of CFC and consumption of all ODS in 2008. **[2]**

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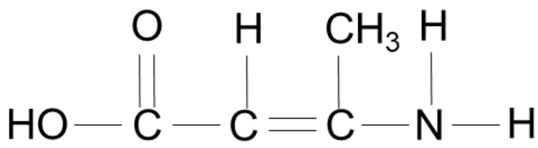
[Total: 10 marks]

Either

B11 An organic compound **T** has the structural formula:



(a) Describe what you would observe when a few drops of aqueous bromine is added to the compound **T**. State the type of reaction that has occurred. **[2]**

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(b) On warming compound **T** with a few drops of concentrated sulfuric acid and ethanol, a sweet-smelling substance was formed.

(i) Name the functional group in compound **T** that was involved in this reaction. **[1]**

……………………………………………………………………………

(ii) Draw the full structural formula of the compound that gave the sweet smell. **[1]**

(c) State one difference between condensation polymerisation and addition polymerisation. **[1]**

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(d) **(i)** Draw the structure of the polymer showing two repeating units when compound **T** undergoes **addition polymerisation**. **[1]**

(ii) State one difference in property between compound **T** and the polymer formed in **d(i)**. **[1]**

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(e) **(i)** Draw the structure of the polymer showing two repeating units when compound T undergoes **condensation polymerisation**. **[2]**

linkage present ………………………..

(ii) A student claimed that the polymer formed in **e(i)** does not have a sharp melting point. Do you agree? Explain why. **[1]**

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[Total: 10 marks]

Or

B12 Lactic acid, α-alanine and β-alanine are three naturally occurring acids.

Their formulae are:

lactic acid	$CH_3CH(OH)COOH$
α-alanine	$CH_3CH(NH_2)COOH$
β-alanine	$NH_2CH_2CH_2COOH$

(a) Explain why these three compounds are considered as *weak acids*. **[2]**

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(b) Draw and label the displayed formulae of α-alanine and β-alanine. **[2]**

(c) The same number of mole of α-alanine and β-alanine each burn to produce the same amount of products. **[1]**

Do you expect their enthalpy change of combustion to be the same?

Explain your answer.

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(d) Draw the structural formulae of two different possible **small organic** molecules formed when lactic acid reacts with α-alanine. **[4]**

(e) The three acids can undergo polymerisation with each other. **[1]**

One possible structure of the polymer formed is shown below.

— $\boxed{\text{lactic acid}}$ — $\boxed{\alpha\text{-alanine}}$ — $\boxed{\beta\text{-alanine}}$ —

Explain why when a mixture of the three acids polymerises, the polymer is unlikely to contain only this regular, repeating pattern.

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[Total: 10 marks]

– The End –

EXP	PUNGGOL SECONDARY SCHOOL SECONDARY 4 EXPRESS PRELIMINARY EXAMINATION **QUESTION & ANSWER BOOKLET**

NAME

CLASS | INDEX NUMBER

Chemistry 6092

Paper 2

26 August 2022

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, register number and name on all the work you hand in.
Write in dark blue or black ink on both sides of the paper.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A (50 marks)
Answer **all** questions.

Section B (30marks)
Answer all **three** questions. The last question is in the form either /or.
Answer **all** questions in the spaces provided.

Write your answers in the spaces provided.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's use	
Section A	/50
Section B	/30
-	-
Total	/80

Parent's Signature

This paper consists of **20** printed pages and **0** blank page.

Section A
Answer **all** the questions in the spaces provided.

A1 A list of ions are given below.

iodide	ammonium	copper(II)	iron(II)	hydroxide
sulfate	iron(III)	manganate(VII)	nitrate	hydrogen

Choose from the list above

(a) **(i)** an ion that forms a yellow precipitate when added to aqueous silver nitrate.

.... [1]

(ii) an ion that produces ammonia gas when warmed with aqueous sodium hydroxide.

.... [1]

(iii) an ion that produces carbon dioxide gas when added to sodium carbonate.

.... [1]

(iv) an ion that is used to convert ethanol to ethanoic acid.

.... [1]

(v) two ions when added together produces a green precipitate that turns brown on standing in air.

.... and .... [1]

(b) Write two equations to represent the reactions in **(a)(v).**

Ionic equation when two ions are added together.

....

Chemical equation when green precipitate turns brown on standing in air. Water is one of the reactants in this reaction.

.... [2]

[Total: 7]

A2 The process of splitting a nucleus is known as nuclear fission. In nuclear fission, a neutron ($^{1}_{0}n$) is fired at a nucleus, which absorbs it and breaks into smaller particles.

In the nuclear fission of uranium-235, barium-141 is obtained as one of the products, together with an unknown atom **X** and 3 free neutrons. The reaction that occurs can be represented by the following equation with nuclide notations:

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{141}_{56}Ba + \mathbf{X} + 3\,^{1}_{0}n$$

There are no loss of protons and neutrons in the process.

(a) **(i)** State the number of protons, neutrons, and electrons in an atom of uranium-235.

protons: …………… neutrons: …………….. electrons: ………………… [2]

(ii) Determine the nuclide notation of atom **X**, showing clearly the chemical symbol, mass number and proton number in your answer.

……………………………………………………………………………………… [1]

(b) A compound of barium, **Y**, is used in fireworks.

Y has the following percentage composition by mass:

Ba: 45.1 C*l*: 23.4 O: 31.5

The relative molecular mass of **Y** is 304. Determine the molecular formula of **Y**.

[2]

[Total: 5]

A3 Bars of zinc can be fixed to a ship's hull to prevent ship's steel body from rusting.

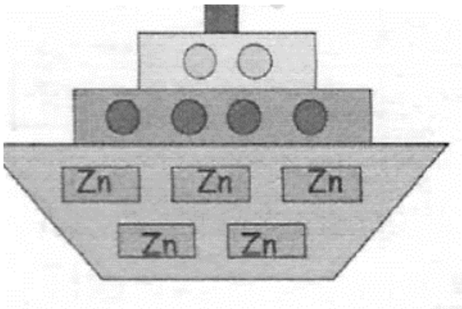


Fig. 3.1

.

(a) Explain how zinc protects ship's steel body from rusting.

Include an ionic half-equation to show what happens to zinc in your answer.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) Oil and paint can also be used to prevent rusting.

Explain how oil and paint prevent rusting.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(c) Using alloys is another method to prevent rusting. Steel is an alloy of iron with carbon and other metals.

Alloys are also used to lower melting point of metals which is used in soldering process to join different types of metals together by melting solder.

Fig. 3.2 is a graph which shows the melting points of mixtures of cadmium and zinc used to make an alloy called Kapp alloy.

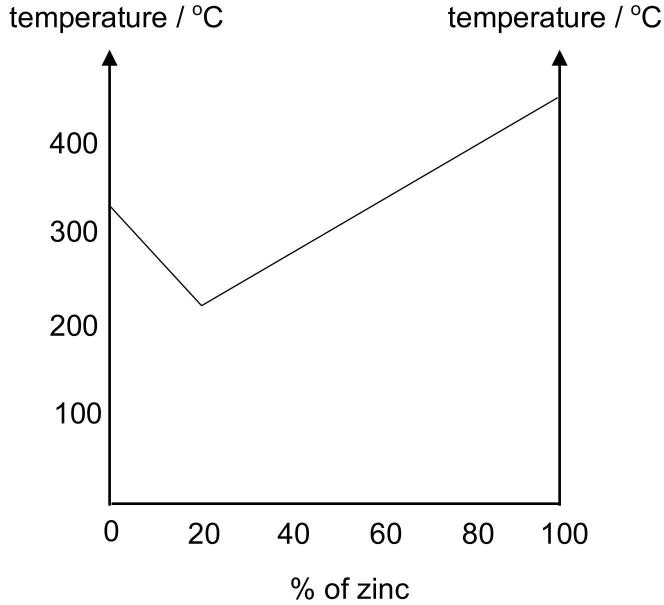


Fig. 3.2

(i) Some types of steel contain more carbon than others.

State one difference in the properties of high carbon steel from those of low carbon steel.

....

.... [1]

(ii) The melting point of a metal depends on the charge and size of the metal cation. The melting point of a metal is higher if the charge is higher and the size of metal cation is smaller.

Cadmium forms ions with charge of +2. Use data from the graph and the information given to account for the difference in the melting point of pure cadmium and pure zinc.

....

....

....

.... [2]

(iii) Determine the optimal ratio of cadmium : zinc to make Kapp alloy for soldering process.

……………………………………………………………………………………… [1]

[Total: 7]

A4 In recent years, there is an increasing demand for diamond simulants. Diamond simulants are materials which look like diamonds visually but they cost much lesser than real diamonds.

(a) One common diamond simulant is cubic zirconia, which is actually the cubic crystalline form of zirconium dioxide, ZrO_2.

Table 4.1 shows the melting point of zirconium dioxide and sodium oxide.

Table 4.1

	melting point / °C
ZrO_2	2750
Na_2O	1132

In terms of structure and bonding, explain the difference in the melting point.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………….. [3]

(b) Zirconium dioxide can be used to catalyse the decomposition of hydrogen peroxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

(i) Explain why zirconium dioxide can act as a catalyst but not sodium oxide.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) Explain, in terms of collisions and energy, why zirconium dioxide increases the rate of decomposition of hydrogen peroxide.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(iii) A disproportionation reaction is a redox reaction in which one substance is simultaneously oxidised and reduced.

State and explain whether decomposition of hydrogen peroxide is a disproportionation reaction.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………. [3]

(c) Boron nitride, BN, can exist in a form which resembles the structure of diamond shown in Fig. 4.2

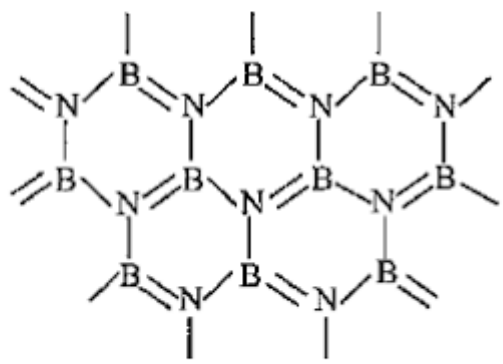


Fig. 4.2

(i) Suggest why it is possible for each boron atom in the structure to form four covalent bonds with nitrogen atoms although boron only has three valence electrons.

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(ii) Boron nitride with the structure shown in Fig. 4.2 does not conduct electricity. Suggest a reason to explain the observation.

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [1]

[Total: 11]

A5 A circuit is connected as shown in the diagram below and a current is passed through for a period of time. Platinum is used as the electrodes.

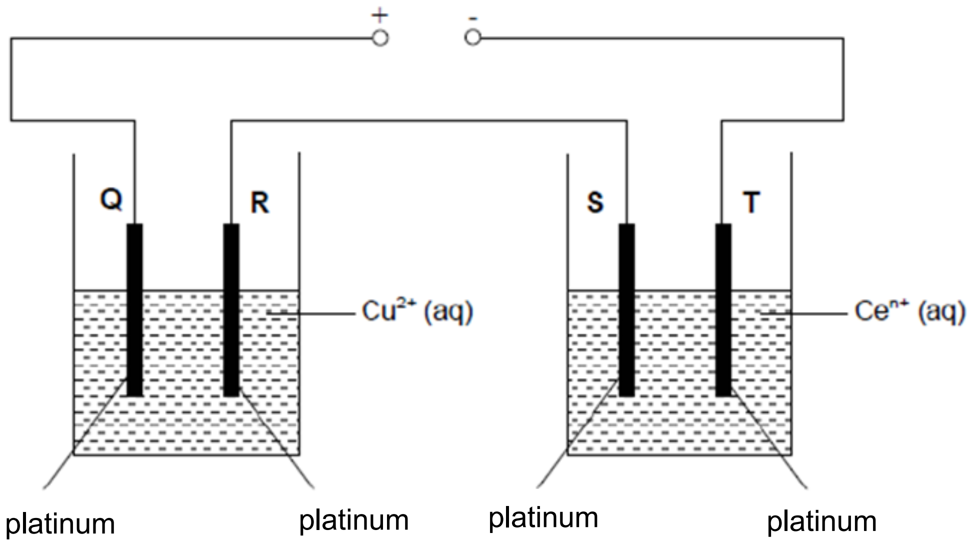


Fig. 5.1

(a) 12.8 g of copper and 14.0 g of cerium are deposited at electrodes **R** and **T** respectively. The charge on the copper ion was 2+.

Determine the charge on the cerium ion.

[Ar: Ce, 140 and Cu, 64]

[3]

(b) Use the experimental result to predict whether cerium react with an acid. Explain your prediction in terms of relative position of cerium in the reactivity series.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………………………………………………….. [2]

[Total: 5]

A6 Beryllium, magnesium and calcium are the first three elements in Group II. The trend in the reactivity of metals down the group is similar to that of Group I.

(a) Rank these elements in increasing order of time taken for complete reaction with dilute hydrochloric acid at room conditions.

……………………………………………………………………………………………….. [1]

(b) A gas is produced when magnesium reacts with dilute hydrochloric acid. Name the gas and describe a laboratory test for this gas.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………………………………………………….. [2]

(c) Name two compounds that can be used to prepare magnesium sulfate salt.

……………………………………………………………………………………………….. [2]

[Total: 5]

A7 The amount of air pollutants emitted by a car depends on its driving mode – whether it is idling or accelerating.

Table 7.1 shows the composition of unburnt hydrocarbons (C_xH_y), nitrogen oxides (NO_x) and carbon monoxide (CO) emitted by a car engine in two different modes.

'ppm' means part per million which is a common unit used to measure the concentration of air pollutant. Higher ppm means higher concentration of air pollutant.

Table 7.1

Driving mode	**Air / petrol mixture**	**Temperature of the car engine**	**Concentration of air pollutant / ppm**		
			C_xH_y	NO_x	CO
Idling	less air	lower	2800	130	45000
Accelerating	more air	higher	20	820	21000

(a) **(i)** How is nitrogen monoxide formed in a car engine? Include an equation to illustrate your answer.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(ii) Describe one environmental problem caused by emission of nitrogen oxides from car engine.

…………………………………………………………………………………………...

…………………………………………………………………………………………... [1]

(iii) Nitrogen monoxide, NO, reacts with ozone in a two-step reaction.

Step 1: $NO + O_3 \rightarrow NO_2 + O_2$

Step 2: $NO_2 + O_3 \rightarrow NO + 2O_2$

Use the equations for step 1 and step 2, state the role of nitrogen monoxide and hence explain why one molecule of nitrogen monoxide can destroy many more ozone molecules.

…………………………………………………………………………………………....

………………………………………………………………………………………… [2]

(b) Comment on the difference in the concentration of air pollutants when the car is in the two different driving modes shown in Table 7.1.

Suggest reasons for the difference.

....

....

....

....

....

....

....

.... [3]

(c) One way of reducing the amounts of carbon monoxide and nitrogen oxides from cars is to use catalytic converters. The equation for one reaction that happens in a catalytic converter is shown.

$$2CO + 2NO \rightarrow 2CO_2 + N_2$$

A student claimed that catalytic converters “solved all car pollution problems”. Explain why the student is not correct.

....

....

.... [2]

[Total: 10]

Section B
Answer all **three** questions in the spaces provided.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Magnesium found in oceans

Magnesium is an important element for plant and animal life. It can be found in a number of minerals such as dolomite, $CaMg(CO_3)_2$ and magnesite, $MgCO_3$, and may enter water through weathering of rocks. Magnesium is the third most abundant element dissolved in oceans, and is estimated to be present in concentration of about 1300 parts per million (ppm). [1 ppm of magnesium = 1 mg of magnesium in 1 dm^3 of solution]

About 71% of the Earth's surface is covered by water. The oceans of the planet have an area of about 3.60×10^{14} m^2 with an average depth of about 3.7×10^3 m.

Extraction of magnesium using Pidgeon process

In the mid-1990s, magnesium was obtained mainly by electrolysis of magnesium salts from seawater. China has taken over United States as the dominant supplier of magnesium, making use of a silicothermic reduction known as the Pidgeon process. This process is less complex technologically while maintaining a comparable energy efficiency to electrolytic ones and produces magnesium of very high purity.

Calcium hydroxide is added to sea water to precipitate magnesium hydroxide. The magnesium hydroxide is then heated to give magnesium oxide by removal of water.

The magnesium oxide and silicon are then heated strongly according to the equation below. The magnesium formed is purified by fractional distillation. Table 8.1 shows the melting point and boiling point of magnesium and the common impurities found during the purification process.

$$Si(s) + 2MgO(s) \rightarrow SiO_2(s) + 2Mg(g)$$

Table 8.1

substance	melting point / °C	boiling point / °C
Mg	650	1091
MgO	3125	3873
Si	1414	3265
SiO_2	1700	2230

Diagonal relationships in the Periodic Table

It was found that period two elements show similar physical and chemical properties to period three elements that are diagonally placed on the Periodic Table. The three pairs of elements that show diagonal relationships are shown in Fig. 8.2.

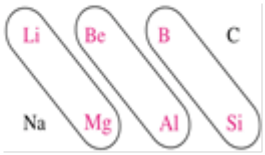


Fig. 8.2

For example, the properties of Be (Group II metal) is similar to A*l* (Group III metal). Both Mg and Be are Group II metals. $MgCl_2$ is an ionic compound. However, $BeCl_2$ is a simple covalent molecule, just like $AlCl_3$.

(a) **(i)** Use the data given to estimate the volume of the Earth's oceans in dm^3.

$1\ m^3 = 10^3\ dm^3$

[1]

(ii) Use the data given to estimate the concentration, in g/dm^3, of magnesium in the oceans.

$1\ mg = 10^{-3}\ g$

[1]

(iii) Use your answers in **(a)(i)** and **(a)(ii),** estimate the total mass of magnesium in the oceans.

[1]

(b) **(i)** In Pidgeon process, magnesium is purified by using fractional distillation. Explain why fractional distillation is suitable for this purification.

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(ii) Using data from Table 8.1, suggest the minimum and maximum temperatures for Pidgeon process.

…………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(c) Write an equation to show how magnesium oxide used in Pidgeon process is obtained from magnesium hydroxide.

………………………………………………………………………………………….. [1]

(d) **(i)** Group I and II metal nitrates decompose in different ways. The two equations below show how sodium nitrate and magnesium nitrate decompose when heated strongly.

$$2NaNO_3 \rightarrow 2NaNO_2 + O_2$$
$$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$$

Use ideas of diagonal relationships in Periodic Table, suggest the equation for the thermal decomposition of lithium nitrate.

………………………………………………………………………………………….. [1]

(ii) Use ideas of diagonal relationships in Periodic Table, predict whether beryllium oxide react with sodium hydroxide. Explain your answer.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

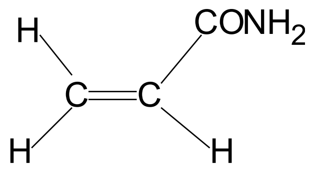
………………………………………………………………………………………….. [2]

[Total: 10]

B9 Acrylamide is a substance that forms through a natural chemical reaction between sugars and asparagine, an amino acid, in plant-based foods including potato and cereal-grain-based foods. Acrylamide forms during high-temperature cooking, such as frying, roasting, and baking.

Under suitable conditions, acrylamide undergoes polymerisation to form poly(acrylamide).

The structure of acrylamide is shown below.



acrylamide

(a) **(i)** State the type of polymerisation that acrylamide undergo to form poly(acrylamide).

………………………………………………………………………………………….. [1]

(ii) Draw the structure of poly(acrylamide) with three repeating units.

[2]

(iii) A sample of poly(acrylamide) has an average relative molecular mass of 852000.

Calculate the number of monomers in a molecule of the polymer.

[2]

(iv) Poly(acrylamide) is widely used in applications such as water treatment and Botox which is injected into patients for aesthetic facial surgery.

Suggest a property of poly(acrylamide) that makes it suitable for the applications.

……………………………………………………………………………………….. [1]

(b) Draw the structures of the products formed when acrylamide reacts with

(i) aqueous bromine
(ii) steam at high temperature and pressure in the presence of a catalyst. There are two products formed.

(i)

(ii) and [3]

(iii) State the observation for the reaction in **(b)(i).**

……………………………………………………………………………………….. [1]

[Total: 10]

Either

B10 Similar to extraction of iron in a blast furnace, zinc is extracted from its ore zinc blende, which contains zinc sulfide, ZnS, and impurities including sand.

The ore is heated in air to produce zinc oxide and sulfur dioxide. The zinc oxide can then be heated with coke and limestone in a blast furnace. Fig. 10.1 shows a simplified diagram of blast furnace used to extract zinc from its ore.

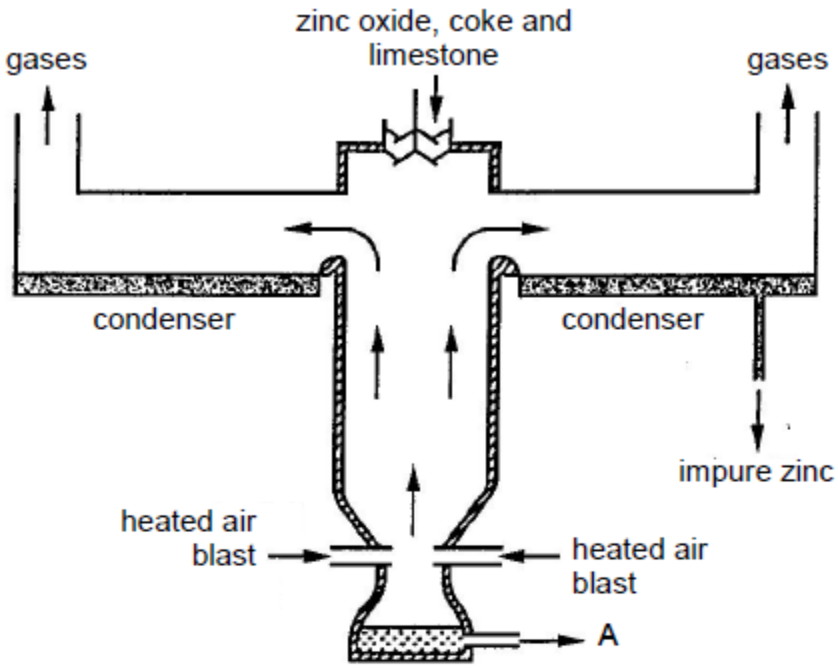


Fig. 10.1

(a) **(i)** Zinc sulfide is heated in air to produce zinc oxide and sulfur dioxide.

Construct an equation for this reaction, including state symbols.

.... [2]

(ii) Limestone is added to remove an acidic impurity. Explain how limestone removes the impurity. Include equations to support your answer.

....

....

....

....

....

.... [2]

(iii) Carbon monoxide formed in the furnace reacts with zinc oxide to form zinc and carbon dioxide. Write an equation for this reaction.

………………………………………………………………………………………… [1]

(iv) State the role of carbon monoxide (reducing agent or oxidising agent) in the reaction in **(a)(iii).** Explain your answer.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(v) Suggest the identity of the substance coming out of the furnace at **A**.

………………………………………………………………………………………….. [1]

(b) State two reasons why it is important to recycle metals.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Total: 10]

OR

B10 Sugar cane juice is used for the manufacture of ethanol which can be consumed as wine.

Sugar cane contains a number of sugars and glucose is one of the sugars.

(a) **(i)** Name the process used to produce ethanol from glucose.

.... [1]

(ii) Write the balanced equation for the process in **(a)(i)**.

.... [1]

(iii) Other than glucose, state one substance and the conditions required for the process named in **(a)(i).**

.... [2]

(b) **(i)** Explain why wine tastes sour if it is left uncovered for many days.

....

.... [1]

(ii) Describe a chemical test to verify that the change in **(b)(i)** has taken place.

....

....

.... [2]

(c) Ethanol reacts with propanoic acid to form an ester. State the structural formula of the ester formed.

.... [1]

(d) In Brazil, ethanol obtained from sugarcane is used to run vehicle engines. This is an example of biofuel. State two advantages of using biofuel over petrol to run vehicle engine.

....

....

.... [2]

[Total: 10]

End of paper

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name: ______________________________

Register No.	Class

'Perseverance Yields Success'

Ping Yi Secondary School

PRELIMINARY EXAMINATION 2022

Secondary 4 Express

CHEMISTRY **6092/02**

Paper 2

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Data Sheet is printed on page 22.
A copy of the Periodic Table is printed on page 23.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Paper 1	40
Section A	50
B9	12
B10	8
B11	10
Total	120

Expected Grade	☐ A1	☐ A2	☐ B3	☐ B4	☐ C5
Teacher's Comment					
Student's Comment					
Parent's Comment and Signature					

This document consists of **23** printed pages including the cover page and inserts.

[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

A1. This question is about the elements in Period 4.

For each of the following, identify and name an element from Period 4, which matches the description.

(a) Its only oxidation state is 0.

……………………………………………………………………………………………….[1]

(b) It is a liquid at room temperature and pressure.

……………………………………………………………………………………………….[1]

(c) It forms an ion with a charge of 3-.

……………………………………………………………………………………………….[1]

(d) It reacts readily with cold water to form a compound of the type $M(OH)_2$ and hydrogen.

……………………………………………………………………………………………….[1]

[Total:4]

A2. The following ionic equations represent some common reactions.

A	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
B	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$
C	$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$
D	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$
E	$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
F	$2I^-(aq) + Br_2(aq) \rightarrow I_2(aq) + 2Br^-(aq)$

Use the letters **A**, **B**, **C**, **D**, **E** or **F** to answer the following questions.

(a) Which equation shows a neutralisation reaction? ……………..[1]

(b) Which equation shows a displacement reaction? ……………..[1]

(c) Which equation shows a reaction that forms a white precipitate? …………… [1]

[Total:3]

[Turn over

A3. The diagram shows a Group in a Periodic Table designed by John Newlands in 1864. The Group contains elements found in Group VII (the halogens) of the modern Periodic Table (fluorine, chlorine, bromine and iodine) and other elements.

H
F
C*l*
Co / Ni
Br
Pd
I
Pt / Ir

(a) Newlands arranged the elements according to their relative atomic masses. What determines the order of the elements in the modern Periodic Table?

.... [1]

(b) Use your modern Periodic Table to suggest why Newlands put cobalt and nickel in the same place.

.... [1]

(c) Cobalt, nickel, palladium, platinum and iridium are now classified as transition elements.
Compare two ways in which the properties of transition elements are different from the halogens.

....

....

....

. ... [2]

(d) Hydrogen is difficult to be placed in the modern Periodic Table.

(i) Give one property of hydrogen which is similar to the first two elements in Group VII.

.... [1]

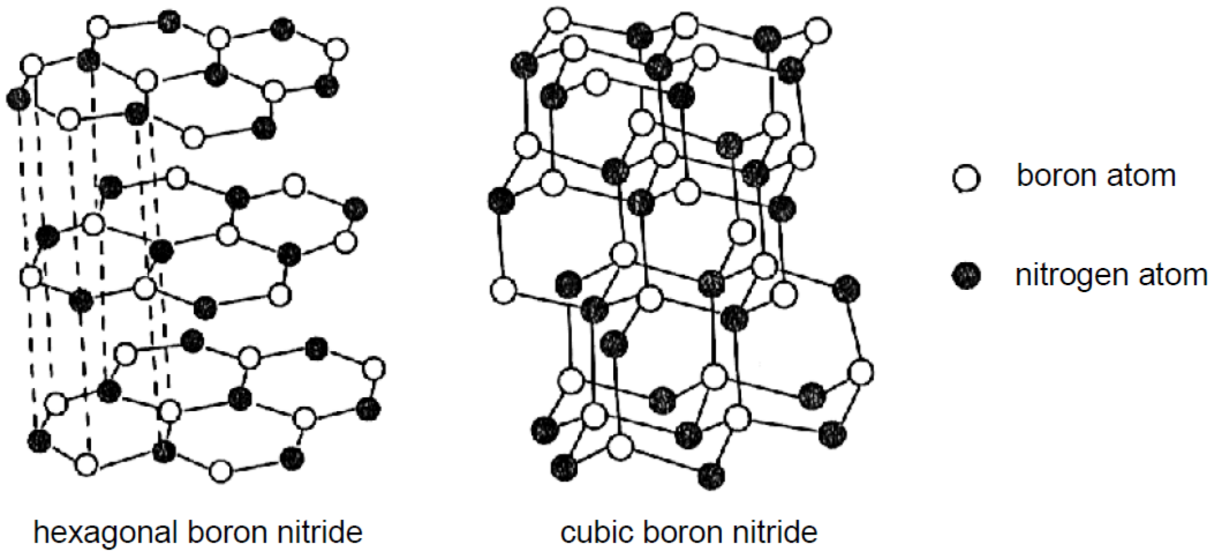
(ii) Give one property of hydrogen which is similar to the elements in Group I.

.... [1]

[Total: 6]

[Turn over

A4. Boron nitride is found to exist in two possible forms, hexagonal boron nitride and cubic boron nitride as shown below.



(a) Carbon can also be found in two different forms known as allotropes.
Name the allotropes of carbon which has a similar structure as

(i) hexagonal boron nitride and, …...

(ii) cubic boron nitride. …... [1]

(b) Based on the structures shown, state and explain the difference in one physical property of hexagonal boron nitride and cubic boron nitride.

hexagonal boron nitride …………………………..……………………………………………

……………………………………..……………………………………………………………

………………..……………………………………..……………………………………………..

………………..……………………………………..……………………………………………..

cubic boron nitride ………………………………………………………………………….…

………………..……………………………………..……………………………………………..

………………..……………………………………..……………………………………………..

………………..……………………………………..……………………………………………..[4]

[Turn over

(c) The melting points of hexagonal boron nitride and another compound of nitrogen, aluminium nitride, are given below.

compound	melting point / °C
hexagonal boron nitride	2973
aluminium nitride (A/N)	2200

Explain, in terms of bonding and structure, why both hexagonal boron nitride and aluminium nitride have very high melting points.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

[Total: 7]

[Turn over

A5. Tartaric acid and its salts are used as additives in food. The molecular formula of tartaric acid is $C_4H_6O_6$. Tartaric acid is used as one of the reactants when preparing the salt sodium tartrate.

(a) Name the method of salt preparation that may be used to prepare sodium tartrate.

…………………………………………………………………………………………………..[1]

(b) Copper(II) tartrate is insoluble in water.
Outline the steps for preparing a pure and dry sample of copper(II) tartrate in the laboratory, starting from aqueous tartaric acid.

…………………………………………………………………………………………………..

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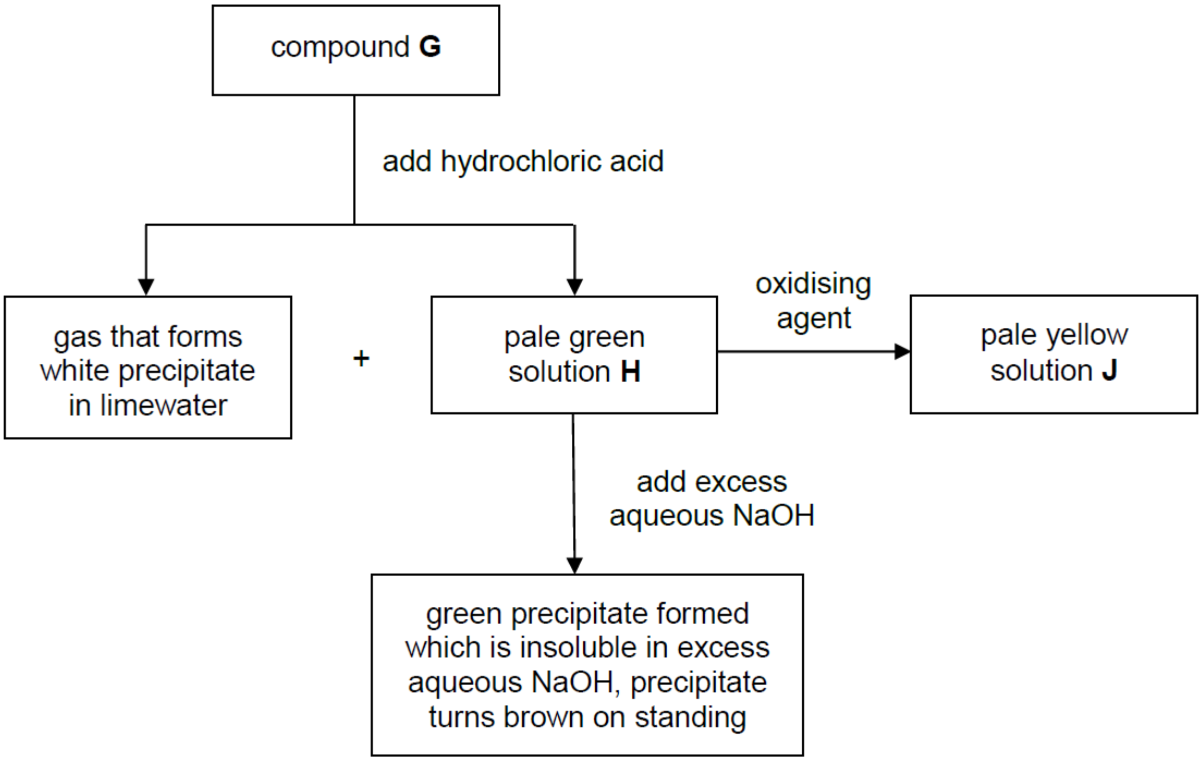
…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

………………………………………………………………………………………………… [3]

(c) Compound **G** was identified using the flowchart below.



Name substances **G**, **H** and **J**.

G: ....

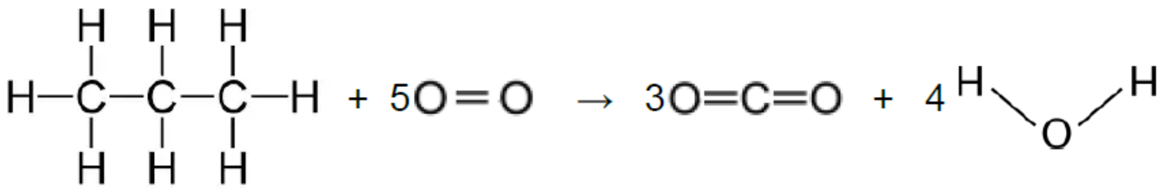
H: ....

J: .... [3]

[Total: 7]

[Turn over

A6. The hydrocarbon C_3H_8 burns in oxygen as shown in the equation below.



Using the data given in the table, answer the following questions.

bond	bond energy / kJ/mol
C – C	347
C = C	612
C = O	803
C – H	412
O = O	496
O – H	464

(a) Calculate the heat change, ΔH, for the combustion of C_3H_8.

[3]

(b) Explain, in terms of bond breaking and bond formation, why the reaction is exothermic or endothermic.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

[Turn over

(c) Draw an energy profile diagram for the combustion of C_3H_8. Your diagram should include the enthalpy change and activation energy for the reaction. [2]

(d) Explain, in terms of bonding and structure, why C_3H_8 exists as a gas at room temperature and pressure.

…………………………………………………………………………………………………

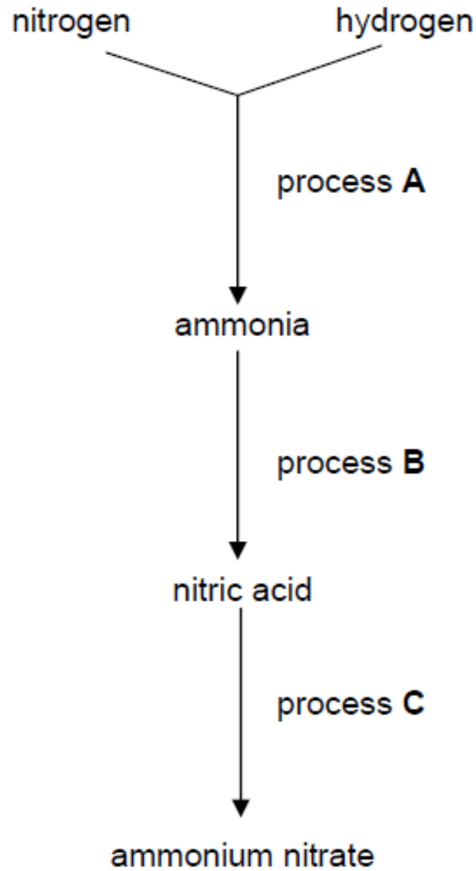
…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

[Total: 8]

A7. The flow chart shows the processes used in the lead up to the manufacturing of important ammonium nitrate.



(a) State the conditions required for process **A**.

……………………………………………………………………………………………….. [1]

(b) The boiling points of ammonia, nitrogen and hydrogen are given in the table.

gas	boiling point/ ºC
ammonia	-33
hydrogen	-252
nitrogen	-183

Describe how ammonia can be separated from the gaseous mixture of nitrogen, hydrogen and ammonia.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

[Turn over

(c) Process **B** involves a three-stage process for converting ammonia into nitric acid.

Stage 1: $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

Stage 2: $4NO(g) + 2O_2(g) \rightarrow 4NO_2(g)$

Stage 3: $4NO_2(g) + 2H_2O(l) + O_2(g) \rightarrow 4HNO_3(aq)$

(i) Stage 3 is a redox reaction. Use oxidation states to show that this statement is true.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(ii) 1080 dm^3 of nitrogen dioxide is used in stage 3 at room temperature and pressure. However, only 567 g of HNO_3 is produced. Calculate the percentage yield.

[3]

(iii) The concentration of the nitric acid produced during the experiment is found to be 15 mol/dm^3. Calculate the volume of water to be added to dilute the nitric acid to 5 mol/dm^3.

[2]

(iv) Use these three equations to write an overall equation for the conversion of ammonia to nitric acid.

…………………………………………………………………………………………………[1]

[Turn over

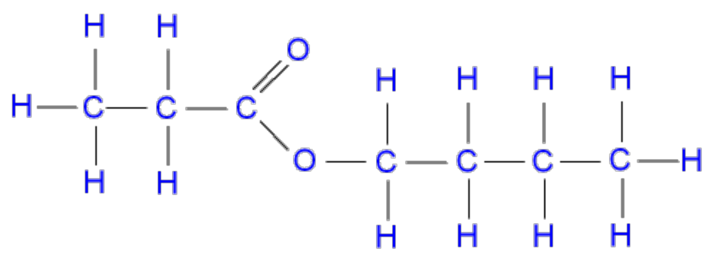
(d) Aqueous ammonia is added to nitric acid in process **C** to produce ammonium nitrate.

What is a major use of ammonium nitrate?

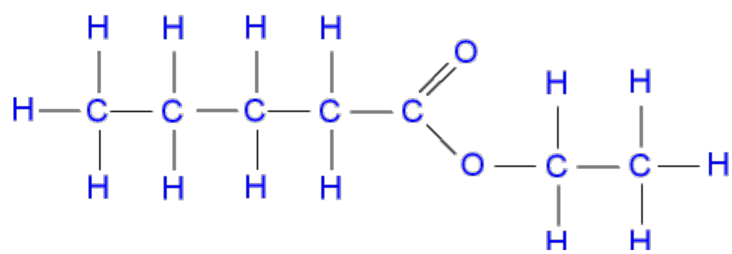
....[1]

[Total: 12]

A8. A team of chemists developed a fragrance for use in a shower gel for women. To give the shower gel a fruity smell, the chemists are considering ester **A** and ester **B**.



ester **A**



ester **B**

(a) State the name of ester **A**.

....[1]

(b) Draw the structures of the two reactants that react together to produce ester **A**.

[2]

[Total: 3]

[Turn over

SECTION B

Answer all **three** questions in this section

The last question is in the form either/or and only one of the alternatives should be attempted.

B9. The story of baking soda and baking powder

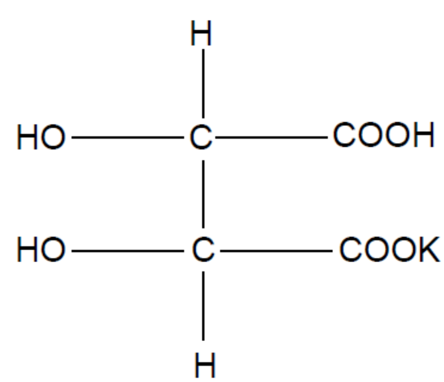
Many food products such as bread, sponge cakes and buns have a honeycomb structure which contains many bubbles. During cooking, these bubbles are formed by a gas and the mixture 'rises'. In some cases, the gas is air which is whipped into the mixture before cooking and expands during cooking. In other cases, the gas is carbon dioxide.

The most common chemical to do this is sodium hydrogen carbonate, $NaHCO_3$. Sodium hydrogen carbonate is found in both baking soda and baking powder. Baking soda consists of only sodium hydrogen carbonate. When it is heated, it forms carbon dioxide gas according to the equation:

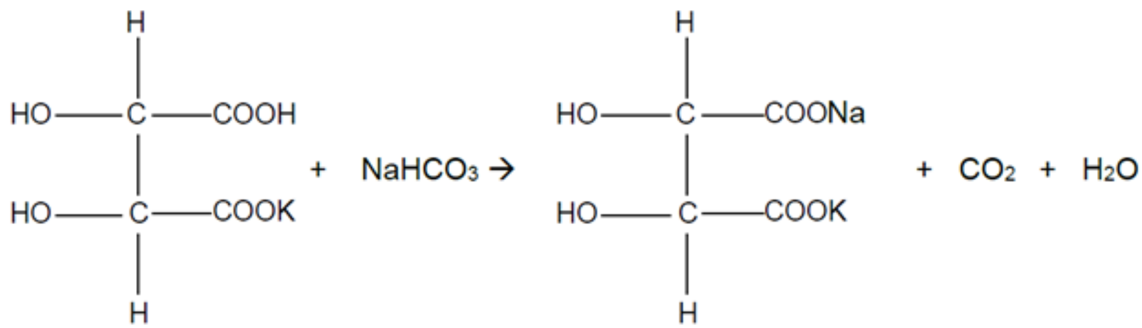
$$2NaHCO_3\,(s) \rightarrow Na_2CO_3\,(s) + CO_2\,(g) + H_2O\,(l)$$

Since the material is relatively cheap, it seems to be an excellent agent to produce carbon dioxide. The above chemical equation, however, also illustrates the disadvantages of baking soda. When used on its own, only half the available carbon dioxide is released and more seriously, the sodium carbonate produced gives the baked product a slightly bitter and 'soapy' taste. To overcome this problem, baking soda is usually mixed with some honey.

Baking powder consists of a mixture of sodium hydrogen carbonate and a weak acid such as potassium hydrogen tartrate (cream of tartar). The formula of this acid is:



Potassium hydrogen tartrate is a solid which means that it is possible to mix it with sodium hydrogen carbonate without the two reacting. The reaction is:



One problem with the use of potassium hydrogen tartrate is that it is very soluble in water. As soon as it becomes wet, it dissolves and reacts. This risks all the gas escaping while the cake mix is still in liquid form and before it goes into the oven.

(a) Using kinetic particle theory, explain how air which has been whipped into the mixture makes the dish 'rise' upon cooking.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………….[2]

(b) Predict the pH value of sodium carbonate when it is dissolved in water.

…………………………………………………………………………………………….[1]

(c) The average pH of honey is 3.9. Explain how the addition of honey to baking soda makes the cake taste better.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………….[2]

[Turn over

(d) Besides taste, explain why most bakers prefer to use baking powder instead of baking soda when they are baking cakes.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[2]

(e) Potassium hydrogen tartrate can be made from the reaction of potassium hydroxide with tartaric acid. Draw the structural formula of tartaric acid.

[1]

(f) The following instruction is found on a bottle of baking powder.

Store in dry place

Explain why this instruction is important.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[2]

(g) The oven was preheated to a certain high temperature before the cake dough with the baking powder is placed in. Suggest why the oven has to be preheated.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[1]

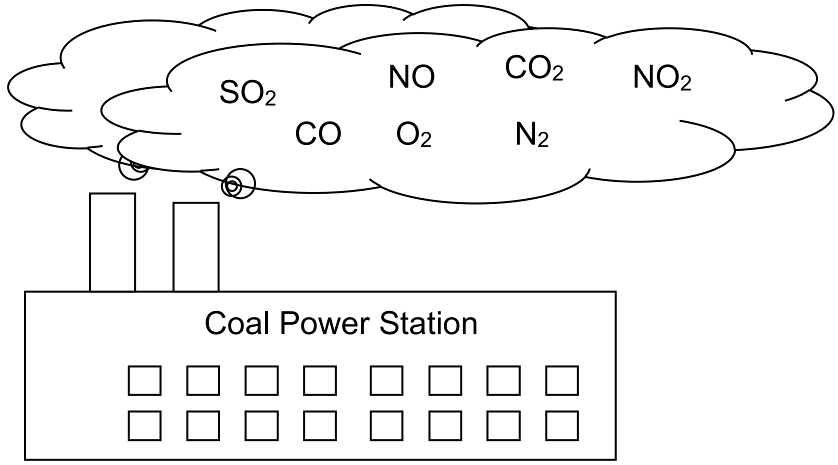
(h) Some recipes may call for adding baking soda even though baking powder was added in the first place. Suggest why this is so.

…………………………………………………………………………………………………..[1]

[Total: 12]

[Turn over

B10. The diagram shows the formulae of some gases emitted by a typical coal power station.



(a) Use the formulae from the diagram to fill in the appropriate blanks below:

(i) a poisonous gas that is produced by incomplete combustion of coal

………………………………………………………………………………………… [1]

(ii) two gases that produces acid rain

…………………………………………………………………………………………..[2]

(iii) two gases that are involved in both respiration and photosynthesis

………………………………………………………………………………………… [2]

(b) Carbon dioxide is one of the main products in the combustion of coal in a coal power station. Excessive carbon dioxide is harmful to the environment**.**
Briefly describe how the carbon cycle helps to regulate the amount of carbon dioxide in the atmosphere.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….[3]

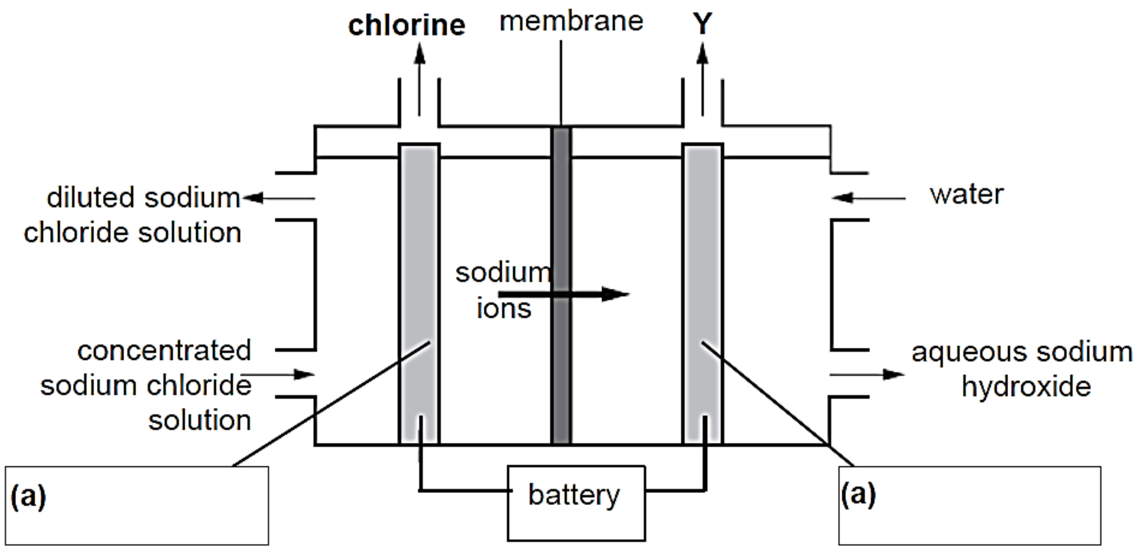
[Total : 8]

[Turn over

EITHER

B11. Sodium hydroxide is a very useful industrial chemical.

The diagram shows a set-up used to produce aqueous sodium hydroxide from concentrated sodium chloride solution.



(a) Label on the diagram the anode and the cathode. [1]

(b) Identify **Y** and explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(c) Explain how aqueous sodium hydroxide is formed as a product.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(d) Describe a simple test to test for the presence of chlorine gas.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

[Turn over

(e) The membrane used in the set-up is porous. A porous membrane has pores of a specific size so that only particles with sizes smaller than the pores can pass through the membrane.

The porous membrane is necessary for aqueous sodium hydroxide to be collected as the only product without any contamination from the chloride ions in the set-up.

Explain why the porous membrane prevents contamination from chloride ion.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[2]

(f) If dilute sodium chloride solution is used in the set-up instead of concentrated sodium chloride solution, the results would be different.

Describe and explain two differences in the results.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[3]

[Total: 10]

[Turn over

OR

B11. Barium is a group II element. Barium hydroxide is soluble in water to form aqueous barium hydroxide of concentration up to 0.1 mol/dm^3.

20.0 g of an impure sample of barium hydroxide, $Ba(OH)_2$, is dissolved in water to produce 1 dm^3 of an aqueous solution. 25.0 cm^3 of this alkaline solution is titrated against nitric acid with a concentration of 0.200 mol/dm^3.

The results obtained is shown in Table 11.1.

Table 11.1

titration number	1	2	3	4
final reading / cm^3	24.55	49.05	24.55	24.10
initial reading / cm^3	0.00	25.00	1.00	0.00
volume of nitric acid used / cm^3				
best titration results				

(a) Complete Table 11.1 to obtain the volume of nitric acid used in the 4 sets of titrations. [1]

(b) Choose the best titration results by putting a tick (√) and calculate the average volume of nitric acid used.

average volume of nitric acid used = ………… cm^3 [1]

(c) Write a balanced chemical equation, including state symbols, for the neutralisation reaction.

……………………………………………………………………………………………… [2]

[Turn over

(d) Calculate the concentration of the barium hydroxide solution in mol / dm^3.

[2]

(e) Calculate the percentage of barium hydroxide in the impure sample.

[2]

(f) If the conical flasks that were used in this experiment had been rinsed with the barium hydroxide solution before carrying out a titration, how would this have affected the answer in **(e)**?

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….[2]

END OF PAPER

DATA SHEET

Colours of some common metal hydroxides

aluminium hydroxide	white
calcium hydroxide	white
copper (II) hydroxide	light blue
iron (II) hydroxide	green
iron (III) hydroxide	red-brown
lead (II) hydroxide	white
zinc hydroxide	white

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protacti 23	92 U anium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at roor erature and pressure (r.t.p.).

Name: ……………………………………………….. (   )   Class: Sec 4A

Queenstown Secondary School

Preliminary Examination 2022
Secondary Four Express
Chemistry
6092/02

23 August 2022
Tuesday

Time: 1100 – 1245h
Duration: 1 hour 45 minutes

Additional Materials: Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 21.

The use of an approved scientific calculator is expected, where appropriate.

Examiner's Use	
Section A	/50
Section B	/30
B9	
B10	
B11	
TOTAL	/80

Section A

Answer **all** questions in this section in the spaces provided.

The total mark for this section is 50.

A1 Choose from the following compounds to answer the questions.

calcium hydroxide	calcium oxide	zinc chloride	magnesium nitrate
aluminium chloride	sodium sulfate	iron(II) carbonate	sodium hydroxide

Each compound may be used once, more than once or not at all.

State one compound which

(a) contains a cation with a 3+ charge,

………………………………………………………………………………………….. [1]

(b) forms a colourless solution when aqueous ammonia is added in excess,

………………………………………………………………………………………… [1]

(c) is commonly used by farmers to increase the pH of the soil,

………………………………………………………………………………………….. [1]

(d) is a coloured solid and has a high melting point at room temperature and pressure,

………………………………………………………………………………………….. [1]

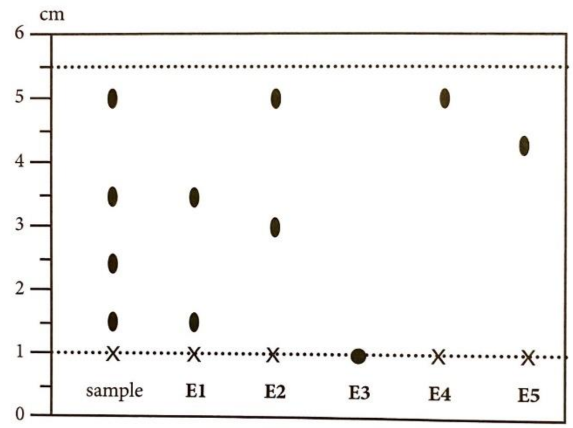
(e) is used in flue gas desulfurisation.

………………………………………………………………………………………….. [1]

[Total: 5]

A2 A food dye sample was sent for laboratory testing.

The diagram below shows the chromatogram for the sample and five other approved food dyes E1, E2, E3, E4 and E5 using water as the solvent.



(a) Using the information above, determine the R_f values for dyes E4 and E5.

dye	R_f value
E4	
E5	

[2]

(b) Should the sample food dye be approved? Explain why.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(c) Dye E3 remains on the starting line of the chromatogram.

Give a possible reason.

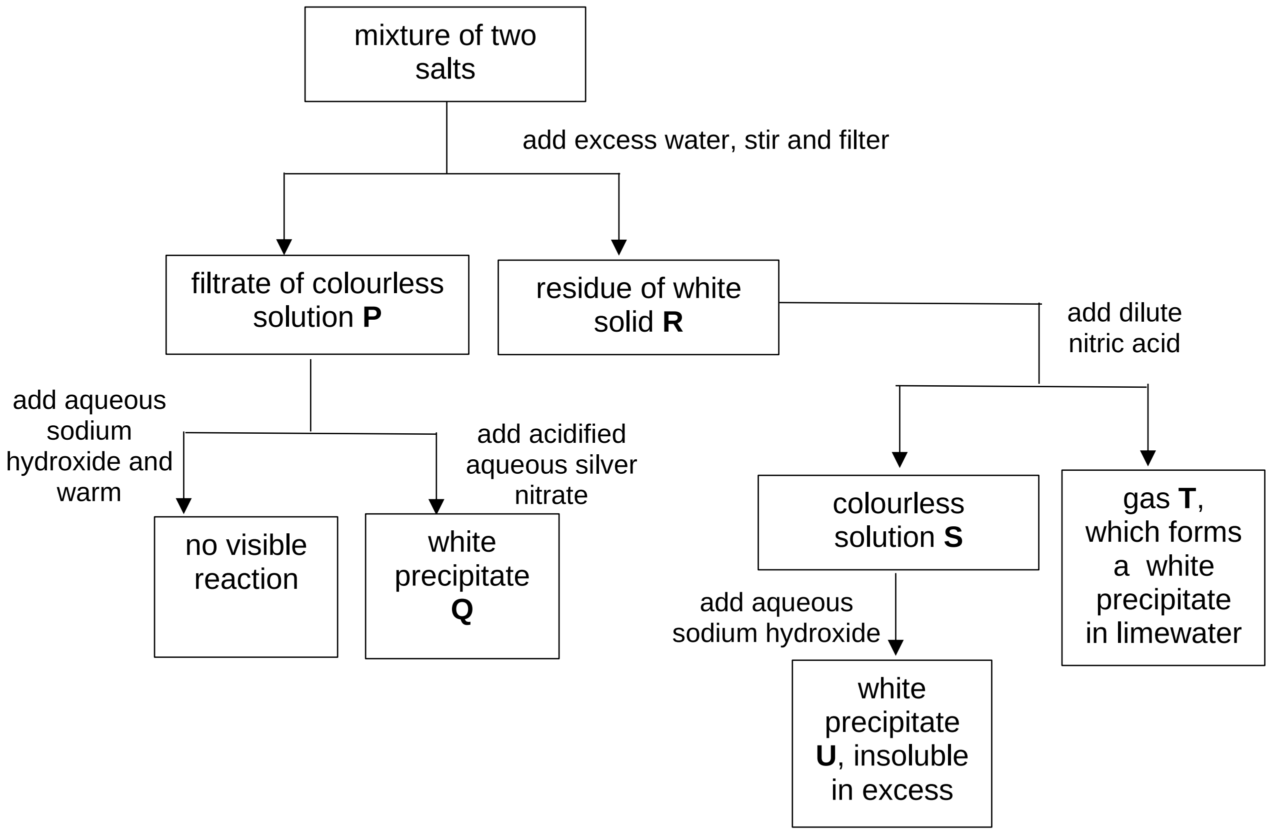
……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

[Total: 4]

A3 A mixture contains a soluble and an insoluble salt.

A series of tests were carried out on the mixture.



(a) Identify the substances **P**, **Q**, **R**, **S** and **T**.

(i) **P** : ………………………………………….... [1]

(ii) **Q** : ………………………………………….... [1]

(iii) **R** : ………………………………………….... [1]

(iv) **S** : ………………………………………….... [1]

(v) **T** : ………………………………………….... [1]

(b) Write the ionic equation for the formation of precipitate **U**.

……………………………………………………………………………………… [1]

[Total: 6]

A4 Fluorine, chlorine, bromine and iodine are halogens, found in Group VII of the Periodic Table.

(a) Describe the trend in colour and physical state at room temperature and pressure as the atomic number increases.

trend in colour ……………………………………………………………………………

trend in physical state ………………………………………………………………….. [2]

(b) Predict what you would observe for the reaction between aqueous chlorine and aqueous sodium iodide. Include a chemical equation to support your answer.

chemical equation ……………………………………………………………………….

…………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(c) The average bond enthalpies and bond lengths of the hydrogen halides are given in the table below.

bond	bond length /nm	average bond energy / kJ/mol
H – F	0.092	568
H – C*l*	0.127	432
H – Br	0.141	366
H – I	0.161	295

Using the information in the table above, explain the relationship between bond length and average bond enthalpy.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [3]

(d) Magnesium reacts with fluorine to form magnesium fluoride.

(i) Draw a ‘dot and cross diagram to show the bonding in magnesium fluoride. Show all the electrons in your drawing.

[2]

(ii) Explain, using ideas about structure, why magnesium fluoride has a high melting point.

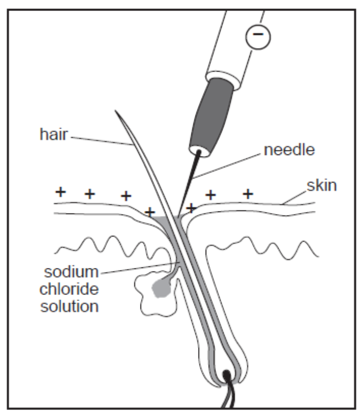
………………………………………………………………………………………

……………………………………………………………………………………… [1]

[Total: 10]

A5 Electrolysis can be used to remove unwanted hair. The customer holds a metal bar which acts as a positive electrode. A needle, which acts as the negative electrode, is held by the operator.

(a) The solution around the tip of the needle is mainly a concentrated aqueous solution of sodium chloride.



(i) Identify all the ions present in the solution during this electrolysis.

……………………………………………………………………………………….. [1]

(ii) During electrolysis, a small amount of chlorine is formed at the surface of the skin. Write an ionic equation for this reaction.

……………………………………………………………………………………….. [1]

(iii) During electrolysis, a gas forms at the tip of the needle and the solution changes from pH 7 to pH 10. Explain both changes.

…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………….. [2]

(b) Explain why aqueous sodium chloride solution conducts electricity but solid sodium chloride does not.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

[Total: 5]

A6 The head of a safety match contains potassium chlorate and antimony sulfide. The side of the matchbox contains red phosphorus. When a match is struck on the side of the box, the friction produces enough heat to light the match.

The equation for this reaction is shown.

$$\underset{\text{potassium chlorate}}{5KClO_3} + 6P \rightarrow 5KCl + \underset{\text{phosphorus(V) oxide}}{3P_2O_5}$$

(a) Using oxidation states, state which substance is the oxidising agent and reducing agent. Explain your answer.

(i) oxidising agent ……………………………………………………………….…

explanation ……………………………………………………………………...

………………………………………………………………………………… [2]

(ii) reducing agent ……………………………………………………………………….

explanation ………………………………………………………………………...

……………………………………………………………………………………… [2]

(b) Phosphorus(V) oxide, P_2O_5, absorbs water from the air to form meta-phosphoric acid, HPO_3. On addition of more water, dilute phosphoric acid is formed. Dilute phosphoric acid has typical acidic properties.

Describe what you would observe when dilute phosphoric acid is added to aqueous sodium carbonate.

……………………………………………………………………………………….. [1]

[Total: 5]

A7 Hydrogen iodide can be formed from the reaction between hydrogen and iodine.

$$H_2\ (g) + I_2\ (g) \rightarrow 2HI\ (g)$$

The following table shows the bond energies of some chemical bonds.

bond	**bond energy/ kJ/mol**
H – H	436
I – I	148
H – I	295

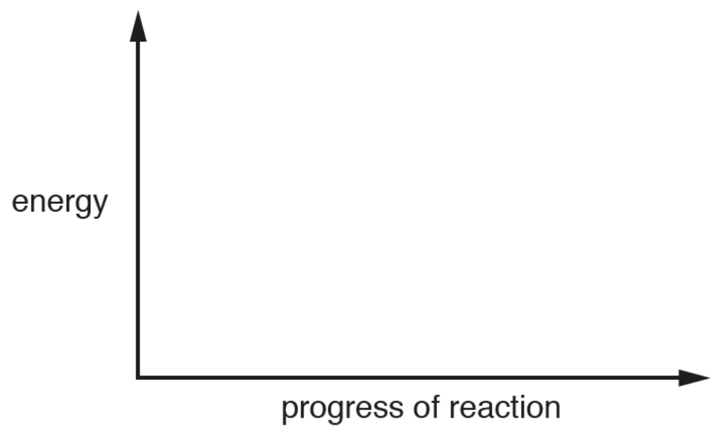
(a) Use the data in the table above, calculate the enthalpy change, ΔH, for the reaction.

enthalpy change, ΔH = …………….. [3]

(b) Draw an energy profile diagram for the above reaction.

Your diagram should include

- the reaction pathway for the reaction showing the **names of the reactants and product**,
- the **activation energy** using a single-headed arrow,
- the **enthalpy change** for the reaction using a single-headed arrow.



[3]

(c) Is the above reaction exothermic or endothermic?

Use ideas about bond breaking and bond making to explain.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(d) The rate of reaction can be increased by changing the reaction conditions.

Explain in terms of collisions between reacting particles, why the rate of reaction increases when:

(i) the hydrogen and iodine mixture is heated to a high temperature.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(ii) the pressure of the reaction vessel increases.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

[Total: 10]

A8 Ethanol is a very important substance because it is used as a fuel in certain countries.

One of the productions of ethanol is by the process of fermentation.

(a) Starting from cane sugar, describe briefly how it is converted to ethanol during this process.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [3]

(b) Write a chemical equation for the fermentation reaction.

………………………………………………………………………………………… [2]

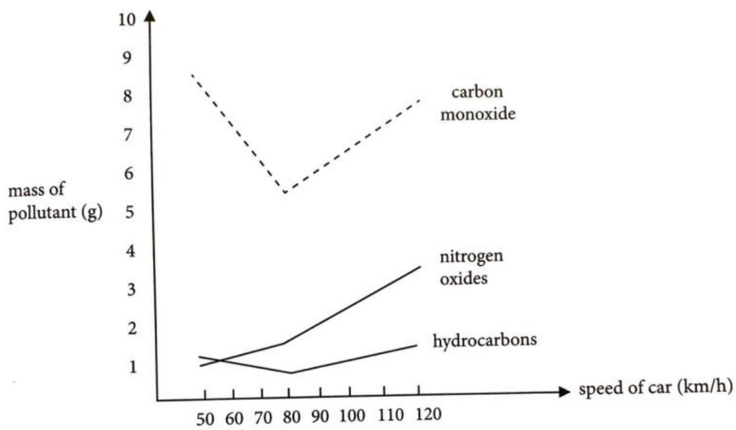
[Total: 5]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 **(a)** The graph below shows the mass of gaseous pollutants released from the exhaust pipe of a car travelling at different speeds.



(i) Which pollutant shows the fastest rate of increase when the speed of the car increases from 50 km/h to 120 km/h? Explain your answer.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(ii) Describe the trend of how the mass of carbon monoxide emitted changes with speed. Explain your answer.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [3]

(iii) State **one** harmful effect of nitrogen oxides to the environment.

…………………………………………………………………………………... [1]

(b) Teflon is used to coat the surfaces of non-stick frying pans.

It is a macromolecule formed by the addition polymerisation of tetrafluoroethene. The formula of tetrafluoroethene is given below.

```
F   F
|   |
C = C
|   |
F   F
```

(i) Explain the term 'addition polymerisation' using Teflon as an example.

…………………………………………………………………………………...

…………………………………………………………………………………..

………………………………………………………………………………….. [2]

(ii) Draw the structure of the Teflon polymer, showing two repeat units.

[1]

(iii) Calculate the percentage by mass of carbon in a Teflon molecule.

percentage by mass of carbon = …………….. [2]

(iv) The Teflon polymer can be compared with the Nylon polymer.

Outline **two** differences between the two polymers.

………………………………………………………………………………………….

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………… [2]

[Total: 12]

B10 **(a)** 0.6 g of powdered sodium chloride is dissolved in 300 cm^3 of water.

100 cm^3 of the solution is then added to an excess of 1 mol/dm^3 silver nitrate solution. The reaction takes place as shown below.

$$AgNO_3\ (aq) + NaCl\ (aq) \rightarrow AgCl\ (s) + NaNO_3\ (aq)$$

(i) Calculate the mass of precipitate formed.

mass = ……………….. [2]

(ii) It is found that it is not possible to retrieve a purified form of sodium nitrate using the reaction above. Explain why this is so.

…………………………………………………………………………………………...

…………………………………………………………………………………………... [1]

(b) **(i)** A student titrates 25.0 cm^3 of dilute sulfuric acid with aqueous sodium hydroxide of concentration 0.0150 mol/dm^3, using methyl orange as an indicator. A volume of 24.0 cm^3 of aqueous sodium hydroxide reacts exactly with the dilute sulfuric acid. The reaction is shown below.

$$H_2SO_4\ (aq) + 2NaOH\ (aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O\ (l)$$

Calculate the molar concentration of the dilute sulfuric acid.

molar concentration = ………………. [2]

(ii) Based on the reaction in **(b)(i)**, describe how to prepare a pure and dry sample of sodium sulfate crystals from its solution.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

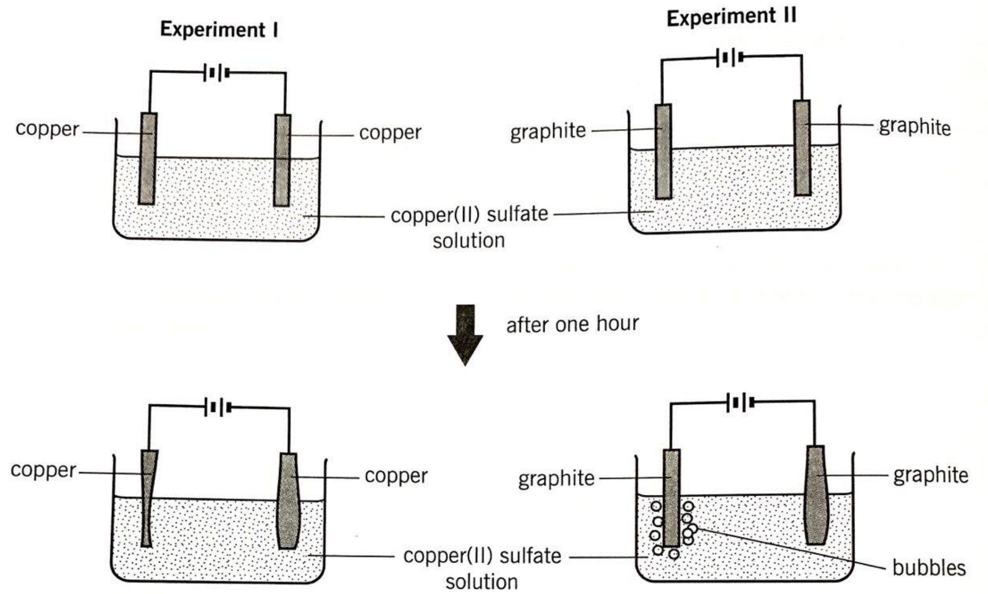
……………………………………………………………………………………..

…………………………………………………………………………………….. [3]

[Total: 8]

B11 EITHER

(a) The diagrams below shows two experimental setup of electrolytic cells containing aqueous copper(II) sulfate solution.



(i) Write the half equation which takes place at the anode in

experiment I: ………………………………………………………………….

experiment II: ………………………………………………………………. [2]

(ii) In Experiment II, 3.2 g of solid is deposited at the cathode.

What would be the volume of gas discharged at the anode at room temperature and pressure?

volume of gas = …………... [2]

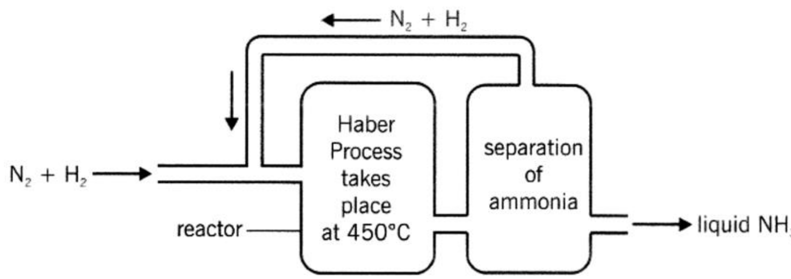
(iii) Describe the observations of the electrolyte in Experiments I and II as these experiments progress.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(b) The diagram below shows a process for manufacturing ammonia on a large scale. The process is called the Haber Process.



The reaction between nitrogen and hydrogen to form ammonia is a reversible reaction. The chemical reaction is shown below.

$$N_2 + 3H_2 \leftrightarrow 2NH_3$$

(i) Why does the wall of the reactor plant usually contain traces of iron?

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) Explain why the temperature of the Haber Process is not raised more than 450°C?

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(c) A piece of agricultural land has alkaline soil and is moist and warm.

A farmer chooses to sprinkle ammonium sulfate onto the soil surface to act as a nitrogenous fertiliser.

Comment on the disadvantage of adding ammonium sulfate to the soil.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………………………………………………….. [2]

[Total: 10]

B11 OR

(a) Several experiments have been carried out to find out the reactivity of the different metals labelled **P** to **S**. The results are shown in the following table.

Use the information given to answer the following questions.

metal	heating with oxygen	reaction with water	heating the metal oxide with carbon
P	does not burn	no reaction	metal oxide reduced to **P**
Q	burns vigorously	vigorous reaction	no reaction
R	burns moderately	reacts with steam only	metal oxide reduced to **R**
S	burns to form an oxide	reacts with hot water	no reaction

(i) Arrange the metals in order of reactivity, starting from the least reactive.

……………………………………………………………………………………….. [1]

(ii) Which of these metals forms the most thermally stable carbonates?

Explain your answer.

…………………………………………………………………………………...

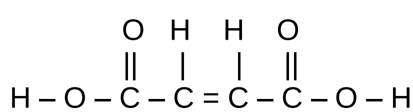
……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

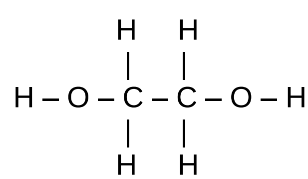
(iii) Given that metal **R** is zinc, write a chemical equation to show the reaction of heating its oxide with carbon.

……………………………………………………………………………………… [1]

(b) The structural formulae of butenedioic acid and ethane-1,2-diol are shown below.



butenedioic acid



ethane-1,2-diol

(i) Describe a chemical test that could be used to determine these two samples.

chemical test ……………………………………………………………………

observation with butenedioic acid..…………………………………………

………………………………………………………………………………………

observation with ethane-1,2-diol ……………………………………………..

……………………………………………………………………………………… [2]

(ii) Draw the structural formula of the product(s) formed for the reaction that has taken place in part **(b)(i)**.

[1]

(iii) Butenedioic acid and ethane-1,2,-diol can undergo polymerisation under suitable conditions to form a polymer.

Draw a section of the polymer, showing two repeat units.

[2]

(iv) Describe **one** environmental problem related to the disposal of waste polymer.

…………………………………………………………………………………...

…………………………………………………………………………………... [1]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

NAME:	NO:	CLASS:

RIVERSIDE SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2022

SUBJECT	:	Chemistry
CODE/PAPER	:	6092/02
LEVEL/STREAM	:	4 Express
DURATION	:	1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class in the spaces provided in the question paper.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 23.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **23** printed pages.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 **(a)** Choose from the following list of aqueous ions to answer the questions below.

ammonium
carbonate
copper(II)
hydrogen
hydroxide
iodide
iron(II)
nitrate

Choose **one** ion from the list above which

(i) is responsible for alkaline properties in a solution,

……………………………………………………………………………………………………[1]

(ii) forms a green precipitate when added to aqueous sodium hydroxide,

……………………………………………………………………………………………………[1]

(iii) forms a gas when added to acids,

……………………………………………………………………………………………………[1]

(iv) forms a gas when added to alkalis,

……………………………………………………………………………………………………[1]

(v) forms a reddish-brown deposit when magnesium is added.

……………………………………………………………………………………………………[1]

(b) Which statements about the separation of mixtures are **true** and which are **false**?

Put a tick (✓) in **one** box in each row.

	true	**false**
The separation of mixtures is a chemical process.		
Simple distillation allows the recovery of ethanol from water.		
In chromatography, the same substance has different R_f values in different solvents.		

[2]

[Total: 7]

A2 Fig. 2.1 shows the structure of an atom.
The electrons are missing.

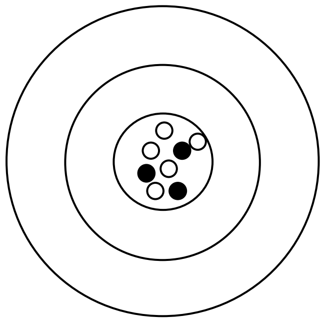


Fig. 2.1

(a) Complete Table 2.2 about the three particles found in this atom.

Table 2.2

particle	name of particle	relative mass of the particle	relative charge of the particle
○		1	
●		1	1+
×	electron		1-

[2]

(b) Complete the diagram in Fig. 2.1 to show the arrangement of the electrons in the atom.
[1]

(c) In the manufacture of the body of aircrafts, a small amount of the atom is added to aluminium to make it stronger.

With the help of a labelled diagram, explain how the addition of a small amount of the atom increases the strength of the body of aircrafts.

....

....

....[3]

[Total: 6]

A3 This question is about the halogens.

(a) Table 3.1 shows data about the densities and melting points of three halogens, chlorine, bromine and iodine.

Complete the table by filling in the name of each halogen.

Table 3.1

name of halogen	density (g/ cm^3)	melting point (^oC)
	3.21	–7.3
	4.94	114
	0.00312	–102

[1]

(b) Seawater contains sodium bromide.

(i) Bromine can be produced from seawater by displacement.

Name an element that can displace bromine and give a reason for your choice.

name: ……………………………………………………………………………………………………..

reason: …………………………………………………………………………………………...[2]

(ii) Describe a simple test, other than displacement, that can be used to show that sea water also contains iodide ions.

test: ……………………………………………………………………………………………………..

result: ………………………………………………………………………………………………....[2]

[Total: 5]

A4 Fig. 4.1 shows a can of soup in a self-heating device.

Piercing an internal water sachet with a special tool causes the solid anhydrous calcium chloride to mix with the water.

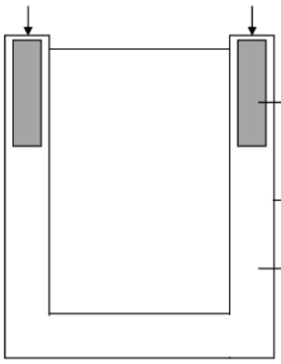


Fig. 4.1

(a) The temperature of the soup rises by 60 °C within 10 minutes.

Name the type of reaction that occurred when anhydrous calcium chloride mixes with water.

……………………………………………………………………………………………………….[1]

(b) Table 4.2 shows the changes in heat energy for the reaction involving some substances with water.

Table 4.2

substances	ΔH (kJ/ mol)
ammonium nitrate	+25
concentrated sulfuric acid	–71
lithium chloride	–37

Discuss why lithium chloride is the most suitable replacement for calcium chloride to warm the soup.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….[3]

(c) When the can is pierced, aqueous calcium chloride forms.

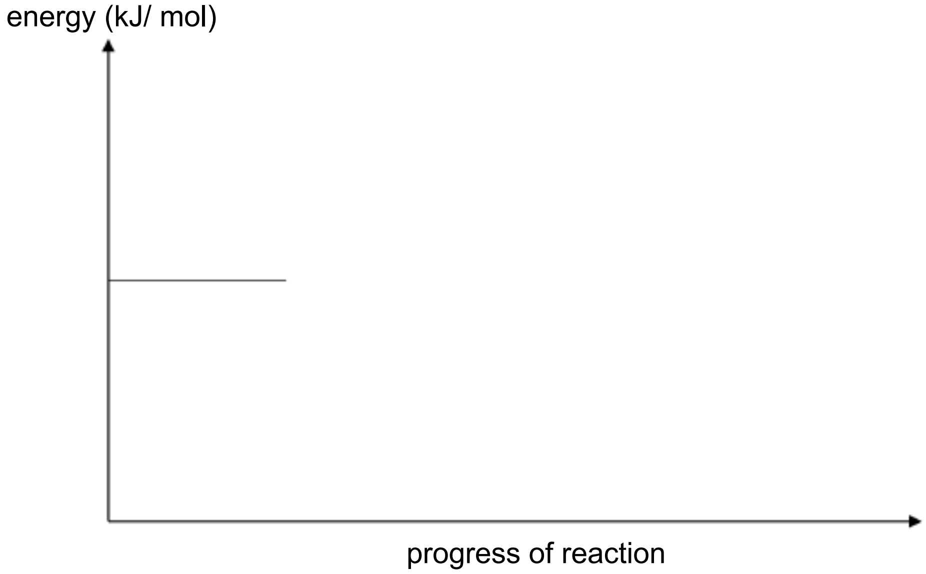
$$CaCl_2(s) \rightarrow CaCl_2(aq)$$

Complete the energy profile diagram below.

Your diagram should include:

• the reactants and products,

• labels to show the enthalpy change and the activation energy.



[3]

[Total: 7]

A5 Hydrogen peroxide is a colourless liquid.

An aqueous solution of hydrogen peroxide reacts with the iodide ions in acidified potassium iodide to form water and iodine according to the equation shown below.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

(a) (i) Complete Table 5.1 to show the oxidation states of oxygen and iodine before and after the reaction.

Table 5.1

element	oxidation state *before* the reaction	oxidation state *after* the reaction
oxygen		
iodine		

[2]

(ii) Use the information in Table 5.1 to explain why this is a redox reaction.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………..[1]

(iii) Describe the colour change for the above reaction.

……………………………………………………………………………………………………..[1]

(b) Table 5.2 shows how the speed of this reaction changes when different concentrations of aqueous potassium iodide and dilute sulfuric acid are used.

The hydrogen peroxide is always added in excess and the temperature remains constant.

Table 5.2

experiment	concentration of aqueous potassium iodide (mol dm^{-3})	concentration of dilute sulfuric acid (mol dm^{-3})	speed of reaction (mol dm^{-3} /s)
1	0.1	0.1	0.00017
2	0.2	0.1	0.00034
3	0.1	0.2	0.00017
4	0.3	0.1	0.00051
5	0.1	0.3	0.00017

A student made the following statement,

"The speed of this reaction is more dependent on the concentration of aqueous potassium iodide than dilute sulfuric acid."

Using the information in Table 5.2, explain if the student is right.

……...

……...

……...

……...

……[2]

(c) The experiment was repeated by increasing the temperature of aqueous potassium iodide, with other variables being kept constant.

Explain, using ideas about particles colliding, how the rate of reaction is affected.

……...

……...

……...

……[3]

. [Total: 9]

A6 Paraffin (kerosene) is a mixture of hydrocarbons. It is used as a fuel for the jet engines of an aircraft.

Paraffin is separated from crude oil using fractional distillation.

(a) What property is used to separate paraffin from crude oil?

…….[1]

(b) There is an alkane molecule in paraffin which contains 11 carbon atoms.

What is the chemical formula of this alkane?

chemical formula of alkane: …………………………… [1]

(c) When paraffin burns in a jet engine, nitrogen monoxide, NO, is formed.

$$N_2 + O_2 \rightarrow 2NO$$

(i) Explain how nitrogen monoxide is formed in the jet engine.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………….[2]

(ii) Calculate the mass of nitrogen monoxide formed from 55 kg of nitrogen.

mass of nitrogen monoxide = ………………………… [2]

(d) Nitrogen monoxide is involved in the formation of sulfur trioxide from sulfur dioxide.

$$2NO + O_2 \rightarrow 2NO_2$$

$$NO_2 + SO_2 \rightarrow NO + SO_3$$

(i) Write the overall equation for the formation of sulfur trioxide from sulfur dioxide.

……………………………………………………………………………………………….[1]

(ii) Explain how the reactions above suggest that nitrogen monoxide is acting as a catalyst.

……………………………………………………………………………………………….[1]

[Total: 8]

A7 An electrolytic set-up consisting of two cells is shown in Fig. 7.1.

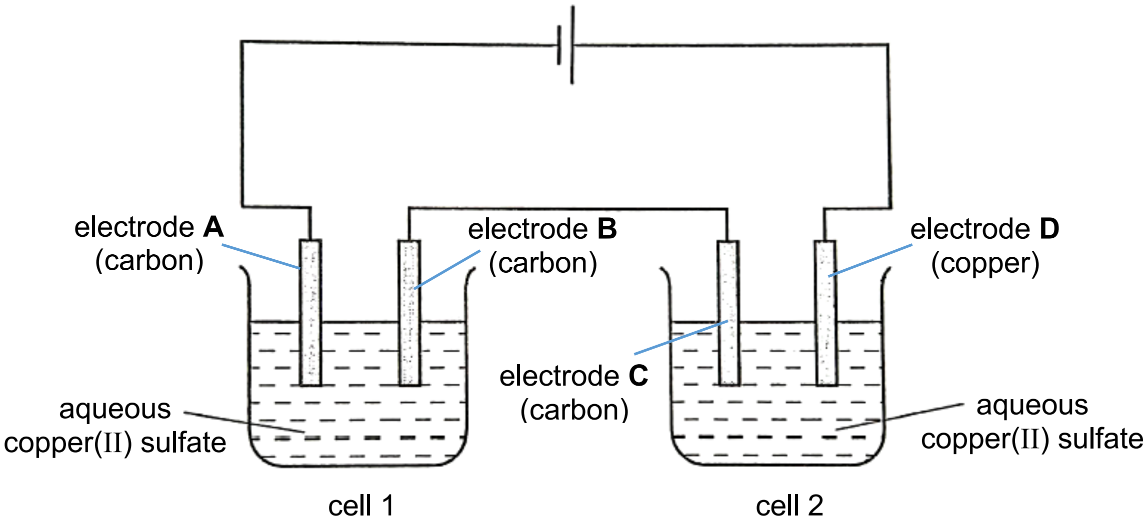


Fig. 7.1

(a) Draw arrows in Fig. 7.1 to indicate the flow of electrons. [1]

(b) At which electrodes do oxidation take place in both cells 1 and 2?

....[1]

(c) Write the half-equation, with state symbols, for the reaction at electrodes **A** and **B**.

electrode **A**: ....

electrode **B**: ....[3]

(d) State and explain the difference in the colour of the electrolyte in cell 1 and cell 2 after the electrolysis is conducted for some time.

....

....

....

....[3]

[Total: 8]

NAME:	NO:	CLASS:

RIVERSIDE SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2022

SUBJECT	:	Chemistry
CODE/PAPER	:	6092/02
LEVEL/STREAM	:	4 Express
DURATION	:	1 hour 45 minutes

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 The formation of a covalent bond involves the sharing of electrons between two atoms to form a balance between attractive and repulsive forces between the two atoms being bonded.

In a hydrogen molecule, the hydrogen atoms share a valence electron each via covalent bonding. The bond energy is the amount of energy required to break one mole of bonds. The bond energy of a H — H bond is 432 kJ/mol.

Figure 8.1 shows how the bond energy between two hydrogen atoms varies with the distance between their nuclei.

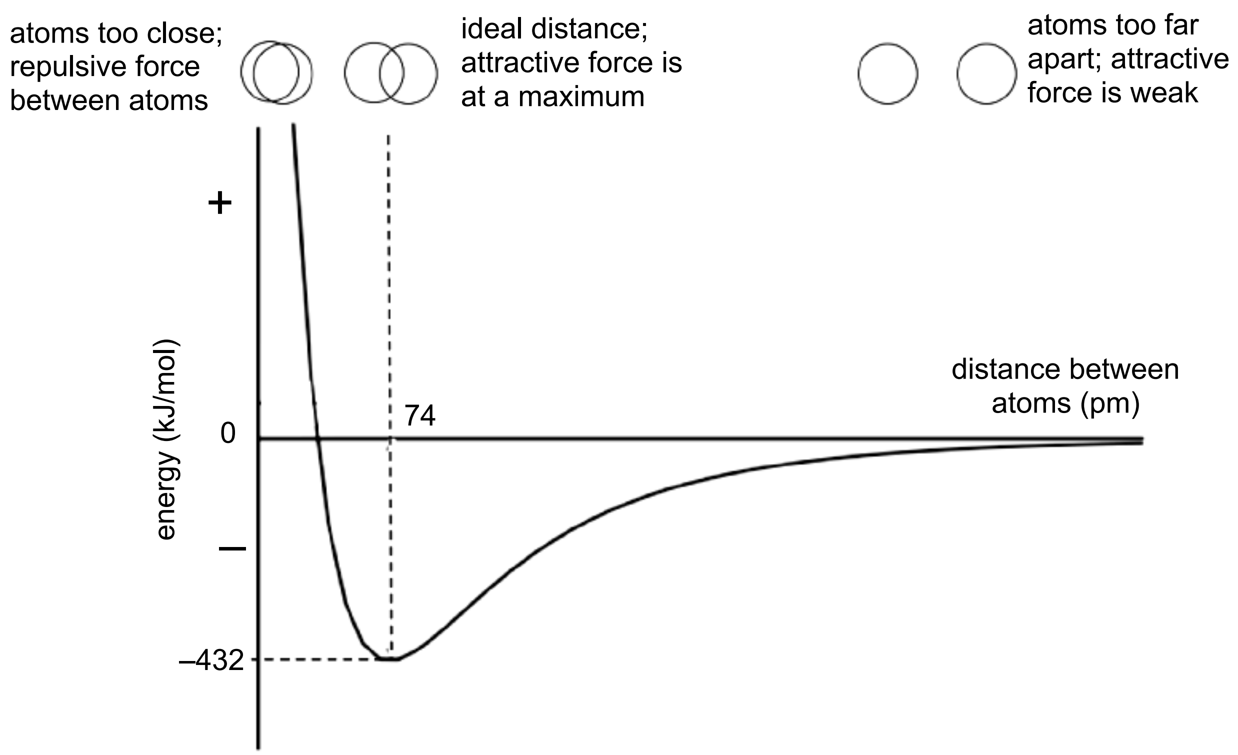


Fig. 8.1

A positive energy value means that repulsive forces between atoms are dominant, while a negative energy value means that attractive forces between atoms are dominant.

The bond length is the average distance between the nuclei of two bonded atoms in a molecule where the attractive force is greatest. For a hydrogen molecule, this distance is 74 picometres.

Table 8.2 shows how the H—H bond compares with the number of bonds, average bond energy and bond length of some elements in Period 2.

Table 8.2

type of bond	number of bonds	average bond energy (kJ/mol)	bond length (pm)
H – H	1	432	74
O – O	1	142	148
O = O	2	494	121
N – N	1	167	145
N = N	2	418	
N ≡ N	3	942	110
F – F	1	155	142

(a) Describe how the bond energy of H—H changes with the distance between the two hydrogen atoms.

....

....

....

....

....[3]

(b) In terms of the forces between the subatomic particles present in the hydrogen atoms, explain the trend of the bond energy as the distance between the hydrogen atoms increases from 74 pm.

....

....

....[2]

(c) **(i)** A student makes the following statement:

"The greater the number of bonds, the shorter the bond length for an element."

Do you agree with the student? Use the information in Table 8.2 to explain your reasoning.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) Use the information in Table 8.2 to predict the length of the N = N bond.

……………………………………………………………………………………………[1]

(d) Chlorine is in Period 3. The bond length of C*l* – C*l* is 199 pm.

In terms of atomic structure, suggest the difference in bond length between chlorine and fluorine.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………[2]

(e) When lightning strikes, nitrogen and oxygen in the air react to form nitrogen dioxide.

$$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g) \quad (\Delta H = +180 \text{ kJ/ mol.})$$

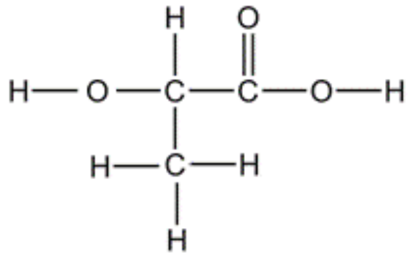
Calculate the energy released during bond forming.

[2]

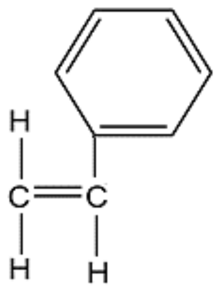
[Total: 12]

B9 Polylactic acid (PLA) is a biodegradable plastic whose feedstock is derived from starch-rich crops such as sugarcane, maize or wheat. It has gained popularity as a suitable plastic to replace polystyrene to make disposable plastic cups and plates.

The monomer of PLA is lactic acid, and the monomer of polystyrene is styrene. Their structures are shown below.



lactic acid



styrene

(a) Describe a chemical test, including observations, to distinguish between lactic acid and styrene.

………

………

………[2]

(b) Outline **one** similarity and **two** differences between the polymerisation of lactic acid and styrene.

………

………

………

………

………[3]

(c) **(i)** Draw the structure of the polymer PLA, showing **one** repeat unit.

[1]

(ii) A polymer of PLA has an M_r of 1,800,000.

Calculate the number of repeat units in this polymer.

number of repeat units = ………………………. [1]

(d) Explain, in terms of the impact on the environment, why polystyrene is being replaced by PLA to make disposable plastic cups and plates.

……………………………………………………………………………………………..………….

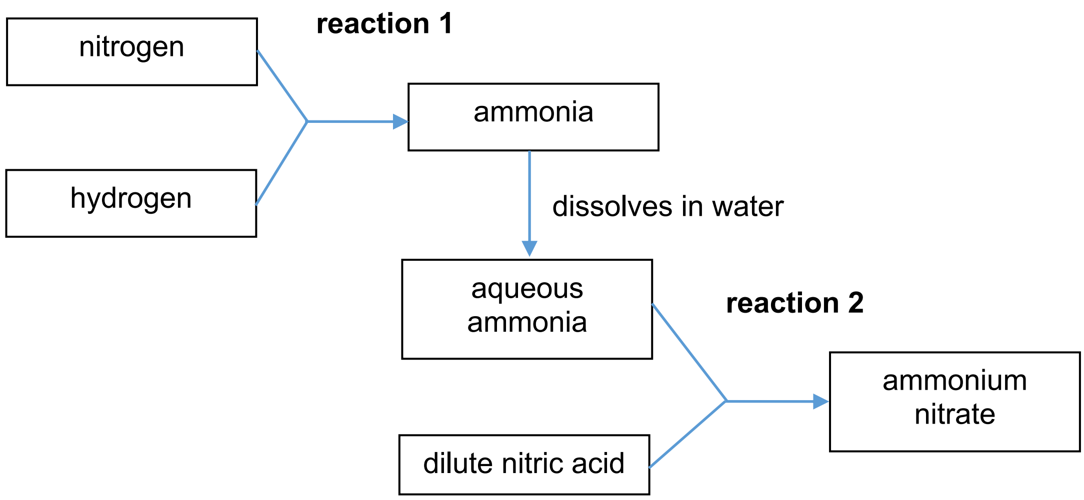
……………………………………………………………………………………….……..…[1]

[Total: 8]

EITHER

B10 Ammonium nitrate is commonly used in fertilisers as it contains nitrogen, which is essential for plant growth.

The following flow diagram shows how ammonium nitrate is manufactured from nitrogen, hydrogen and nitric acid.



(a) Describe the conditions required for **reaction 1** to take place.

....[2]

(b) Construct the ionic equation, with state symbols, for **reaction 2**.

....[2]

(c) Calculate the percentage of nitrogen by mass in ammonium nitrate.

percentage by mass of nitrogen = ...[1]

(d) Draw a dot-and-cross diagram to show the bonding in ammonia.

Show outer-shell electrons only.

[2]

(e) Ammonium nitrate can also be produced from the following reaction.

$$Ca(NO_3)_2(aq) + 2NH_3(g) + CO_2(g) + H_2O(l) \rightarrow 2NH_4NO_3(aq) + CaCO_3(s)$$

Describe how a pure and dry sample of ammonium nitrate crystals can be obtained from the products of this reaction after all the aqueous calcium nitrate has reacted.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...[3]

[Total: 10]

OR

B10 Methanol, CH_3OH, is a member of the homologous series of alcohols.

(a) Methanol can be made from methane in a two-step process.

step 1 Methane is reacted with chlorine gas to produce chloromethane, CH_3Cl.

step 2 CH_3Cl is reacted with sodium hydroxide to produce CH_3OH and one other product.

(i) State the type of reaction occurring in **step 1**, and the condition needed.

type of organic reaction: ……………………………………………..

condition needed: ……………………………………………………… [2]

(ii) Write the chemical equation for the reaction which occurs in **step 1**.

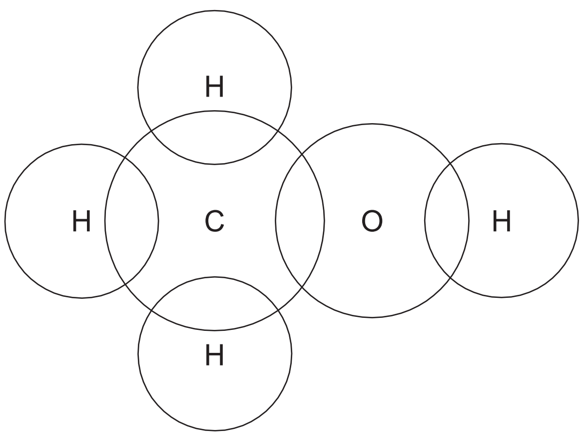
………………………………………………………………………………………………..[1]

(iii) Complete the chemical equation for **step 2**.

$CH_3Cl + NaOH \rightarrow CH_3OH +$ .... [1]

(b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of methanol.

Show outer-shell electrons only.



key

X C electron

o H electron

● O electron

[2]

(c) Methanol reacts with propanoic acid to form a small molecule and an ester with a molecular formula $C_4H_8O_2$.

(i) Name the products formed when methanol reacts with propanoic acid.

…………………………………………………………………………………………….[1]

(ii) Draw the full structural formula of an ester which is an isomer of the ester named in **(c)(i)**.

Show all the atoms and bonds.

[2]

(iii) Compare the esters in **(c)(i)** and **(c)(ii)**.

…………………………………………………………………………………………………

…………………………………………………………………………………………….[1]

[Total: 10]

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name:		Index Number:		Class:	

ST. ANTHONY'S CANOSSIAN SECONDARY SCHOOL
Preliminary Examination 2022
Secondary 4 Express

CHEMISTRY **6092/02**

Paper 2

31 August 2022

Setter: MRS ESTHER BOO

1 hour 45 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen. You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

If working is needed for any question, it must be shown with the answer.
Omission of essential working will result in loss of marks.
Calculators should be used where appropriate.

Section A: Consists of **8 Structured Questions**.
Answer **all** questions in the spaces provided.

Section B: Consists of **3 Free Response Questions**.
Answer **all three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page **29**.

For Examiner's Use	
Section A	
Section B	
Total	80
Parent's signature:	

This document consists of **29** printed pages (including the cover page) **[Turn over**

Section A

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Choose from the following substances to answer the questions below.

ethene	**iron**	**silicon dioxide**
ammonia	**potassium**	**lead(II) nitrate**
graphite	**copper**	**magnesium oxide**

Each substance can be used **once**, **more than once** or **not at all**.

(a) State **two** substances that exists as simple molecules.

.... [1]

(b) Which substance is displaced from its salts in alkaline conditions?

.... [1]

(c) Which element exists as a macromolecule?

.... [1]

(d) Which substance, other than iron, contains the element that is used in the manufacture of steel?

.... [1]

[Total: 4]

A2 Fig. 2.1 below shows the leaf and stem of the rhubarb plant.

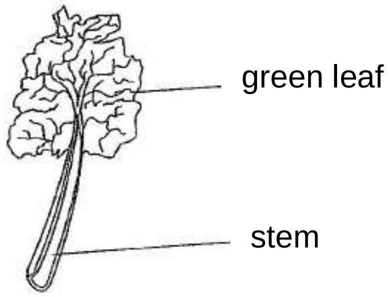


Fig. 2.1

(a) When the leaf is crushed and mixed with solvent propanone, the coloured pigments are extracted to form a blue solution. One of the pigments is chlorophyll.

Fig. 2.2 shows a chromatogram done with the blue solution to separate the different pigments. One of the pigments found is chlorophyll.

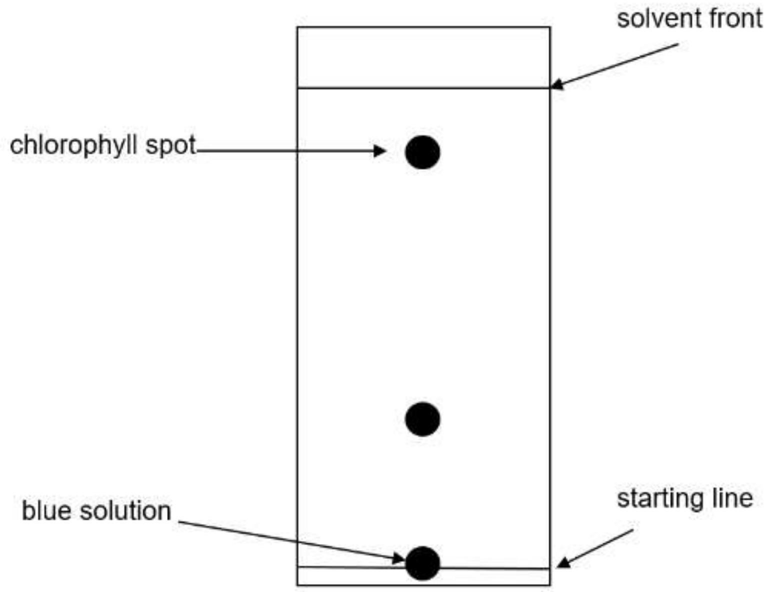


Fig. 2.2

From Fig. 2.2, calculate the R_f value for chlorophyll from the chromatogram shown above. Show your working.

R_f value = ……………………… [1]

[Turn Over

(b) From the plant, an unknown substance **X** can be extracted.

What can be deduced about substance **X** from the results of each of the following experiments?

(i) Experiment 1: **X** has a pH of 4.

……………………..…………………………………………………………. [1]

(ii) Experiment 2: When **X** is added to acidified potassium manganate(VII), the solution changes from purple to colourless.

……………………..…………………………………………………………. [1]

(iii) Experiment 3: One mole of **X** reacts with two moles of aqueous sodium hydroxide.

……………………..…………………………………………………………. [1]

(c) The relative molecular mass of substance **X** is 90 and its composition by mass is

- carbon = 26.7%
- hydrogen = 2.1%
- oxygen = 71.1%

Calculate the empirical formula of substance **X** and hence its molecular formula.

[2]

[Total: 6]

[Turn Over

A3 **(a)** Fluorine, chlorine and bromine belong to Group VII of the Periodic Table.

A new element, gistine (G), in Group VII is just discovered. Its relative atomic mass is 370.

Predict and explain the observations when aqueous bromine is added to a solution of sodium gistide.

Support your explanation with the help of a balanced chemical equation with state symbols.

....

....

....

....

....

....

....

....

.... [3]

(b) Electronegativity is a measure of the attractive power of atoms for electrons in chemical bonds. It is a number between 0 and 4.0. A covalent bond is formed if the difference in electronegativity is small (usually less than 1.5) and an ionic bond is formed if the difference is large (usually more than 1.5).

Table 3.1 shows the electronegativities of elements in Period 2 and 3.

Table 3.1

symbol	Li	Be	B	C	N	O	F	Ne
electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0	0
symbol	Na	Mg	A*l*	Si	P	S	C*l*	Ar
electronegativity	0.9	1.2	1.5	1.8	2.1	2.5	3.0	0

(i) Describe the trend seen in the electronegativity of elements across the Period in Table 3.1.

....

.... [1]

[Turn Over

(ii) When two atoms form a bond, the average distance between nuclei of the two atoms can be measured. This is known as the bond length. Table 3.2 shows the bond lengths of the covalent bonds formed between carbon atoms and halogen atoms.

Table 3.2

covalent bond	C – F	C – C*l*	C – Br
bond length / nm	0.135	0.177	0.194

Two students made the following conclusions:

Student 1: “A more reactive halogen will form a covalent bond with a longer bond length with carbon.”

Student 2: “The greater the difference in electronegativity between carbon atom and halogen atom, the shorter is the bond length.”

Comment on the two students’ conclusions.

Use the information in Table 3.1 and Table 3.2 to support your answer.

……………………………………………………………………………………

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…………………………………………………………………………… [3]

[Total: 7]

A4 Fig. 4.1 shows four titration curves, **A**, **B**, **C** and **D** for combination of different aqueous solutions of acids and alkalis.

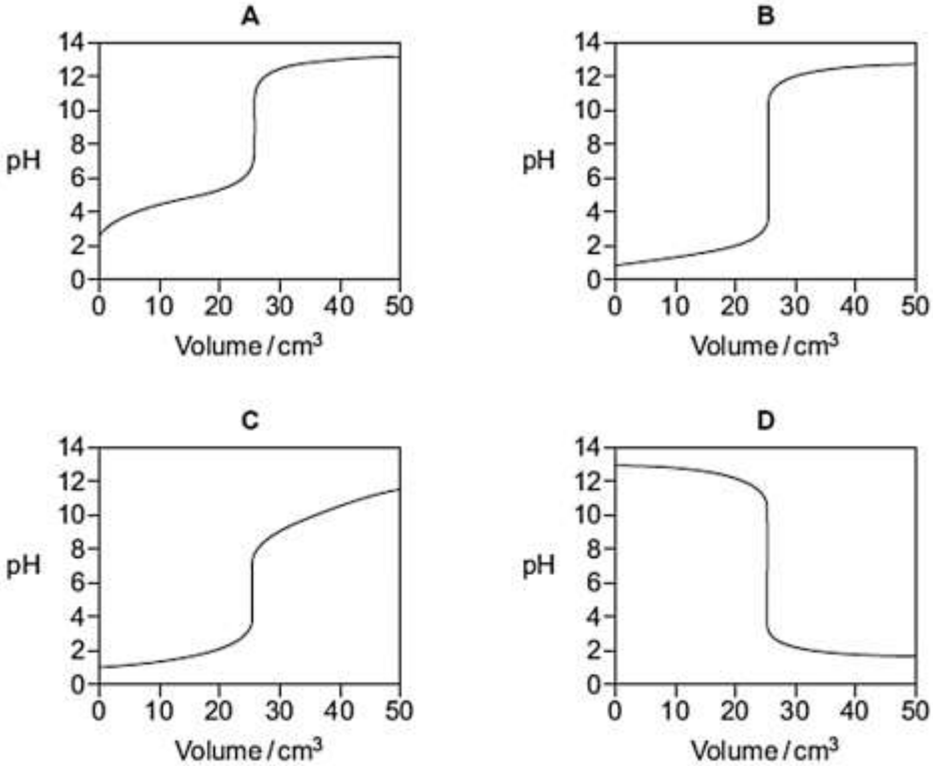


Fig. 4.1

(a) In titration curve **A**, 20.0 cm^3 of acid with a concentration of 7.5 g/dm^3 reacts with 25 cm^3 of alkali with concentration of 0.1 mol/dm^3.

Given that 1 mole of acid reacts with 1 mole of alkali, calculate the relative molecular mass of the acid.

[2]

(b) 25.0 cm^3 of aqueous sodium hydroxide was used to completely neutralise a sample of dilute hydrochloric acid in titration curve **B.**

State and explain how the volume of aqueous sodium hydroxide of the same concentration would change if the dilute hydrochloric acid was substituted with dilute sulfuric acid of the same volume and concentration.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(c) State and explain **two** differences in how titration curve **C** and titration curve **D** were obtained.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[Total: 6]

A5 The amount of air pollutants emitted by a car depends on its driving mode – whether it is waiting at traffic junction (idling) or if it is zooming off (accelerating) when the light turns green.

Table 5.1 shows the composition of unburnt hydrocarbons (C_xH_y), nitrogen oxides (NO_x) and carbon monoxide (CO) emitted by a car engine in two different driving modes.

Table 5.1

driving mode	air / petrol mixture	temperature of the car engine	concentration of air pollutant / ppm*		
			C_xH_y	NO_x	CO
idling	less air	lower	2800	130	45000
accelerating	more air	higher	20	820	21000

*ppm refers to parts per million

(a) Describe how nitrogen oxides and carbon monoxide are formed in a car engine.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) With reference to Table 5.1, describe the difference in the concentration of air pollutants when the car is in the two different driving modes.

Suggest reasons for the difference.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

[Turn Over

(c) The equation below shows the reaction in the catalytic converter which reduces the amount of carbon monoxide and nitrogen monoxide from cars.

$$2CO + 2NO \rightarrow 2CO_2 + N_2$$

Explain, in terms of oxidation states, why the reaction is a redox reaction.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(d) Describe the environmental problem caused by high amount of carbon dioxide.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

[Total: 8]

A6 The Haber process is an industrial process for producing ammonia from nitrogen and hydrogen, using an iron catalyst at high temperature and pressure.

Fig. 6.1 shows the yield of ammonia that is made under different conditions.

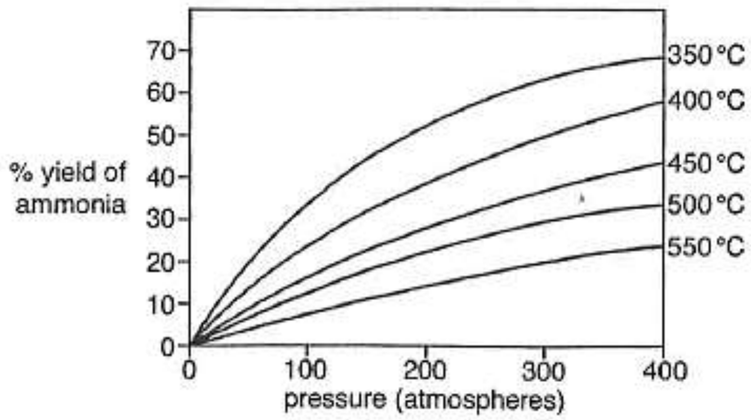


Fig. 6.1

Nowadays the process has been adapted to work at a pressure of 50 atmospheres.

(a) Explain, in terms of collisions between reacting particles, how a lower pressure affects the rate of reaction in the reactor.

....

....

....

.... [2]

(b) Use Fig. 6.1 to predict how a lower pressure affects the relative amounts of ammonia, nitrogen and hydrogen that leave the **main reactor**.

Explain your reasoning.

....

....

....

.... [2]

[Turn Over

(c) What effect does a lower pressure have on the **final amount** of ammonia made from a fixed amount of nitrogen and hydrogen?

Explain your reasoning.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(d) In practice, when nitrogen reacts with hydrogen, the yield of ammonia is never 100%.

Suggest a reason why.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

[Total: 8]

A7 The enthalpy of combustion of a substance is defined as the heat energy given out when one mole of a substance burns completely in oxygen.

Table 7.1 gives values for the enthalpy change of combustion (ΔH) for some common alkanes and alcohols used as fuels.

Table 7.1

substance	combustion reaction	ΔH_c (kJ/mol)
ethane	$2\ C_2H_6\ (g)\ +\ 7\ O_2\ (g) \rightarrow 4\ CO_2\ (g)\ +\ 6\ H_2O\ (l)$	- 1560
butane	$2\ C_4H_{10}\ (g)\ +\ 13\ O_2\ (g) \rightarrow 8\ CO_2\ (g)\ +\ 10\ H_2O\ (l)$	- 2874
octane	$2\ C_8H_{18}\ (g)\ +\ 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g)\ +\ 18\ H_2O\ (l)$	- 5460
ethanol	$C_2H_5OH\ (l)\ +\ 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g)\ +\ 3\ H_2O\ (l)$	- 1368
butanol	$C_4H_9OH\ (g)\ +\ 6\ O_2\ (g) \rightarrow 4\ CO_2\ (g)\ +\ 5\ H_2O\ (l)$	- 2671

(a) Using information from Table 7.1, describe the relationship between the number of carbon atoms in alkanes and enthalpy change of combustion.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(b) Based on the information given in Table 7.1, comment on the enthalpy change of combustion for the alkanes and alcohols with the same number of carbon atoms.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(c) Explain, using bond breaking and bond formation, why the combustion of ethane is an exothermic reaction.

……………………………………………………………………………………………

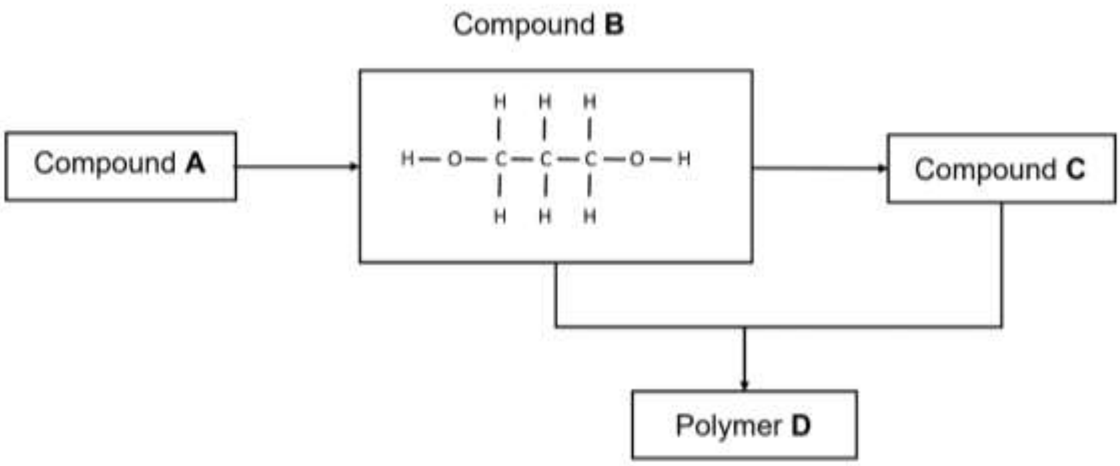
……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

[Total: 6]

A8 Fig. 8.1 shows the reaction scheme for compound **A.**



(a) One mole of compound **A** reacts with one mole of steam to form compound **B** at high temperature and pressure in the presence of a catalyst.

Draw the full structural formula of compound **A**.

[1]

(b) Describe a chemical test to determine if all of the compound **A** has been converted into compound **B**.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………….. [1]

[Turn Over

(c) Compound **A** can form an addition polymer.
Draw **two** repeat units of this addition polymer.

[1]

(d) Compound **B** can be oxidised by acidified aqueous potassium manganate(VII) to form compound **C**.

Draw the full structural formula of compound **C**.

[1]

(e) Compound **B** and compound **C** can undergo condensation polymerisation to form polymer **D**.

Draw a repeat unit of polymer **D**.

[1]

[Total: 5]

Section B (30 marks)

Answer all **three** questions in this section.
The last question is in the form of an either/or and only **one** of the alternatives should be attempted.

B9 Read the information below about the processing of hydrocarbons in the petrochemical industry.

Various processing units are required in the petrochemical industry. The following describes three of such units: cracking unit, isomerisation unit and reforming unit.

Cracking unit

There are two main types of cracking units: thermal crackers and catalytic crackers.

Thermal crackers use high temperatures (600 ^oC – 900 ^oC) to crack long chain alkanes, producing straight chain hydrocarbons.

Catalytic crackers involve the use of a catalyst consisting of aluminium oxide and silicon dioxide in the cracking process and produce mostly small branched alkanes from long chain alkanes.

Isomerisation unit

In an isomerisation unit, straight chain hydrocarbons are converted into branched hydrocarbons in the presence of a catalyst. The catalyst used is similar to that in a catalytic cracker. For example, an isomerisation unit could convert butane into methylpropane as shown in Fig. 9.1.

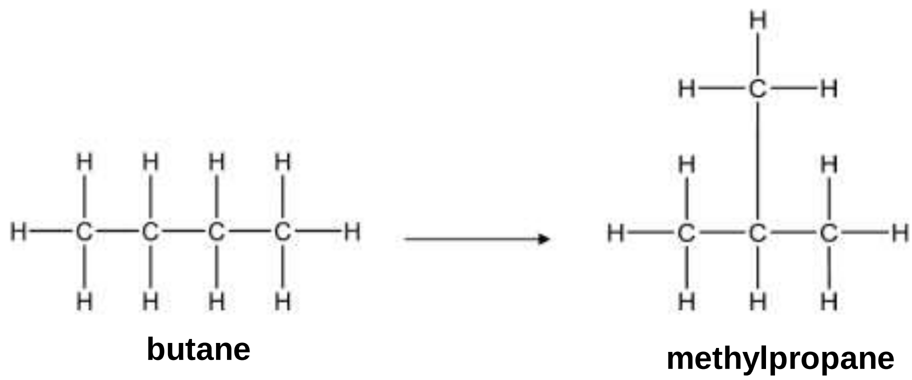
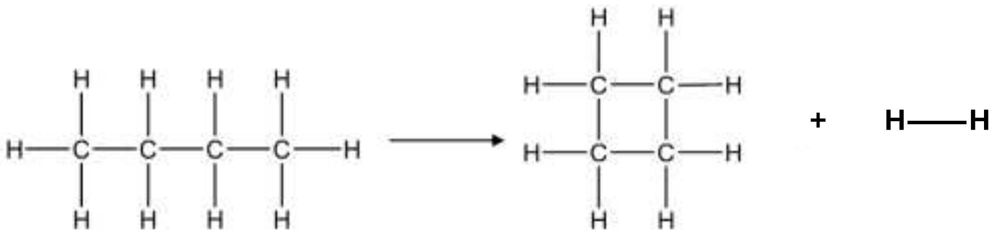


Fig. 9.1

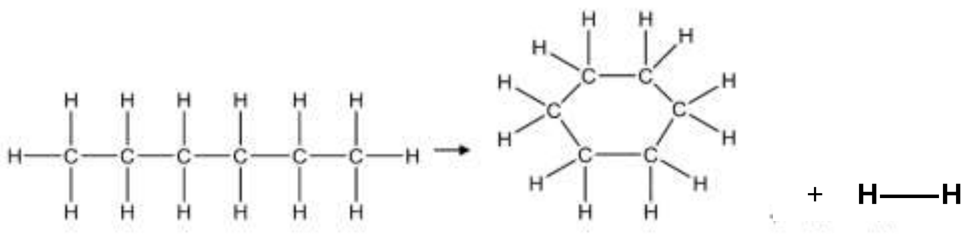
[Turn Over

Reforming unit

In a reforming unit, straight chain alkanes are converted into ring structures, called cycloalkanes, using a fairly high temperature (500°C) and a platinum catalyst. Hydrogen is usually obtained as the other product. For example, a reforming unit could convert butane into cyclobutane and hexane into cyclohexane as shown in Fig. 9.2.



butane **cyclobutane**



hexane **cyclohexane**

Fig. 9.2

These units can then be assembled together for processing of long chain alkanes.

Fig. 9.3 shows one such assembly unit in a petrochemical plant. First, long chain alkanes are passed through the cracking unit. Ethene, but-1-ene and hexane are produced, which are then subjected to different processes, respectively.

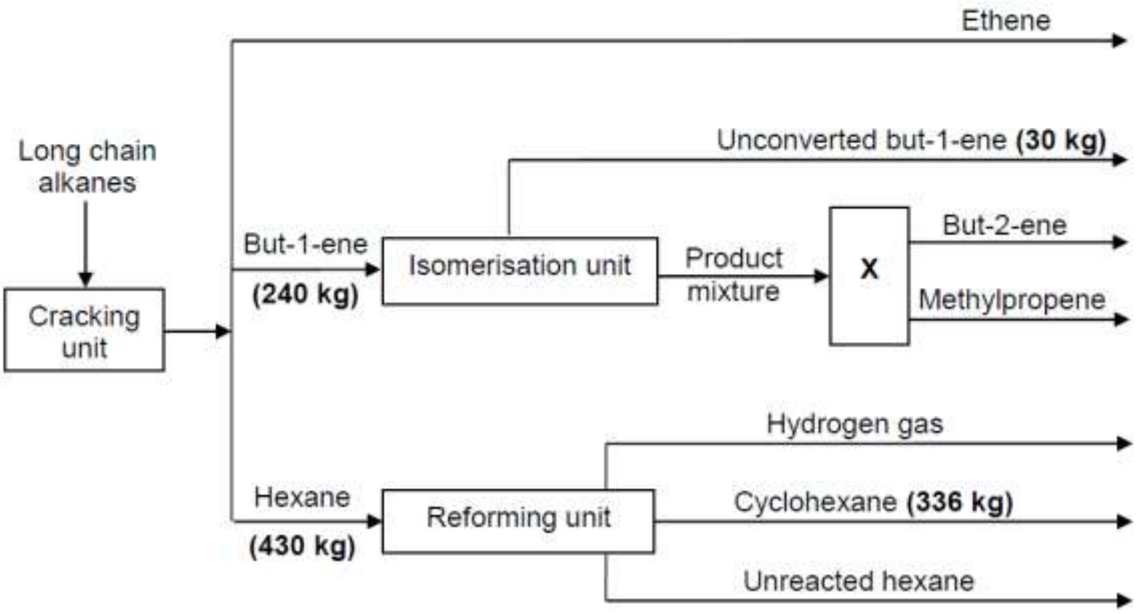
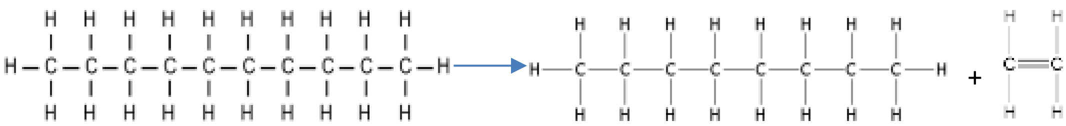


Fig. 9.3

(a) The following equation shows a cracking reaction.



With reference to information on the cracking unit, suggest whether this reaction is more likely to take place in a thermal cracker or a catalytic cracker.

Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) With reference to Fig. 9.2, explain whether cyclobutane is an isomer of butane.

………………………………………………………………………………………….

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(c) **(i)** The mass ratio of but-2-ene to methylpropene in the product mixture of the isomerisation unit was found to be 1 : 1.

With reference to Fig. 9.3, calculate the mass of but-2-ene and methylpropene produced.

mass of but-2-ene = ………………………..

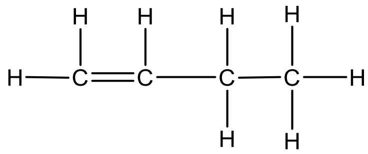
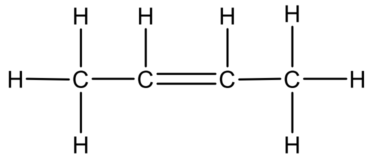
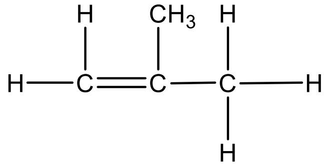
mass of methylpropene = …………………

[2]

[Turn Over

(ii) Table 9.4 shows some information about but-1-ene, but-2-ene and methylpropene.

Table 9.4

hydrocarbon	structure	boiling point / °C
but-1-ene		-6.3
but-2-ene		3.7
methylpropene		-6.6

The mixture of but-2-ene and methylpropene is separated by process **X**. Suggest what process **X** is likely to be.

Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(d) With reference to Fig. 9.2 and Fig. 9.3, calculate the mass of hydrogen gas produced by the reforming unit.

mass of hydrogen gas .... kg [2]

(e) Suggest the minimum number of carbon atoms that should be present in the long chain alkanes in Fig. 9.3.

…………………………………………………………………………………………….. [1]

[Total: 10]

[Turn Over

B10 In an experiment, hydrogen gas was passed over equal masses of three heated metal oxides in identical porcelain boats as shown in Fig. 10.1.

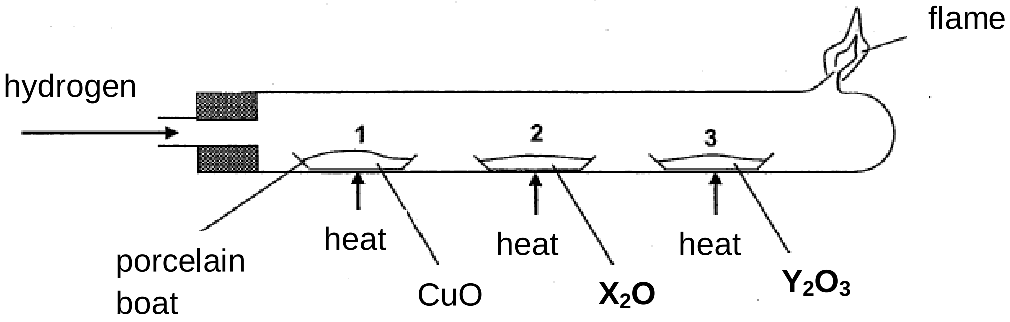


Fig. 10.1

The porcelain boats were weighed 5 minutes into the experiment. After weighing, the experiment was allowed to continue for another 30 minutes where no further changes were observed. At the end of the experiment, the heat source was turned off. However, the hydrogen gas is kept flowing until the tube has cooled down.

Table 10.1 shows some data from this experiment.

Table 10.1

	at the start of experiment	5 minutes into the experiment	at the end of experiment
mass of empty porcelain boat/ g	16.35	-	16.35
mass of porcelain boat **1** and its content/ g	22.35	21.15	20.15
mass of porcelain boat **2** and its content/ g	22.35	22.35	22.35
mass of porcelain boat **3** and its content/ g	22.35	21.20	20.55

(a) What would you expect to see happen in porcelain boat **1**.

Explain with the aid of a balanced equation for the reaction that had occurred.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Turn Over

(b) **(i)** Of the three metals, Cu, **X**, and **Y**, state the most reactive metal.

……………………………………………………………………………….… [1]

(ii) With reference to the data given, explain how you reach the conclusion in **(b)(i)**.

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………………….. [2]

(c) **(i)** Use the data given to calculate the mass of oxygen in $\mathbf{Y_2O_3}$ in porcelain boat **3**.

[1]

(ii) Hence, calculate the relative atomic mass of **Y**. From your result, identify **Y**.

[2]

[Turn Over

(d) **X**$_2$O has a high melting point.

Draw a dot-and-cross diagram to show the bonding of **X**$_2$O. Show the outer shell electrons only.

[2]

[Total:10]

Either

B11 **(a)** Describe a way to prepare a pure sample of silver chloride from silver metal.

Use the following information to help you.

- Silver does **not** react with hydrochloric acid
- Silver reacts with hot concentrated nitric acid to form silver nitrate.

…………………………………………………………………………………….....

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…………………………………………………………………………………….....

…………………………………………………………………………………... [4]

(b) Hydrogen peroxide is often used to bleach or lighten hair colour. It slowly decomposes to produce water and oxygen.

$$2H_2O_2\,(l) \rightarrow 2H_2O\,(l) + O_2\,(g)$$

(i) The decomposition of hydrogen peroxide involves a change from a liquid reactant to a gaseous product.

Describe the differences in movement and arrangement of particles between a liquid and a gas.

movement

……………………………………………………………………………………

…………………………………………………………………….……… [1]

arrangement

....

…………………………………………………………………...……… [1]

(ii) Two experiments were performed to investigate the effect of a change in concentration on the rate of decomposition of hydrogen peroxide at room temperature.

1 g of a catalyst in the form of small pellets was added.

Experiment 1:
mixture of 4 cm^3 of hydrogen peroxide and 46 cm^3 of water

Experiment 2:
mixture of 6 cm^3 of hydrogen peroxide and 44 cm^3 of water

The results of the two experiments were plotted and shown in Fig. 11.1.

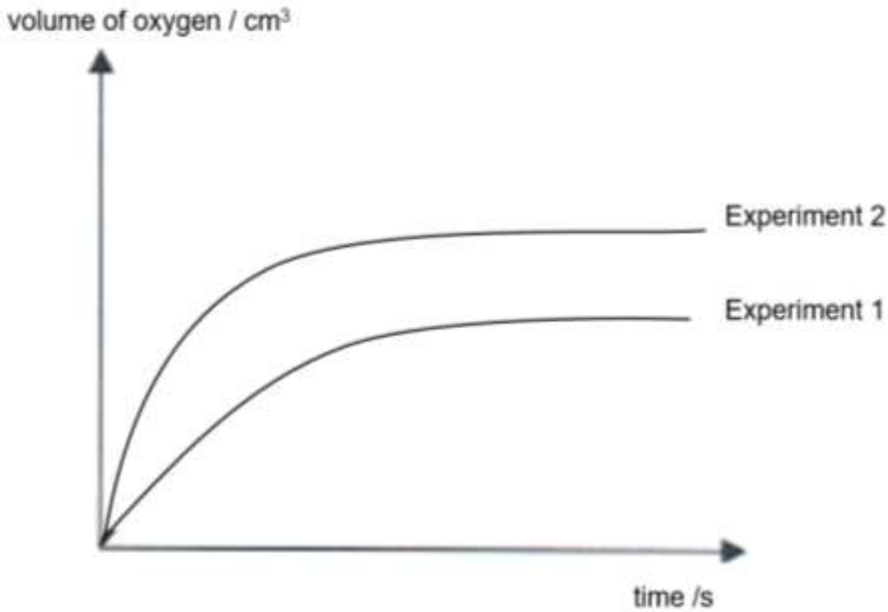


Fig. 11.1

Two further experiments were carried out.

In experiment 3, a mixture of 2 cm^3 of hydrogen peroxide and 48 cm^3 of water was used. 1 g of the same catalyst was added.

In experiment 4, a mixture of 6 cm^3 of hydrogen peroxide and 44 cm^3 of water was used. 1 g of the same catalyst was added in powdered form.

Sketch, on the same axes, the two curves to show the progress of reaction in both experiment 3 and 4. [4]

[Total: 10]

[Turn Over

OR

B11 **(a)** A student used the following apparatus as shown in Fig. 11.2 to electrolyse concentrated aqueous sodium chloride using inert electrodes.

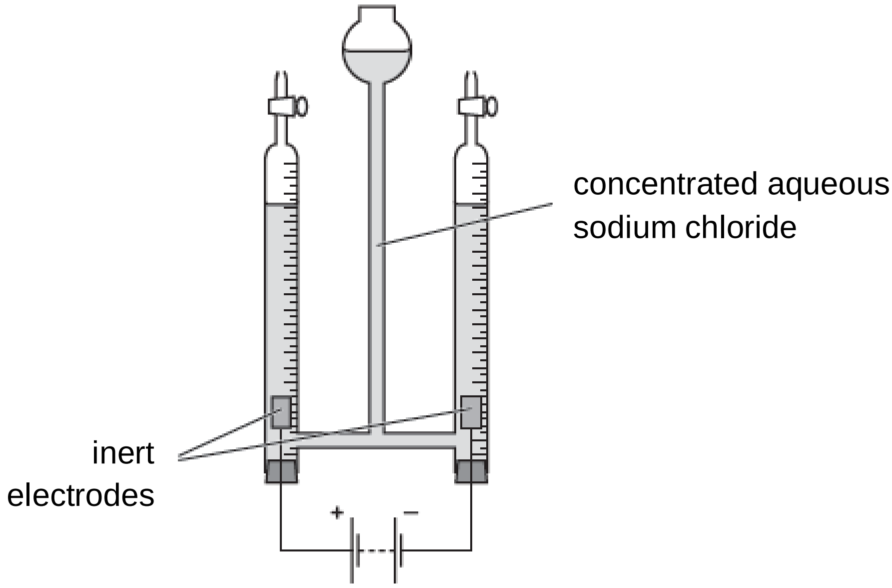


Fig. 11.2

(b) **(i)** Write ionic half-equation for the reactions at the cathode and anode.

at the cathode

……………………………………………………………………………………

at the anode

……………………………………………………………………………….… [2]

(ii) How, if at all, does the pH of the solution change during the electrolysis?

Explain your answer.

………………………………………………………………………………….

………………………………………………………………………………….

………………………………………………………………………………….

………………………………………………………………………………….

………………………………………………………………………………….

………………………………………………………………………………….

…………………………………………………………………………… [2]

[Turn Over

(iii) Initially, the volume of gas collected at the anode is slightly lower than the volume of gas collected at the cathode. As the electrolysis proceeds, the difference in volume does not increase but keeps constant.

Suggest a reason for this observation.

……………………………………………………………………………………...

……………………………………………………………………………………..

…………………………………………………………..………………… [2]

(b) A student used the following electrochemical cell as shown in Fig. 11.3.
The reading on the voltmeter was +1.10 V.

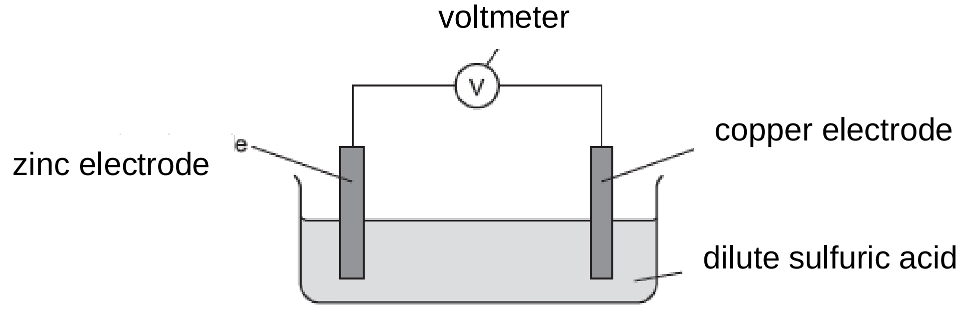


Fig. 11.3

(i) Draw an arrow on Fig. 11.3 to show the direction of electron flow. [1]

(ii) Suggest the change, if any, in the voltmeter reading if the zinc electrode was replaced with an iron electrode.

Explain your answer.

……………………………………………………………………………………...

……………………………………………………………………………………..

…………………………………………………………..………………… [2]

(iii) The zinc electrode was replaced with a silver electrode. The reading on the voltmeter was – 0.46 V.

Suggest why the sign of the voltmeter reading became negative.

……………………………………………………………………………………..

…………………………………………………………..………………… [1]

[Total:10]

END OF PAPER

[Turn Over

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –		91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is at room temperature and pressure (r.t.p.).

SINGAPORE CHINESE GIRLS' SCHOOL
Preliminary Examination
Secondary Four

CANDIDATE NAME	

CLASS	4			REGISTER NUMBER				
CENTRE NUMBER				INDEX NUMBER				

CHEMISTRY

6092/02

Paper 2 Theory

23 August 2022

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer **all three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 21.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	**50**
Section B	**30**
Total	**80**

This question paper consists of 21 printed pages and 1 blank page.

Section A

Answer **all** questions in this section in the spaces provided.

The total mark for this section is 50.

A1 Use the substances in the list below to answer the following questions. Each option may be used once, more than once or not at all.

aluminium iodide   sodium chloride   ammonium chloride   zinc

chlorine   nitric acid   sodium bromide   potassium carbonate

(a) Which substance in aqueous form reacts with aqueous chlorine to form a brown solution with black crystals?

.... [1]

(b) Which substance can reduce hydrochloric acid in a redox reaction?

.... [1]

(c) Which substance, when warmed in a mixture with aqueous sodium hydroxide and aluminium, produces a gas that turns moist litmus blue?

.... [1]

(d) Which substance produces a reddish brown vapour when it conducts electricity in the molten state?

.... [1]

(e) Which salt cannot be prepared by titration method?

.... [1]

[Total 5]

A2 The table below lists some information about the elements in Period 3 in the Periodic Table.

Element	Na	Mg	Al	Si	P	S	C*l*	Ar
Number of valence electrons	1	2	3	4	5	6	7	8
Common oxidation state	+1	+2	+3	+4 / - 4	-3	-2	-1	0
Melting point /^{o}C	98	650	660	1414	317	115	-101	-189

(a) Explain the variation in oxidation state(s) across the period.

....

....

....

....

[2]

(b) Explain the large difference in melting points between silicon and chlorine.

....

....

....

....

.... [3]

(c) Sodium phosphide is a reagent that is used in the production of other chemicals and as a catalyst in polymerisation. Sodium phosphide can be produced by reacting sodium with phosphorus in the reaction shown below.

$$12Na + P_4 \rightarrow 4Na_3P$$

(i) Draw a dot and cross diagram to show the bonding in sodium phosphide. Show all the electrons in your diagram. [2]

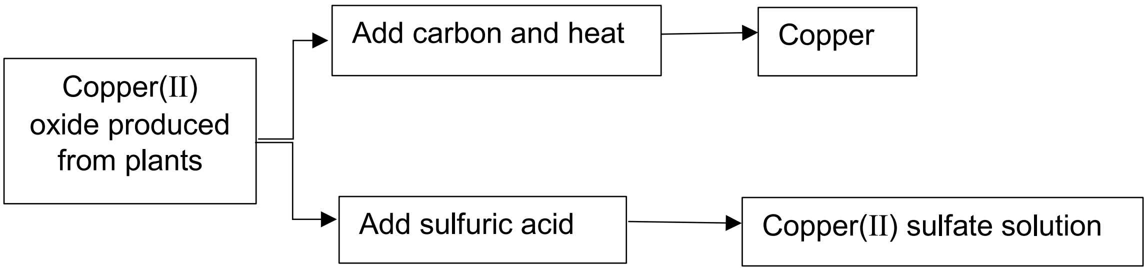
(ii) 5.75 g of sodium was reacted with 3.1 g of phosphorus.

Show by calculation which reactant is in excess and calculate the mass of sodium phosphide formed. [3]

[Total 10]

A3 To mine copper from land that contains very low percentages of copper compounds, plants may be cultivated to absorb these compounds through their roots.

These plants are then burnt to produce copper(II) oxide, which can then undergo reactions to produce copper or copper(II) sulfate solution as shown in the diagram below.



(a) Excess copper(II) oxide was reacted with carbon. Suggest how the solid copper metal can be separated from the resulting mixture.

....

.... [2]

(b) Name another non-metallic element that can be reacted with copper(II) oxide to obtain copper.

.... [1]

(c) Copper can be obtained from the copper(II) sulfate solution in two ways. One way involves reacting the copper(II) sulfate solution with iron.

(i) Write the ionic equation with state symbols for the reaction.

.... [1]

(ii) Describe two observations seen in the reaction.

....

.... [2]

(d) Another method to obtain copper from the copper(II) sulfate solution involves the electrolysis of copper(II) sulfate solution using carbon electrodes.
State an advantage of obtaining copper from copper(II) sulfate by the addition of iron compared to electrolysis.

....

.... [1]

(e) Suggest a reason why copper should be recycled.

....

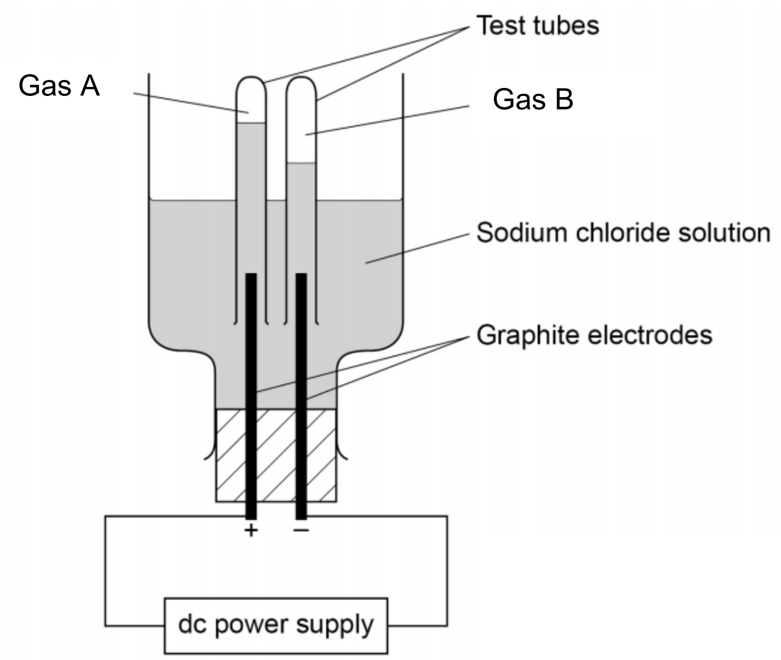
....

.... [1]

[Total 8]

[Turn Over

A4 A student carried out electrolysis on a solution of sodium chloride using the apparatus shown.



(a) Write the half equation for the formation of

(i) gas A: ……………………………………………………………………………………….

(ii) gas B: ……………………………………………………..……………………………. [2]

(b) Describe a test to confirm the identity of gas A.

……

…… [1]

(c) Explain why the ratio of gas A to gas B is 1:2.

……

……

…… [1]

(d) The student carried out a second experiment using a different solution of sodium chloride and the gases she obtained were in the ratio of 1:1. The gas collected at the positive electrode turned moist litmus blue and bleached it.

(i) How is the sodium chloride solution used in the second experiment different from that in the first experiment?

...…………………………………………………………………………………………………

…………………………………………………...………………………………………… [1]

(ii) Describe and explain the changes in the electrolyte as the electrolysis progressed in the second experiment.

....

....

....

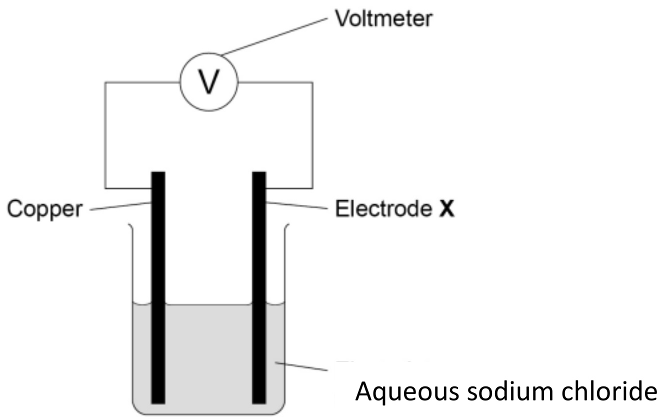
....[2]

(e) What must the student do if she wants to obtain sodium by electrolysis from sodium chloride?

.... [1]

[Total 8]

A5 A student investigated the voltage produced by different chemical cells.
The apparatus used is shown below.



The student measured the voltage obtained using different metals as electrode **X**.
The table below shows the results obtained.

Electrode **X**	Voltage / V
cobalt	+0.62
copper	0.00
magnesium	+2.71
nickel	+0.59
silver	-0.46
tin	+0.48

(a) List the six metals used for electrode **X** in decreasing order of reactivity.

……………………………………………………………………………………………………. [1]

(b) If **X** is zinc,

(i) write a half equation for the reaction at the copper electrode. Is this reaction oxidation or reduction? Explain your answer.

…………………………………………………………………………………………….

……………………………………………………………………………………………. [2]

(ii) describe what would be observed at electrode **X**.

……………………………………………………………………………………………. [1]

(c) Hydrogen fuel cells are chemical cells that can be used to power different forms of transport. Some diesel trains are being converted to run on hydrogen fuel cells. A newspaper article referred to the converted trains as the new 'steam trains'. Suggest why.

…………………………………………………………………………………………………….

……………………………………………………………………………………………………. [1]

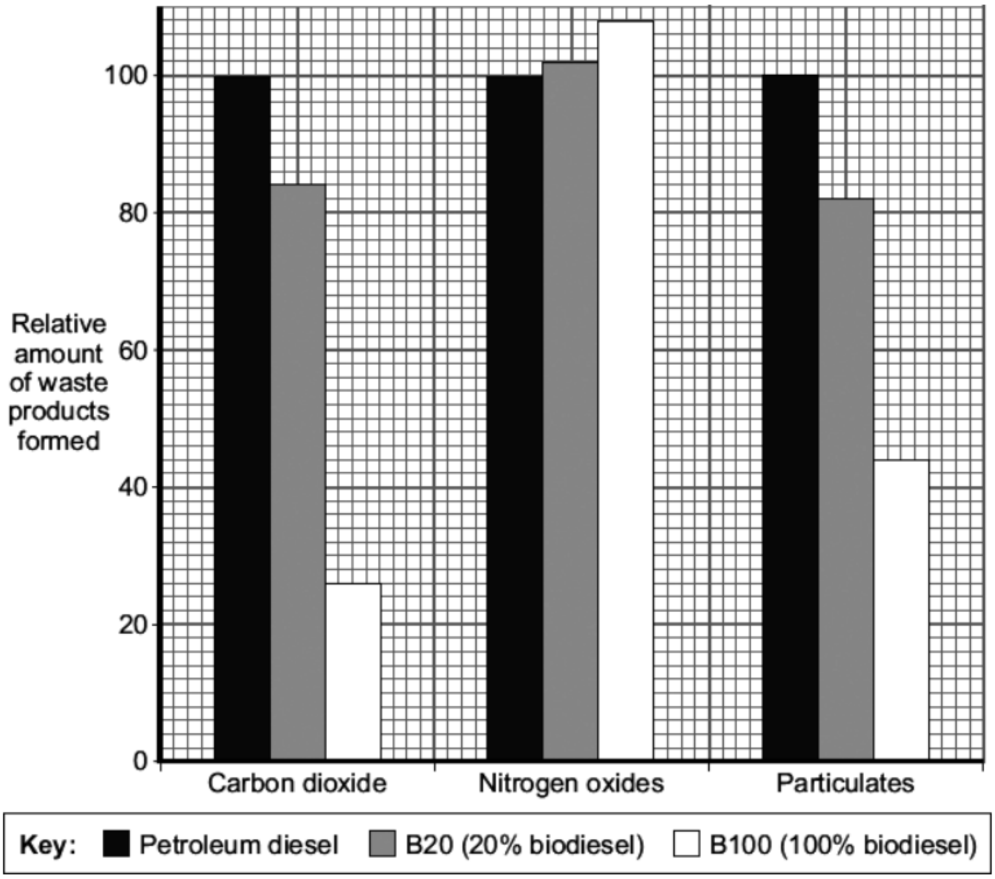
[Total 5]

[Turn Over

670

A6 There are two main types of diesel fuel used for cars:
- biodiesel, made from vegetable oils,
- petroleum diesel, made from crude oil.

(a) Biodiesel can be mixed with petroleum diesel (e.g. B20) to make a fuel for cars. In a car engine, the fuel burns in air. The waste products leave the car engine through the car exhaust system. The bar chart compares the relative amounts of waste products made when three different types of diesel fuel burn in a car engine.



(i) Mary studied the data in the graph and concluded that B100 is the best fuel to use as it causes the least pollution when used. Do you agree with her statement? Justify your answer by referring to data from the graph.

……

……

……

……[2]

(ii) What is the percentage reduction in particulates when B20 is used instead of petroleum diesel?

…… [1]

[Turn Over

(iii) A carbon neutral fuel does not add extra carbon dioxide to the atmosphere. Is biodiesel (B100) a carbon neutral fuel? Use the data and your knowledge to explain your answer.

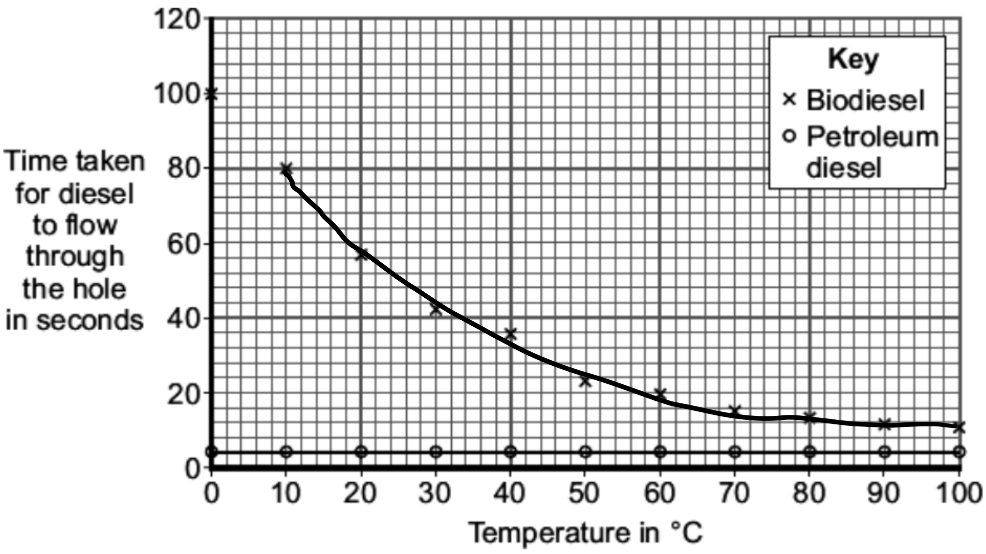
…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………[2]

(b) A scientist compared the viscosity of biodiesel with petroleum diesel at different temperatures. The scientist measured the time for the same volume of diesel to flow through a small hole in a cup. The scientist's results are plotted on the grid.



(i) What conclusions can the scientist make about the viscosity of biodiesel compared with the viscosity of petroleum diesel at different temperatures?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………[2]

(ii) Besides the difference in output of the products when used as a fuel, suggest another advantage of biodiesel over petroleum diesel.

…………………………………………………………………………………………………

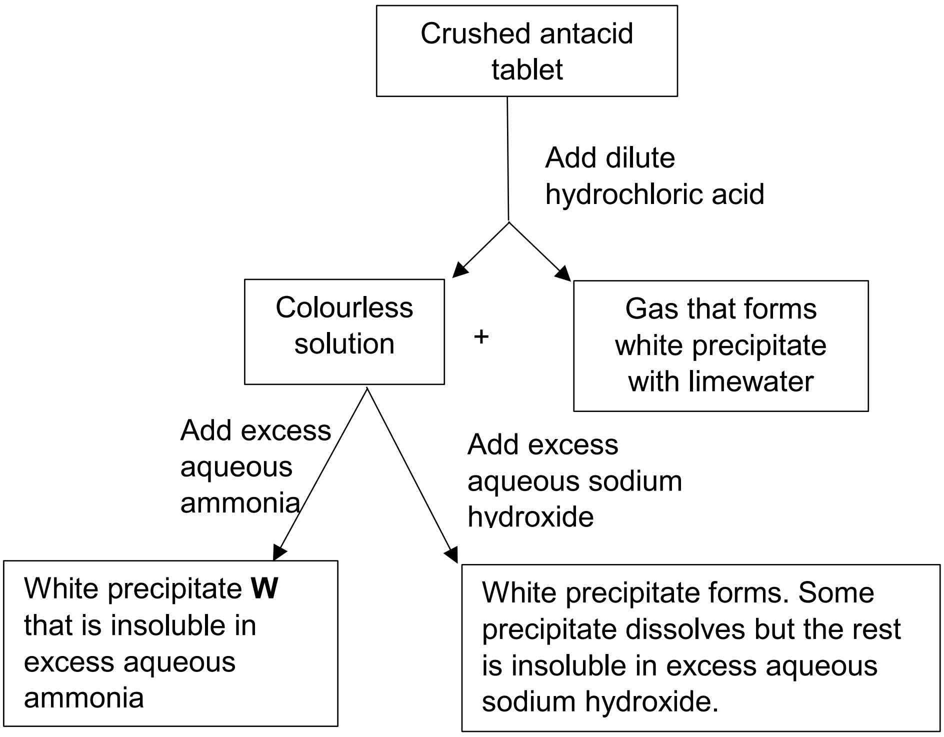
…………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

[Total 8]

[Turn Over

A7 Gastric pain is often caused by hyperacidity due to excess hydrochloric acid in the stomach. Antacid tablets contain active ingredients that react and neutralise the acid. An antacid tablet was crushed and tested as shown in the flow chart below.



(a) Give the formulae of three ions present in the active ingredient of the antacid.

.... [3]

(b) Write the ionic equation for the formation of white precipitate **W**.

.... [1]

(c) Magnesium hydroxide is another active ingredient that can be found in other antacids. Magnesium hydroxide is insoluble in water.

Describe how a pure dry sample of magnesium hydroxide can be made, starting from suitable common reagents in the laboratory.

....

....

....

....

....

....

.... [2]

[Total 6]

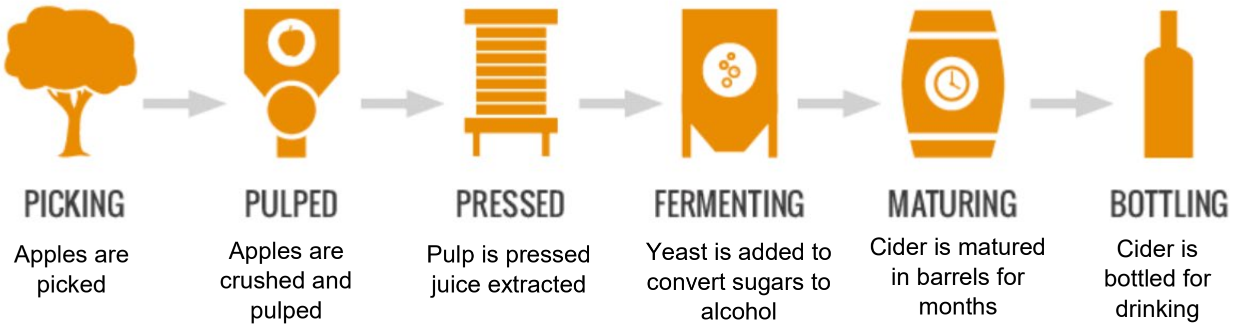
Section B

Answer all three questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Read the following information on the chemistry of cider production.

Cider is made from apples in a process that involves the following steps.

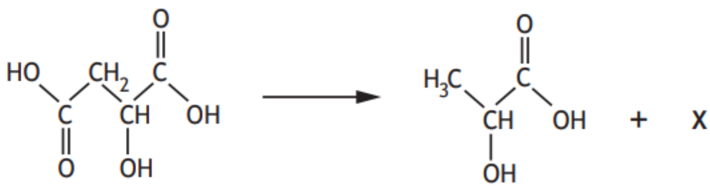


During the fermenting stage, yeast is added to convert the sugars in the apple juice into alcohol and carbon dioxide.

The percentage mass of alcohol in cider can be calculated using the formula

Percentage mass of alcohol = $\frac{\text{mass of alcohol}}{\text{mass of cider}}$ x 100 %

During the maturing process, malic acid in apple juice is converted to lactic acid and a gas **X**.

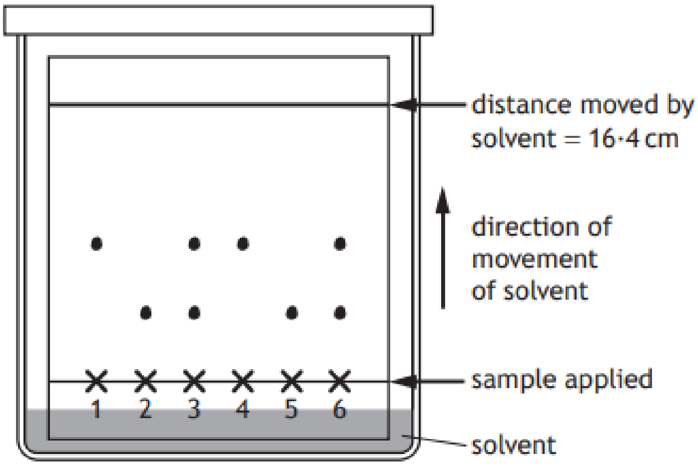


malic acid lactic acid

The maturing process can monitored using chromatography using thin layer chromatography.

Samples of lactic acid, malic acid and the cider are spotted on a silica plate and a solvent is allowed to travel up the plate.

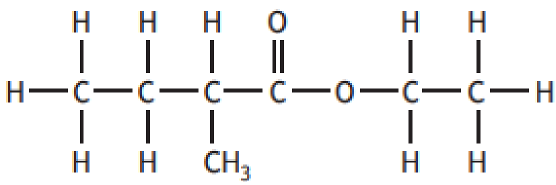
The diagram below shows a chromatogram obtained when ciders A, B, C and D from different barrels of cider are monitored for maturity by chromatography.



Number	Sample applied	Distance moved by spot(s) /cm
1	Lactic acid	8.2
2	Malic acid	4.1
3	Cider A	4.1, 8.2
4	Cider B	8.2
5	Cider C	4.1
6	Cider D	4.1, 8.2

The maturing process is complete when all the malic acid is converted to lactic acid.

Cider contains many naturally occurring substances that can affect its taste and aroma Cider's characteristic aroma comes from ethyl 2-methylbutanoate.



ethyl 2-methylbutanoate

Ethanol in cider can be oxidised by microorganisms when left exposed to the atmosphere, spoiling the aroma.

(a) State 2 conditions required for the conversion of sugars in the apple juice to alcohol, other than the addition of yeast.

....

.... [2]

[Turn Over

(b) 50 cm^3 of a sample of cider was found to contain 3.05 g of alcohol. 1 cm^3 of the cider weighs 1.36 g.
Calculate the percentage mass of alcohol in the cider. [1]

(c) Name the gas **X** that is formed in the maturing process.

.... [1]

(d) The retention factor or R_f value is a useful way to identify a substance from a chromatogram.

With reference to the chromatogram,

(i) calculate the R_f value of malic acid. [1]

(ii) state which cider is ready for bottling.

.... [1]

(e) **(i)** Draw the structures of two organic compounds that can be reacted to synthesise ethyl 2-methylbutanoate in the laboratory. [2]

(ii) State the conditions required for the reaction in **(e)(i)**.

.... [1]

(iii) Name the substance formed that spoils the aroma of the cider when ethanol is oxidised.

.... [1]

[Total 10]

B9 Hydrogen peroxide is unstable and decomposes to form oxygen gas and water.
At room temperature, the reaction can be very slow but the reaction can be speeded up by heating the mixture.

(a) Explain, in terms of colliding particles, the effect of increasing temperature on the rate of decomposition of hydrogen peroxide.

....

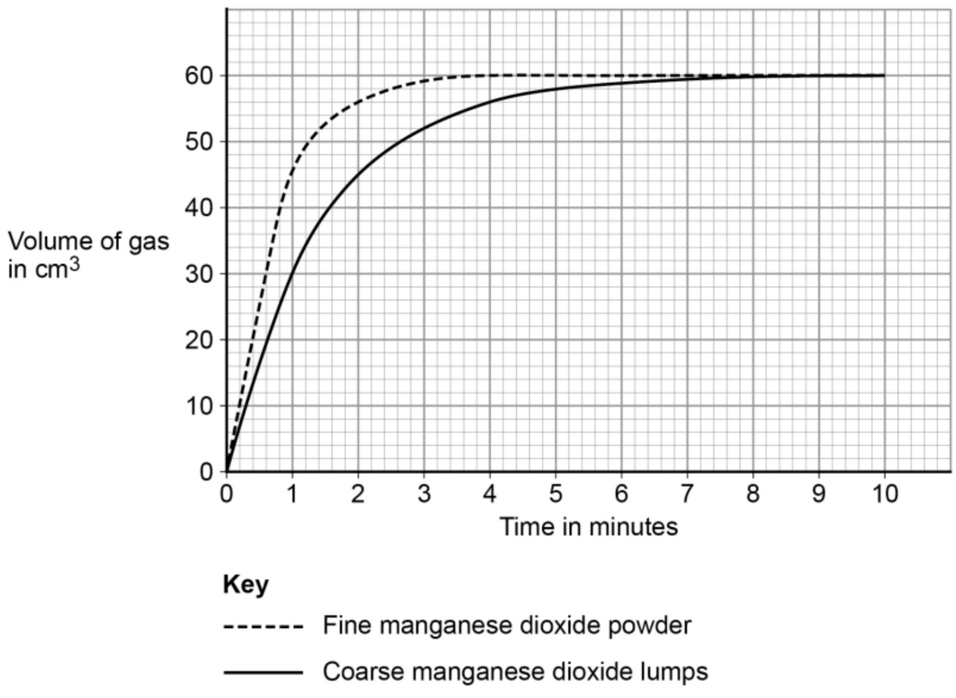
....

.... [2]

(b) Manganese dioxide can be used as a catalyst for the decomposition of hydrogen peroxide.

A student investigated the effect of the particle size of manganese dioxide on the rate of the reaction. She added 2 g of fine manganese dioxide powder to 25 cm^3 of 0.2 mol/dm^3 hydrogen peroxide solution in a conical flask and measured the volume of gas produced every minute for 10 minutes. She then repeated the experiment with 2 g of coarse manganese dioxide granules.

The graph below shows the results she obtained.



(i) Explain the difference in the shapes of the two graphs obtained.

....

....

....

....

.... [2]

(ii) If 25 cm^3 of 0.1 mol/dm^3 hydrogen peroxide was decomposed using 2 g of coarse manganese dioxide granules as catalyst, the reaction was completed at 4 min.

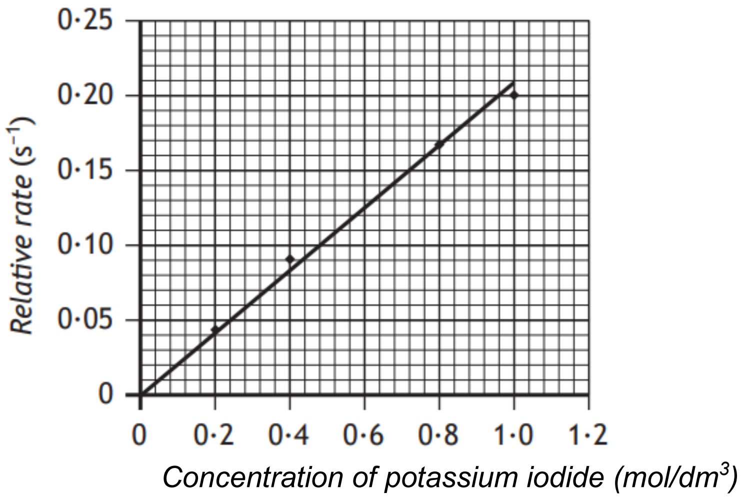
Sketch the expected graph on the grid on page 14. [2]

(c) The concentration of hydrogen peroxide is often described as volume strength. This relates to the volume of oxygen that can be produced from a hydrogen peroxide solution.

volume of oxygen produced	=	volume strength	×	volume of hydrogen peroxide solution

In an experiment, 74 cm^3 of oxygen was produced from 20 cm^3 of hydrogen peroxide solution. Calculate the volume strength of the hydrogen peroxide. [1]

(d) Hydrogen peroxide can react with potassium iodide to produce water and iodine.
A student carried out an experiment to investigate the effect of changing the concentration of potassium iodide on the reaction rate. The results are shown below.



(i) Calculate the time taken, in s, for the reaction when the concentration of potassium iodide used was 0.6 mol/dm^3. [1]

[Turn Over

(ii) Explain, in terms of oxidation states, if hydrogen peroxide is acting as an oxidising or reducing agent in this reaction.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………….. [1]

(iii) Describe what would be observed when hydrogen peroxide is added to potassium iodide.

…………………………………………………………………………………………………….

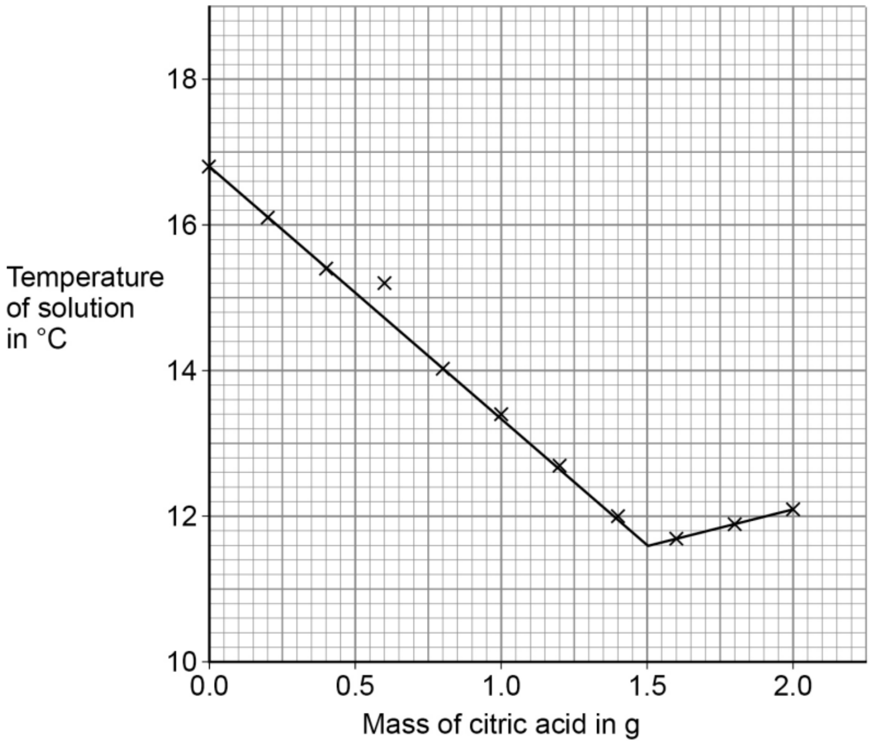
…………………………………………………………………………………………….. [1]

[Total 10]

B10 Either

Citric acid is a solid. A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution. This is the method used.

1. Pour 25 cm^3 of sodium hydrogencarbonate solution into a polystyrene cup.
2. Measure the temperature of the sodium hydrogencarbonate solution.
3. Add 0.20 g of citric acid to the polystyrene cup.
4. Stir the solution.
5. Measure the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added. The student plotted the results on a graph.



(a) Explain the shape of the graph in terms of the energy transfers taking place.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [3]

(b) Is this reaction exothermic or endothermic? Explain your answer in terms of bond breaking and bond forming.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Turn Over

(c) The equation for the reaction between citric acid and sodium hydrogencarbonate is shown below:

$H_3C_6H_5O_7 + 3NaHCO_3 \rightarrow Na_3C_6H_5O_7 + 3CO_2 + 3H_2O$

Use the data from the graph to calculate the concentration of the sodium hydrogencarbonate used in the reaction. [2]

(d) Draw the energy profile diagram for the reaction between citric acid and sodium hydrogencarbonate. Label the activation energy and the enthalpy change clearly. [2]

(e) A second student repeated the investigation using a metal container instead of the polystyrene cup. The container and the cup were of the same size and shape. The initial temperature of the solution was also the same.

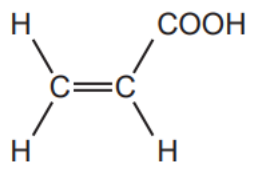
Sketch a line on the grid on Page 17 to show the second student's results.

Your line needs only show the expected results up to 1.00 g of citric acid added. [1]

[Total 10]

B10 Or

Propenoic acid (C_2H_3COOH) is an unsaturated carboxylic acid. The structural formula of propenoic acid is given below.



(a) Describe a chemical test to distinguish propenoic acid from propanoic acid.

....

....

.... [2]

(b) State how propenoic acid can be converted to propanoic acid. Give the conditions needed.

....

.... [1]

(c) Write the chemical equation for the reaction of propenoic acid with calcium carbonate.

.... [1]

(d) Draw the possible structure of the organic compound formed when steam is reacted with propenoic acid. [1]

(e) An organic compound has a molecular formula $C_6H_8O_4$. It is an unsaturated carboxylic acid.

(i) Explain the term *molecular formula*.

....

.... [1]

(ii) What is the empirical formula of this acid?

.... [1]

(iii) One mole of this carboxylic acid reacts with two moles of sodium hydroxide. How many moles of –COOH groups are there in one mole of this compound?

.... [1]

(iv) Identify the other functional group in this compound.

….. [1]

(v) Deduce a structural formula of this compound. [1]

[Total 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			proton (atomic) number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

ST JOSEPH'S INSTITUTION
PRELIMINARY EXAMINATION 2022
(YEAR 4)

CANDIDATE NAME	
CLASS	
INDEX NUMBER	

CHEMISTRY **6092/02**

Paper 2 **19 August 2022**

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes
(10:40 – 12:25)

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black fluid ink pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

The use of an approved scientific calculator is expected, where appropriate.

A copy of the Periodic Table is printed on **page 2**.

For Examiner's Use	
Section A	/ 50
Section B	/ 30
Total	/ 80

This document consists of **22** printed pages including this cover page.

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
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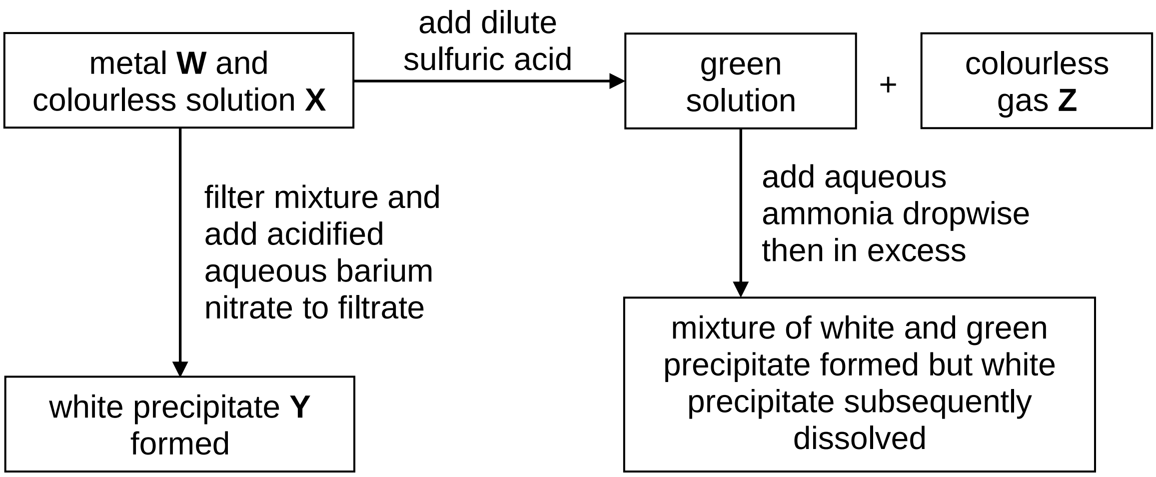
The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Section A (50 marks)

Answer **all** questions in this section in the spaces provided.

A1 Study the flowchart below and answer the following questions.



(a) Identify substances **W**, **X** and **Y**.

W: ……………………………………………………………..

X: ……………………………………………………………...

Y: …………………………………………………………….. [3]

(b) Describe a chemical test to confirm the identity of the colourless gas **Z**.

……………………………………………………………………………………………

…………………………………………………………………………………………..[1]

[Total: 4]

A2 Silicon tetrachloride, $SiCl_4$, and ethoxyethane, $(C_2H_5)_2O$, are both liquids at room temperature and pressure.

An experiment is performed to react silicon tetrachloride with ethoxyethane to produce two oxochlorides, Si_2OCl_6 and $Si_3O_2Cl_8$.

(a) **(i)** The temperature of the experiment is increased.

State the effect of increasing temperature on the rate of reaction. Explain your answer in terms of reacting particles.

....

....

....

....

....

....[2]

(ii) A student suggested that the rate of reaction of the experiment can be increased by increasing the pressure.

Do you agree? Explain your answer.

....

....[1]

(b) The oxochlorides that are formed can be reacted with water to convert all the chlorine atoms in the oxochlorides into chloride ions.

(i) Calculate the number of moles of chloride ions produced when 1.00 g of the oxochloride, Si_2OCl_6, completely reacts with water.

[1]

(ii) Calculate the number of moles of chloride ions produced when 1.00 g of the oxochloride, $Si_3O_2Cl_8$, completely reacts with water.

[1]

(c) Excess aqueous silver nitrate is added separately to the solutions formed by the two different oxochlorides, Si_2OCl_6 and $Si_3O_2Cl_8$. This helps to remove the chloride ions by forming a precipitate.

(i) Write an ionic equation for the formation of the precipitate.

[1]

(ii) Using your answers in **(b)** and **(c)(i)**, identify the oxochloride that will produce 3.03 g of precipitate. Explain how you arrived at your answer.

………………………………………………………………………………………

……………………………………………………………………………………[2]

[Total: 8]

A3 **(a)** The Medupi Power Station is a coal-fired power station in South Africa. When coal is burnt in the power station, one of the pollutants formed is nitrogen dioxide.

(i) Describe how nitrogen dioxide is formed in the power station.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(ii) Analysis of soil samples in the region in close proximity to the power station showed a high nitrate ion content.

Suggest the reason for the above.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(iii) Over a period of time, marble structures near the power station were observed to be corroding.

Write the chemical equation for the reaction which resulted in the corrosion of the marble structures.

[1]

(b) The following message was displayed on the side of a bus in Singapore.

This bus is more environmentally friendly than a car.
40 cars = 230 000 kg of carbon dioxide per year
This bus = 3200 kg of carbon dioxide per year

(i) Describe the environmental problem caused by carbon dioxide.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) Using the information provided, explain how the environmental problem caused by carbon dioxide in **(b)(i)** can be reduced.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(c) The Haber Process is used to manufacture ammonia in the chemical industry.

(i) State the optimum conditions used in the Haber Process.

…………………………………………………………………………………………[1]

(ii) Explain why the yield of ammonia produced in the Haber Process can never be 100 %.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

[Total: 10]

A4 Zinc can be obtained from zinc blende (ZnS) in a two-step process.

In Step 1, zinc blende is roasted in air and converted into zinc oxide according to the equation shown below.

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

In Step 2, the zinc oxide formed in Step 1 is then converted into zinc by reacting zinc oxide with the same gaseous reducing agent used in the extraction of iron.

(a) Explain, in terms of oxidation states, why the reaction shown in Step 1 is a redox reaction.

....

....

....[2]

(b) Write the chemical equation with state symbols for the reaction in Step 2.

[2]

(c) Two iron rods are coated, one with zinc and the other with copper.

Both rods were damaged with their coating scratched when they were piled into the ground to construct a structure. The damaged iron rods were exposed to the wet ground and air.

(i) Describe what will be observed on the exposed iron surfaces of both rods after a few days.

....

....[2]

(ii) Explain your answer in **(c)(i)**.

....

....

....

....[2]

[Total: 8]

692

A5 Transition metals are a block of elements in the centre of the Periodic Table. Some information about the transition metals in Period 4 are shown in the tables below.

Table 5.1

element	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
density / g/cm^3	2.99	4.50	5.96	7.20	7.20	7.86	8.90	8.90	8.92	7.14
melting point / °C	1541	1660	1890	1857	1244	1535	1495	1455	1083	420

Table 5.2

element	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
common oxidation states that occur in compounds	+3	+4 +3 +2	+5 +4 +3 +2	+6 +5 +4 +3 +2	+7 +6 +5 +4 +3 +2	+6 +5 +4 +3 +2	+4 +3 +2	+4 +3 +2	+2 +1	+2

(a) State one characteristic property of a transition metal that is not shown in both Tables 5.1 and 5.2.

…………………………………………………………………………………………….[1]

(b) Some scientists do not consider two of the metals found in Period 4 as transition metals.

(i) Name the two metals.

…………………………………………………………………………………[1]

(ii) Explain your answer in **(b)(i)**, using relevant information to support your answer.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………[3]

[Total: 5]

A6 Different electrolytes were electrolysed using different electrodes as shown in the table below.

experiment	electrolyte used	cathode	anode
1	concentrated copper(II) nitrate solution	electrode used: copper product formed: ……….………………..	electrode used: carbon product formed: oxygen
2	zinc nitrate solution	electrode used: platinum product formed: ……….………………..	electrode used: ……….……………….. product formed: zinc ions

(a) Complete the table above. [3]

(b) State two observations in Experiment 1.

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(c) Write an ionic equation with state symbols for the reaction at the anode for Experiment 1.

[2]

(d) In both Experiments 1 and 2, gases are produced as products of electrolysis.

By naming suitable apparatus and reagents, suggest how the gases can be dried and their volumes determined.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

[Total: 9]

A7 Propene is an unsaturated hydrocarbon which is widely used as a raw material for many plastic products.

(a) **(i)** Explain what is meant by *unsaturated*.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) Describe a chemical test to show that propene is unsaturated.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(b) Propene can be used to produce propanol.

(i) Describe how propanol can be produced from propene.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) Name and draw the full structural formula of the product formed when propanol reacts with ethanoic acid.

……………………………………………………………………………………………[2]

[Total: 6]

Section B (30 marks)

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Alcohols can be classified into primary, secondary or tertiary alcohols according to the number of alkyl groups on the carbon atom to which the hydroxyl group is attached to.

An alkyl group consists of carbon and hydrogen atoms and is formed by removing one hydrogen atom from the alkane chain. An alkyl group is usually attached to a carbon chain, forming a branch. An alkyl group can be represented using **R**.

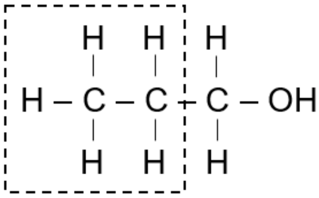
Examples of alkyl groups can be methyl ($-CH_3$), ethyl ($-C_2H_5$), propyl ($-C_3H_7$), butyl ($-C_4H_9$), etc.

Table 8.1 below shows the different types of alcohols and their structures.

Table 8.1

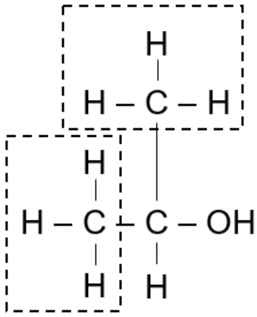
type of alcohol	**no. of alkyl groups attached to the carbon atom with hydroxyl group**	**structure**
primary	1	H | **R** – C – OH | H
secondary	2	**R** | **R** – C – OH | H
tertiary	3	**R** | **R** – C – OH | **R**

Some examples of the different types of alcohols are shown below.



propan-1-ol

This alcohol contains one alkyl group attached to the carbon atom with hydroxyl group, hence it is a primary alcohol.



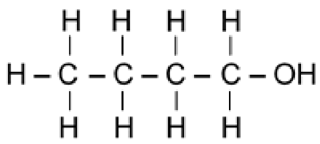
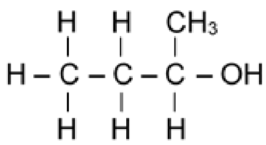
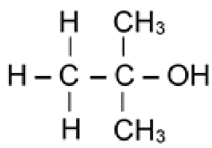
propan-2-ol

This alcohol contains two alkyl groups attached to the carbon atom with hydroxyl group, hence it is a secondary alcohol.

The boiling point of an alcohol is affected by the number of alkyl groups attached to the carbon atom with the hydroxyl group.

Table 8.2 below shows the boiling points of three different alcohols with molecular formula $C_4H_{10}O$.

Table 8.2

alcohol	butan-1-ol	butan-2-ol	2-methylpropan-2-ol
structure			
boiling point / °C	118	99	82

Alcohols can behave as weak acids and react with sodium metal to form alkoxides and hydrogen gas.

Some examples of the reactions between alcohols and sodium metal are shown below.

$$\underset{\text{ethanol}}{2C_2H_5OH} + 2Na \rightarrow \underset{\text{sodium ethoxide}}{2C_2H_5O^-Na^+} + H_2$$

$$\underset{\text{propanol}}{2C_3H_7OH} + 2Na \rightarrow \underset{\text{sodium propoxide}}{2C_3H_7O^-Na^+} + H_2$$

The acidity of an alcohol is also affected by the number of alkyl groups attached to the carbon atom with the hydroxyl group.

The strength of an acid is indicated by pK_a. The smaller the value of pK_a, the stronger the acid. The larger the value of pK_a, the weaker the acid.

Table 8.3 below shows the pK_a values of the three alcohols from Table 8.2 and a few carboxylic acids.

Table 8.3

substance	**pK_a**
butan-1-ol	16.1
butan-2-ol	17.6
2-methylpropan-2-ol	19.2
ethanoic acid	4.77
butanoic acid	4.82

(a) Which alcohol shown in Table 8.2 is a secondary alcohol? Explain your answer.

………………………………………………………………………………………………

………………………………………………………………………………………………[1]

(b) Draw the structure of a tertiary alcohol with the molecular formula $C_5H_{12}O$.

[1]

(c) **(i)** State the trend in the boiling point and the number of alkyl groups attached to the carbon atom with the hydroxyl group in Table 8.2.

………………………………………………………………………………………………

………………………………………………………………………………………………[1]

(ii) Suggest a reason for your answer in **(c)(i)**.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………[1]

(d) State one similarity and one difference between the reaction of an alcohol with sodium compared to the reaction of a carboxylic acid with sodium.

Similarity: ………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

Difference: ………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………[2]

(e) What is the relationship between the number of alkyl groups attached to the carbon atom with the hydroxyl group and the acidity of the alcohol?

………………………………………………………………………………………………

………………………………………………………………………………………………[1]

(f) Which substance from Table 8.3 will react most vigorously with sodium?

Explain your answer using the information provided.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………[2]

(g) Write the chemical equation for the reaction between butanol and sodium.

[1]

(h) Butanoic acid can be produced from butanol using a laboratory reagent.

(i) Name a suitable reagent for the above reaction.

……………………………………………………………………………………[1]

(ii) Describe the observations for **(h)(i)**.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[1]

[Total: 12]

B9 Methylamine, CH_3NH_2, is a substance with similar properties to ammonia.

The equation below shows what happens when methylamine is dissolved in water.

$$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$$

(a) According to the Brønsted-Lowry theory, an acid is a species that donates a proton (H^+) and a base is a species that accepts a proton (H^+).

Using the equation, state whether methylamine is acting as an acid or a base.

Explain your answer.

....

....[1]

(b) An aqueous solution of sodium hydroxide has pH 13.

(i) Predict the pH of an aqueous solution of methylamine.

....[1]

(ii) Explain your answer in **(b)(i)**.

....

....

....

....

....[2]

(c) Methylamine can react with acids to form soluble salts.

The equation below shows the reaction of methylamine with hydrochloric acid.

$$CH_3NH_2 + HCl \rightarrow \underset{\text{methylammonium chloride}}{CH_3NH_3Cl}$$

(i) Suggest the method used to prepare methylammonium chloride salt.

....[1]

(ii) Describe how a pure and dry sample of methylammonium chloride crystals can be obtained from the salt solution obtained in **(c)(i)**.

....

....

....

....

....[2]

(iii) Give the formula of the salt formed when methylamine reacts with sulfuric acid.

....[1]

[Total: 8]

EITHER

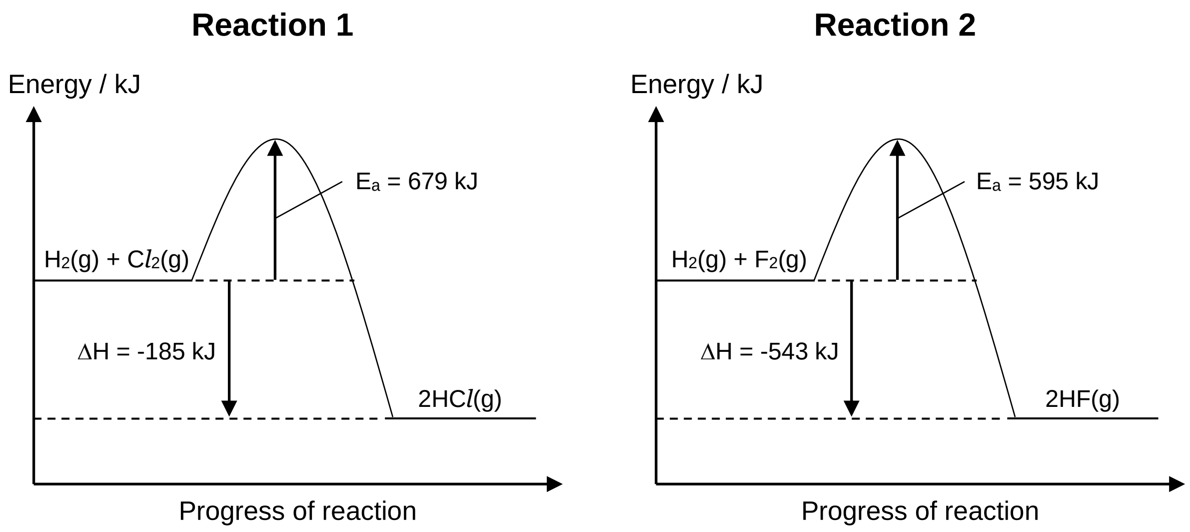
B10 Halogens can react with hydrogen to form hydrogen halides.

The following equations show the formation of the hydrogen halides, hydrogen chloride and hydrogen fluoride.

Reaction 1: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Reaction 2: $H_2(g) + F_2(g) \rightarrow 2HF(g)$

The energy profile diagrams for Reactions 1 and 2 are also shown below.



(a) Use the Kinetic Particle Theory to describe the arrangement and movement of the particles of hydrogen chloride formed in Reaction 1.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………..[2]

(b) Which reagent is the oxidising agent in Reaction 2?

Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………..[2]

(c) **(i)** Explain why the activation energies for both reactions are different.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) Calculate the energy released during the formation of bonds for both Reactions 1 and 2.

[2]

(iii) From your results in **(c)(ii)**, state whether the hydrogen chloride bond or hydrogen fluoride bond is stronger.

……………………………………………………………………………………………[1]

(iv) Draw a dotted line on the energy profile diagram for Reaction 2 to indicate the new energy level of the product if it is cooled to liquid state. [1]

[Total: 10]

OR

B10 The table below shows the melting points of some compounds formed between aluminium, phosphorus, chlorine and fluorine.

substance	melting point / °C
aluminium chloride	192
aluminium fluoride	1290
phosphorus trichloride	-94
phosphorus trifluoride	-152

(a) Which compounds are most likely to have simple molecular structures?

Explain your reasoning.

....

....

....[2]

(b) **(i)** Draw a 'dot-and-cross' diagram to represent the bonding in aluminium fluoride, showing only the outermost electrons.

[2]

(ii) In which states can aluminium fluoride conduct electricity?

Explain your answer.

....

....

....[2]

(iii) Predict whether aluminium oxide has a higher or lower melting point than aluminium fluoride.

Explain your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(c) Explain, in terms of structure and bonding, the difference in melting points between phosphorus trichloride and phosphorus trifluoride.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

[Total: 10]

- End of Paper -

Name and Index Number: ( )	Class:

SENG KANG SECONDARY SCHOOL
PRELIMINARY EXAMINATION

CHEMISTRY **6092/02**

Secondary 4 Express **24 August 2022**

Paper 2 Theory **1 hour 45 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 26.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's use	
Section A	**/ 50**
1	/ 5
2	/ 6
3	/ 5
4	/ 6
5	/ 5
6	/ 4
7	/ 9
8	/ 10
Section B	**/ 30**
9	/ 12
10	/ 8
E11	/ 10
O11	/ 10
Total	**/ 80**
Total %	**/ 100**

Parent's / Guardian's Signature: ……………………….…………...

This document consists of **26** printed pages.

Do not turn over the page until you are told to do so.

[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.

1 Use the list of substances to answer the questions.

nitrogen monoxide	**ammonia**	**iron(III) oxide**
brass	**chlorofluorocarbon**	**concentrated sodium chloride**
zinc	**carbon dioxide**	**iron**
concentrated silver chloride	**neon**	**caesium**

(a) Which substance has a molecule made up of only three atoms?

………………………………………………………………………………………… [1]

(b) Which substance(s) undergo(es) rusting?

………………………………………………………………………………………… [1]

(c) Which substance(s) is/are involved in the Haber process?

………………………………………………………………………………………… [1]

(d) Which substance undergoes electrolysis to produce two gases?

………………………………………………………………………………………… [1]

(e) Which substance is responsible for the depletion of the ozone layer?

………………………………………………………………………………………… [1]

[5 marks]

2 Fig 2.1 shows a gas syringe filled with 80 cm^3 of hydrogen chloride gas at 20°C. The syringe is then placed in a beaker of hot water at 50°C.

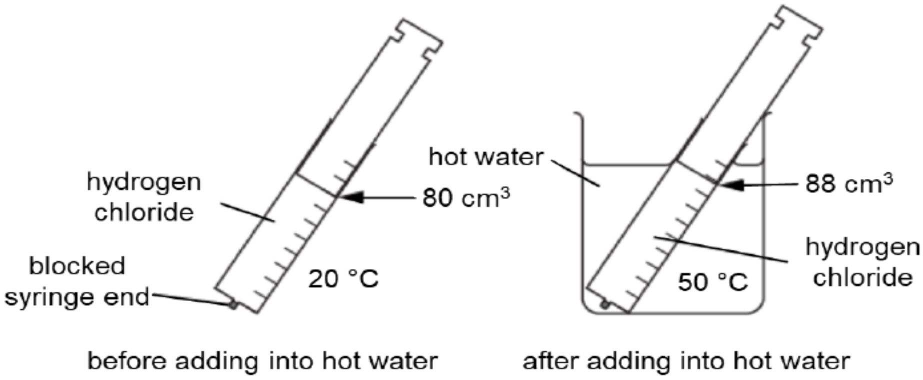


Fig 2.1

The atmospheric pressure remains unchanged but the volume of gas in the syringe increases to 88 cm^3.

(a) A student made the following comment:

As the temperature increases, the molecules of gas in the syringe increases.

Using kinetic particle theory, explain if you agree with this statement.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(b) Draw 'dot-and-cross' diagrams to show the bonding in hydrochloric acid and hydrogen chloride. Show valence electrons only.

[4]

[6 marks]

[Turn over

3 Table 3.1 shows the properties of some non-metallic elements A, B, C and D.

Table 3.1

element	physical state at room temperature	colour	melting point / °C	electrical conductivity
A	solid	black	3317	good
B	solid	grey	1410	poor
C	gas	green	-101	does not conduct
D	solid	yellow	119	does not conduct

(a) Which two elements have giant covalent structures?

Give a reason for your answer.

elements ……………… and ……………….

explanation ...……..………………………………………………………………

……………………..…………..……………………………………………………… [2]

(b) In terms of **bonding**, explain the differences in electrical conductivity of element A and B.

……………………..…………..………………………………………………………

……………………..…………..………………………………………………………

……………………..…………..………………………………………………………

……………………..…………..……………………………………………………… [3]

[5 marks]

4 Sorrel is a small green plant with spear-shaped, deep green leaves and reddish-brown veins.

(a) Sorrel plants contain a poisonous chemical **X**.

A 0.1 mol/dm^3 solution of **X** has a pH of 3 whereas a 0.1 mol/dm^3 solution of hydrochloric acid has a pH of 1.

What can be deduced about **X** from the following information?

……………………..………….…………………………………………………………

……………………..………….………………………………………………………… [1]

(b) Analysis of 10.0 g of chemical **X** shows that it contains 2.67 g carbon, 0.22 g hydrogen and the remaining being oxygen.

(i) Deduce the empirical formula of **X**.

empirical formula ……………………………………. [3]

(ii) Given that the relative molecular mass of **X** is 90, deduce the molecular formula of **X**.

molecular formula ……………………………………. [2]

[6 marks]

[Turn over

5 **E** is one of the substances used in a Blast furnace to manufacture iron.

Fig. 5.1 describes some of the reactions of **E**.

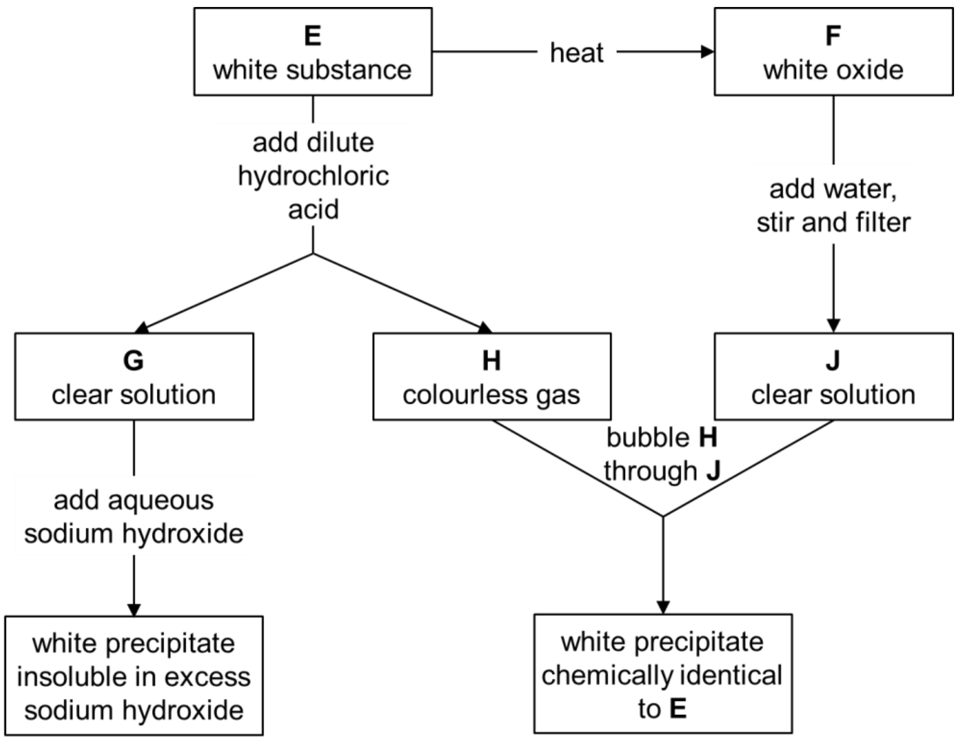


Fig 5.1

(a) Identify **E**, **F**, **G**, **H** and **J**.

E ………………………………………………

F ………………………………………………

G ………………………………………………

H ………………………………………………

J ………………………………………………

[3]

(b) State the purpose of substance **E** in the Blast furnace.

……………………………………………………………………………………………… [1]

(c) Describe any difference in observation if the clear solution **G** was tested with aqueous ammonia instead.

……………………..…………….…………………………………………………………

……………………..…………….………………………………………………………… [1]

[5 marks]

6 The head of a safety match contains potassium chlorate(V) and antimony(III) sulfide. The side of the matchbox contains red phosphorus.

When a match head is struck on the side of the box, the friction produces enough heat to light the match.

The equation for this reaction is shown.

$$5KClO_3 + 6P \rightarrow 5KCl + 3P_2O_5$$

(a) What is meant by '(V)' in potassium chlorate(V)?

.... [1]

(b) 'Potassium chlorate(V) is the oxidising agent in this reaction.'

Explain, in terms of oxidation state, the validity of this statement.

....

....

.... [2]

(c) The cation in antimony(III) sulfide found in the match head can be reduced to its metal by a reducing agent.

Write an ionic equation to show the transfer of electrons involved in this reduction reaction. Include state symbols.

.... [1]

[4 marks]

7 Methane steam reforming is the most common and cost-effective method for hydrogen production.

The equations show the two-stage process for the hydrogen production.

Stage 1 : $CH_4 + H_2O \longrightarrow CO + 3H_2$ $\Delta H = -206$ kJ/mol

Stage 2 : $CO + H_2O \longrightarrow CO_2 + H_2$ $\Delta H = -41$ kJ/mol

(a) Explain, in terms of bond breaking and bond forming, why **stage 1** is an exothermic reaction.

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) Construct the overall equation for the reaction.

…………………………………………………………………………………………… [1]

(c) Hence, calculate the volume of hydrogen gas evolved at room temperature and pressure when 8 kg of methane is used.

[3]

[Turn over

(d) Table 7.1 shows some bonding energies.

Table 7.1

bond	H-H	O-H	C=O
bond energy / kJ/mol	432	460	799

Use the overall enthalpy change of **stage 2** and the bond energies in Table 7.1 to calculate the bond energy of the covalent bond in CO.

[3]

[9 marks]

[Turn over

8 Fig 8.1 shows an experimental set-up of two cells.

Cell One and **Cell Two** are connected together. Both electrodes **X** and **Y** are made of graphite.

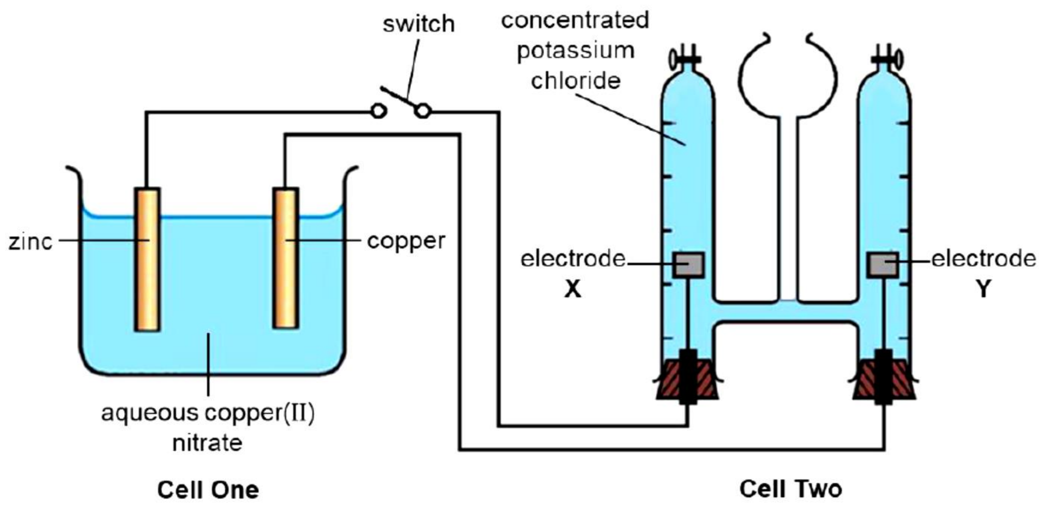


Fig 8.1

When the switch is closed, reactions occur in both cells.

(a) Construct half equations for the reaction that occurs at the electrode in **Cell One**.

zinc electrode: ……………………………………………………………………………

copper electrode: …………………………………………………………………………… [2]

(b) Hence, describe three observations seen in **Cell One**.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

[Turn over

(c) A gas is produced at each of the electrodes in **Cell Two**.

(i) Identify the gas evolved at electrode **Y**.

Explain your answer.

gas evolved ……………………………………………………………………………

explanation ……………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) A student attempts to predict the water level in **Cell Two** after the switch is closed for a period of time.

He drew Fig 8.2 to show the predicted volume of gas collected at each electrode.

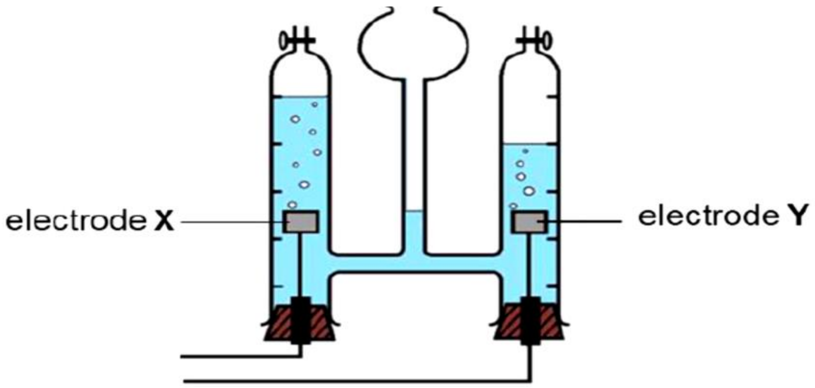


Fig 8.2

Is the student's prediction correct? Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

[Turn over

(iii) After the electrolysis has been running for some time in **Cell Two**, a new product is formed at electrode **Y**.

Identify the new product and explain why it is formed.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[10 marks]

Section B

Answer **all** the questions in this section in the spaces provided.
The last question is in the form of an either/or and only **one** of the alternatives should be attempted.

9 Singapore's water treatment process

In Singapore, raw water from reservoirs is conveyed by pipelines to the waterworks where it is chemically treated, filtered and disinfected. The treatment process removes harmful bacteria and suspended particulate matter, making the water clear, odourless, colourless, and safe for drinking.

The water treatment process that the Public Utilities Board (PUB) in Singapore uses is shown in Fig 9.1 and Table 9.2.

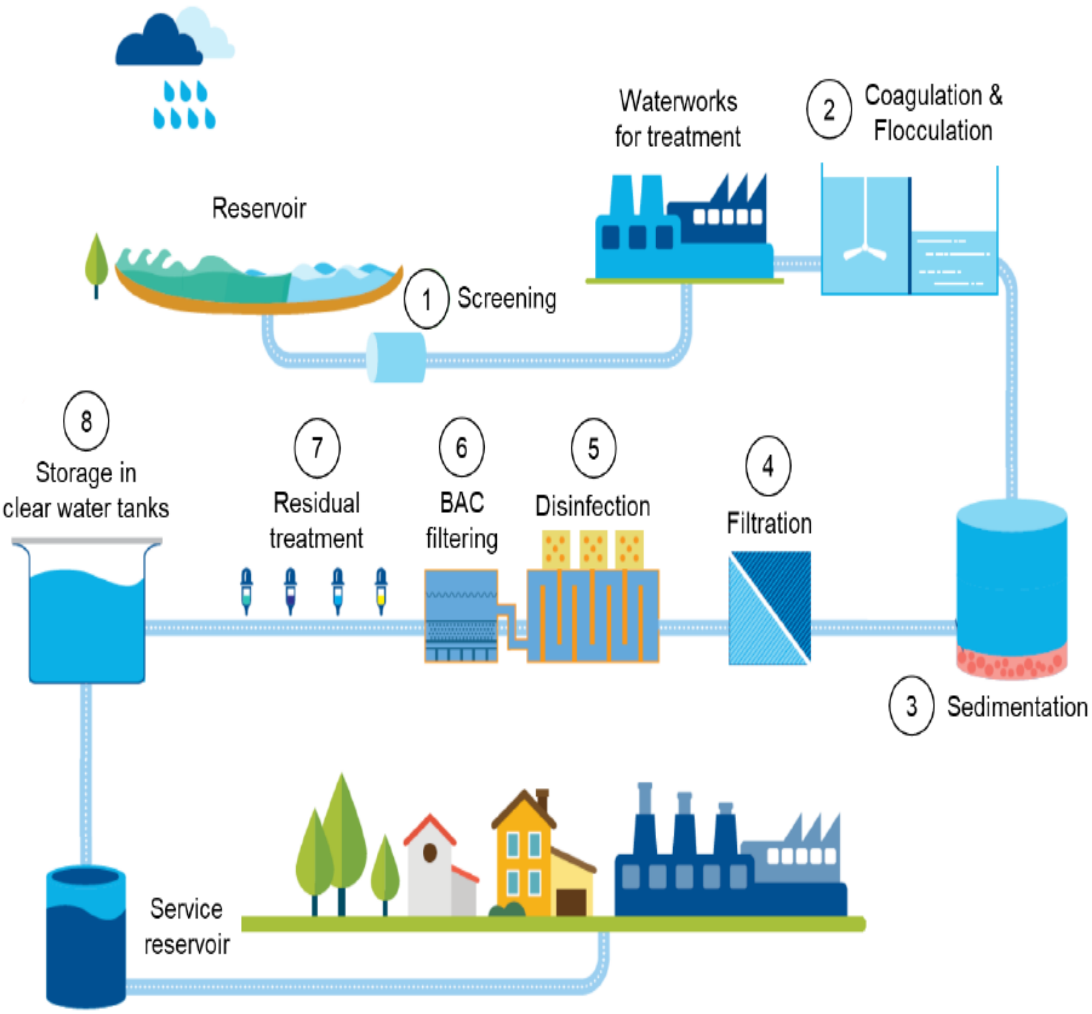


Fig 9.1

Table 9.2

step	process	description of process
1	screening	Water is pumped through self-cleaning screens to remove particles greater than 1mm.
2	coagulation & Flocculation	Coagulants are added to bind or “flocculate” smaller suspended particles, like silt and sand, to form larger, heavier clumps.
3	sedimentation	Large particles settle to the bottom of the tank and are removed.
4	filtration	The water then passes through filters or membranes to remove the finer residual particles of up to 0.02 µm (micrometres).
5	disinfection	After filtration, the water is disinfected with chlorine or ozone to kill all harmful bacteria and viruses.
6	BAC filtering	Filters containing Biologically Activated Carbon (BAC) help to remove natural organic matter, making the water biologically-stable.
7	residual treatment	The water is then dosed with lime, chlorine and ammonia, as well as compounds containing fluoride.
8	storage	The water is then stored in tanks before pumping to service reservoirs for distribution to customers.

Image and information modified from https://www.pub.gov.sg/watersupply/watertreatment

Chemistry behind the water treatment process

The goal of water treatment is to produce clean, drinking water in which chemicals are present within safety limits. Potentially harmful chemicals are removed using various separation techniques and chemical reactions. Some useful chemicals are supplemented during the residual treatment step to improve the quality and safety of our drinking water.

In step 6, Biologically Activated Carbon or BAC is used to separate dissolved organic compounds. It is termed biologically activated because the carbon is coated with bacteria. Firstly, the carbon preferentially attracts dissolved organic compounds. The bacteria coating then helps to digest and break down the organic compounds into simpler, harmless products.

In step 7, lime (calcium oxide) is added to adjust the pH of drinking water to an acceptable level of between 6.5 and 9.0. Chlorine is added to destroy any remaining bacteria and viruses. Different fluoride-containing compounds, such as sodium fluorosilicate, Na_2SiF_6, and hydrofluoric acid, HF, are added to enrich the fluoride content in drinking water, which helps to prevent tooth decay.

Routine laboratory tests

Water in Singapore is safe to drink straight from the tap without any further filtration. Samples of water at various stages of treatment at all waterworks, raw water from all sources, treated water from all service reservoirs and selected points in the distribution network are collected for daily or periodic analysis at PUB’s Water Quality Laboratory.

One method used by the laboratory is chromatography. This method is used in the detection of transition metal ions.

[Turn over

Table 9.3 shows the standard R_f values for some cations using 5% aqueous benzalkonium chloride as the solvent.

Table 9.3

name of ion	**R_f value**
copper(II)	0.41
nickel(II)	0.69
iron(III)	0.24
cobalt(II)	0.53

(a) Water treatment involves sedimentation in step 3 and filtration in step 4. To facilitate these steps, aluminium sulfate is first added as a coagulant in step 2.

Use the data to suggest why coagulation helps to increase the effectiveness of sedimentation and filtration.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) Use the data to explain the differences in how filtration and Biologically Activated Carbon (BAC) helps in the treatment of water.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) Explain how and why calcium oxide helps in adjusting the pH of water.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(d) Show, by calculation, that hydrofluoric acid has a higher percentage by mass of fluorine than sodium fluorosilicate.

[2]

(e) A sample of water collected for routine testing is suspected to contain copper(II) and nickel(II) ions.

Draw on Fig 9.4 how the chromatogram would look like if chromatography is performed on this sample of water using 5% aqueous benzalkonium chloride. Label clearly.

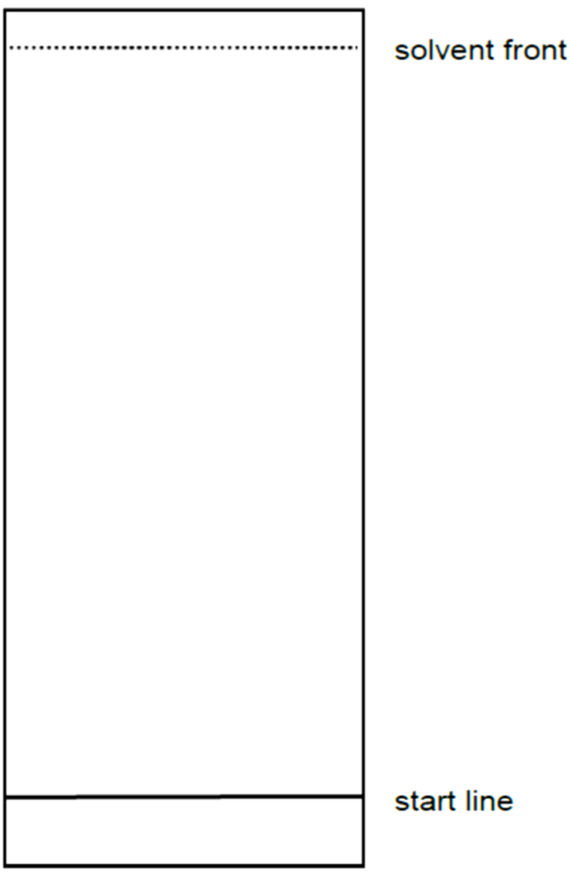


Fig 9.4 [2]

[Turn over

(f) A company selling a special type of household water filter claimed that a sample of Singapore's tap water was tested and found to contain high concentration of ions, as shown in Table 9.5.

Table 9.5

name of ion	concentration in mol/dm^3
calcium	0.78
lead(II)	0.40
aluminium	0.32
iron(III)	0.46
sulfate	0.53
nitrate	0.57
chloride	0.91

The company made another claim that its water filtration system uses 'alkaline filters' containing hydroxide ions to remove all the positive metal ions present in the tap water. This is done by passing the tap water though multiple 'alkaline filters', exposing the metal ions to excess hydroxide ions, forming precipitates that can be filtered away.

Scientists at PUB's Water Quality Laboratory spotted a glaring error in each of the company's claims and took action to stop the sale of these water filters.

Explain each error in the two claims made by the company.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

[12 marks]

[Turn over

10 A student investigates the rate of reaction of 5 g of small pieces of impure calcium carbonate with 50 cm^3 of 1 mol/dm^3 ethanoic acid, CH_3COOH. One of the products formed is a soluble salt.

Fig. 10.1 shows how the mass of the reaction mixture changes with time.

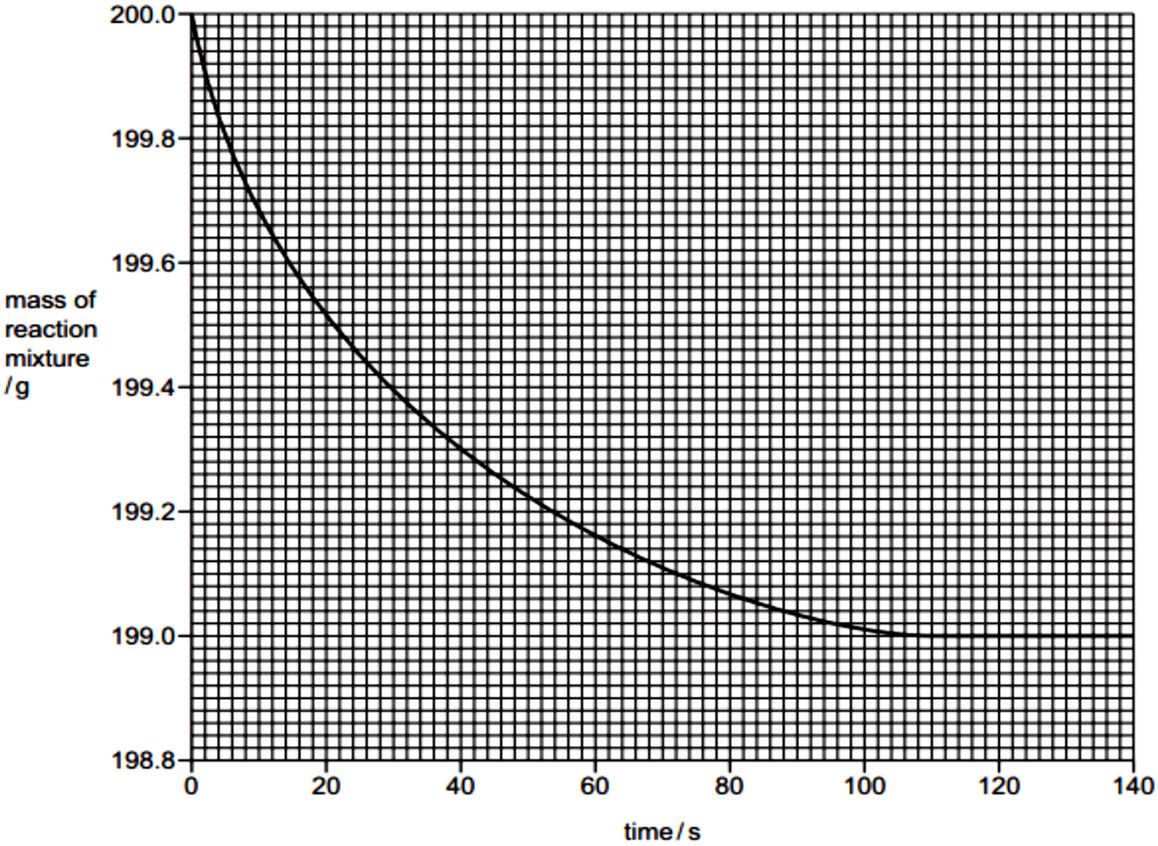


Fig. 10.1

(a) Write the ionic equation for the reaction, including state symbols.

.... [1]

(b) Determine the limiting reactant. Show your working clearly.

[3]

[Turn over

(c) Determine the percentage yield of the reaction.

[2]

(d) The experiment is repeated using hydrochloric acid of concentration 1 mol/dm^3. All other conditions are kept the same.

Draw a graph for the experiment using hydrochloric acid of concentration 1 mol/dm^3 on Fig. 10.1.

[1]

(e) The experiment is repeated using the same mass of different sized pieces of calcium carbonate – powdered, lumps, granular. All other conditions are kept the same.

Using the terms 'powdered', 'lumps' or 'granular', complete the table by writing the sizes of the pieces of calcium carbonate in the first column.

size of pieces of calcium carbonate	initial rate of loss in mass in g/s
	0.005
	0.030
	0.100

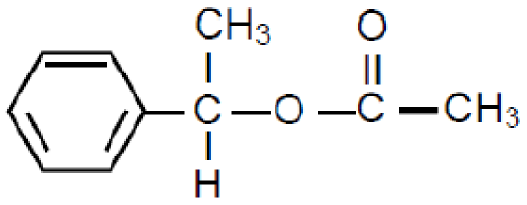
[1]

[8 marks]

EITHER

11 Perfumes usually contain three groups of compounds called the top note, the middle note and the end note.

(a) Top notes consist of small, light molecules that evaporate quickly. An example of a top note compound is styrallyl acetate as shown below:



(i) With reference to the structure of the compound, explain why it is likely to have a pleasant smell.

……………………………………………………………………………………….

………………………………………………………………………………………. [1]

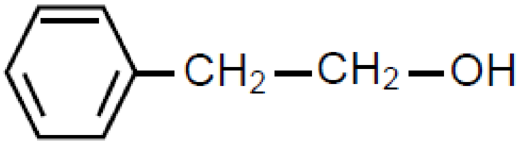
(ii) Draw the structural formula of the alcohol and carboxylic acid used to make styrallyl acetate. Label the structures you have drawn.

[2]

[Turn over

(b) The middle note compounds form vapours less rapidly than the top note compounds. A typical compound of the middle note is 2-phenylethanol.

The structure of 2-phenylethanol is shown below:



(i) Describe a chemical test which would distinguish between the top note and the middle note compounds.

………………………………………………………………………………………….

………………………………………………………………………………………….

………………………………………………………………………………………….

………………………………………………………………………………………….

…………………………………………………………………………………………. [2]

(ii) Name and draw the full structural formula of the molecule formed from 2-phenylethanol in the positive test to part **(b)(i)**.

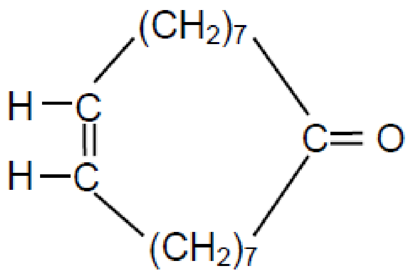
name …………………………….

structure

[2]

[Turn over

(c) The end note compound of a perfume has a long lasting odour which stays with the user. An example of an end note compound is shown below.



(i) Explain why the end note compound is described as unsaturated.

………………………………………………………………………………………

……………………………………………………………………………………… [1]

(ii) The end note compound undergoes a hydrogenation reaction.

State the conditions that are essential for the hydrogenation reaction.

………………………………………………………………………………………

……………………………………………………………………………………… [1]

(iii) Iodine reacts with unsaturated compounds. The iodine value is a measure of how unsaturated a compound is. It is based on the mass, in grams, of iodine that reacts with 100 g of the compound.

If the relative molecular mass of the end note compound is 250, calculate the iodine value for the end note compound.

[1]

[10 Marks]

[Turn over

OR

11 Table 11.1 gives some information about five metals.

Table 11.1

metal	abundance in the earth's crust / %	price per kg / $	relative resistance to corrosion (1 = least resistant 4 = most resistant)	relative strength of metal (1 = lowest 3 = highest)	density of metal / g/cm^3
A*l*	8.1	170	3	1	2.7
Cu	0.005	140	3	3	8.94
Au	0.0000004	1100000	4	2	19.3
Fe	5.0	20	1	3	7.86
Zn	0.007	160	2	2	7.13

Five students made the following statements:

Student 1: The more reactive the metal is, the more expensive it is.

Student 2: The less resistant the metal is to corrosion, the more expensive it is.

Student 3: The lower the density of the metal, the more expensive it is.

Student 4: The stronger the metal is, the more expensive it is.

Student 5: The less readily it is found, the more expensive it is.

(a) Referring to the information in Table 11.1, suggest which statements you agree and disagree with. Explain your reasonings.

....

....

....

....

....

....

.... [3]

[Turn over

(b) Suggest one **other** factor not included in Table 11.1 which could also affect the price of a metal.

………………………………………………………………………………………… [1]

(c) Explain why aluminium does **not** corrode easily.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(d) State **two** reasons why copper is often recycled.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(e) Iron is obtained through extraction using the Blast furnace. Two of the waste gases are carbon monoxide and carbon dioxide. Describe a harmful effect for each waste gas.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(f) Iron is also a transition metal. State one property of transition metals.

………………………………………………………………………………………… [1]

[10 marks]

[Turn over

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

SERANGOON SECONDARY SCHOOL
PRELIMINARY EXAMINATION
SECONDARY 4 EXPRESS

CANDIDATE NAME	( )	CLASS	
CENTER NUMBER	S	INDEX NUMBER	

CHEMISTRY

Paper 2

6092/02
26 Aug 2022
1 hour 45 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staplers, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on the last page.

The use of an approved scientific calculator is expected, where appropriate.

For examiner's use	
Section A	**50**
Section B	**30**
9	
10	
11	
Total	**80**

This question paper consists of **21** printed pages, including this cover page.

Section A [50 marks]

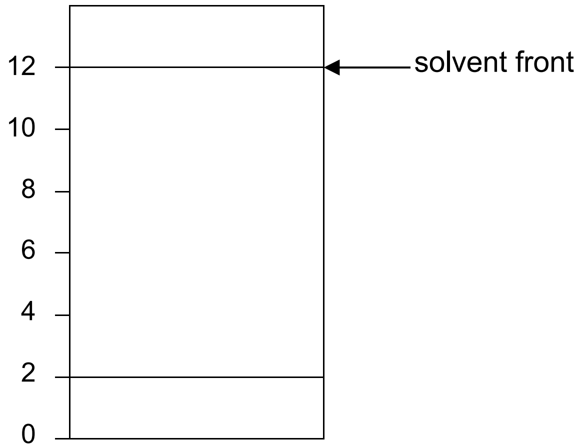
Answer **all** questions.

A1 The table below gives some information of an unknown substance **Y**.

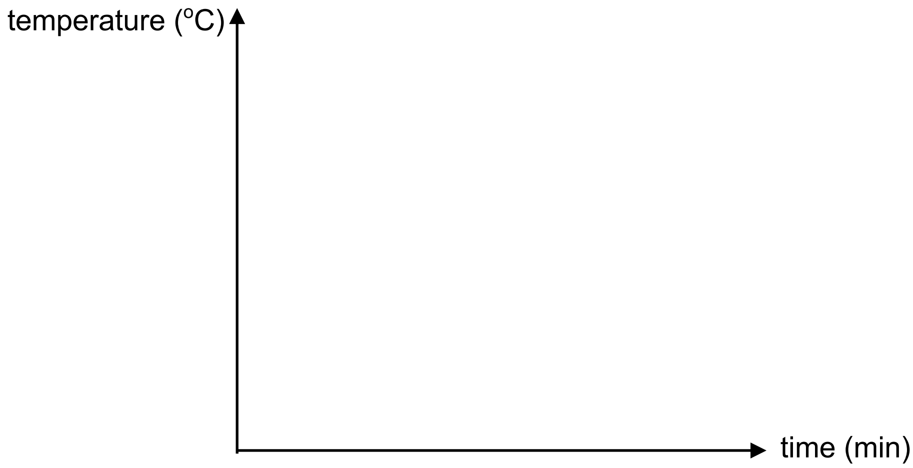
property of substance Y	
colour	black
melting point	1326 °C
boiling point	2000 °C
solubility in water	insoluble
chromatogram	R_f = 0.7

(a) Based on the information given above,

(i) Draw in the chromatogram the spot for **Y** that would be obtained below. [2]
Show your workings clearly on how the answer is derived.



(ii) Sketch in the axes below, the **freezing curve** of substance **Y**. [1]



(b)(i) Based on the information given, substance **Y** can be classified as either an element or a compound. Explain why this is so. [1]

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(ii) Describe and explain what can be done to determine whether substance **Y** is an element or a compound. [2]

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A2 Electronegativity is a measure of an atom's ability to attract shared electrons to itself.

The bond dissociation energy is the energy required to break a bond and form two atomic or molecular fragments, each with one electron of the original shared pair.

The table below shows the electronegativity and bond dissociation energy of halogens.

halogen	**electronegativity**	**bond dissociation energy kJ/mol**
fluorine	4	156
chlorine	3	243
bromine	2.8	193
iodine	2.5	151

(a)(i) Excluding fluorine, describe the relationship between electronegativity and bond dissociation energy of halogens. [1]

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(ii) Suggest a plausible reason for the relationship observed in **(a)(i)**. [3]

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(b) Suggest a plausible reason for fluorine for **not** following the relationship describe in **(a)(i)**. [1]

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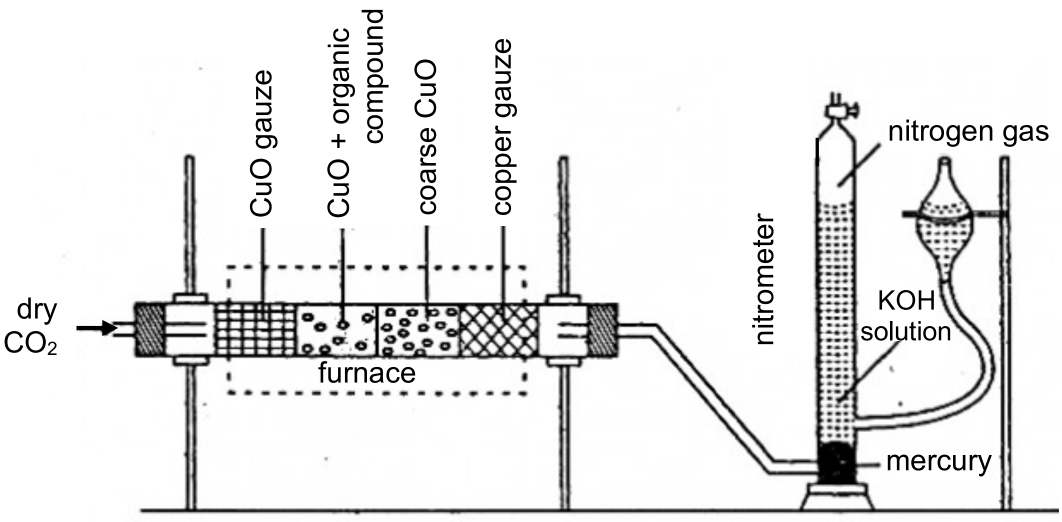
A3 Dumas method is a quantitative method used to determine nitrogen content in a given organic compound. The diagram below shows the setup used to determine nitrogen content in the Dumas method.



In the Dumas method, the organic compound containing nitrogen would be heated with excess copper(II) oxide in an atmosphere of carbon dioxide. During the reaction, nitrogen gas, carbon dioxide gas and water would be obtained.

Oxides of nitrogen is a by-product that would be also formed during the reaction. It would be converted to nitrogen when they are passed over heated copper gauze. Copper(II) oxide would also be formed during the reaction.

(a)(i) Write the chemical equation between nitrogen dioxide and copper gauze. [1]

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(ii) State and explain, in terms of oxidation state, whether nitrogen dioxide is oxidised or reduced by the copper gauze. [2]

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(b) Suggest a possible reason for the potassium hydroxide in the setup. [1]

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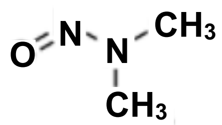
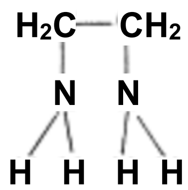
(c) From the analysis of an unknown organic compound, it was found that the percentage of nitrogen is 37.8%.

The table below shows a list of possible organic compound and their structural formula.

name of organic compound	structural formula
acetonitrile	$N{\equiv}C{-}CH_3$
N, N-dimethylnitrous amide	
ethylenediamine	

Determine the identity of the unknown organic compound. Explain how you derive your answer. You may show your workings to aid in your explanation. [2]

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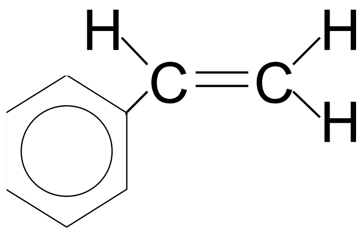
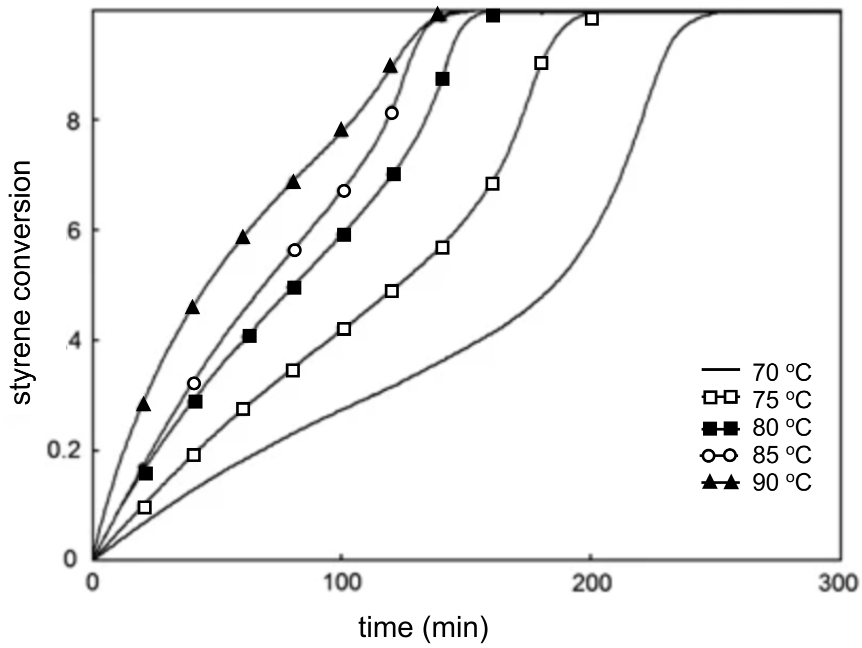
A4 The diagram below shows the structural formula of styrene. It can undergo polymerisations in the presence of a catalyst.



(a) Draw the structural formula of the polymer formed by styrene and give the name of the polymer formed. [2]

name of polymer: ……………………………..

(b) Experiments were carried out to determine the optimum temperature to carry out the polymerisation of styrene. The diagram below shows the results obtained.



Based on the results obtained, at which temperature should the polymerisation of styrene be carried out? Explain your answer in terms of collision theory. [3]

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(c) What would happen to the rate of polymerisation of styrene if the catalyst is not used? Explain. [1]

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A5 A student measured the temperature change when 5.0 g of potassium chloride was dissolved in excess water. The table below shows the results obtained.

temperature / °C	24.5
highest /lowest recorded temperature / °C	22.0
calculated energy change / J	1160

https://socratic.org/questions/5709d5887c014947fcb6e231

(a) State and explain if the change is exothermic or endothermic. [1]

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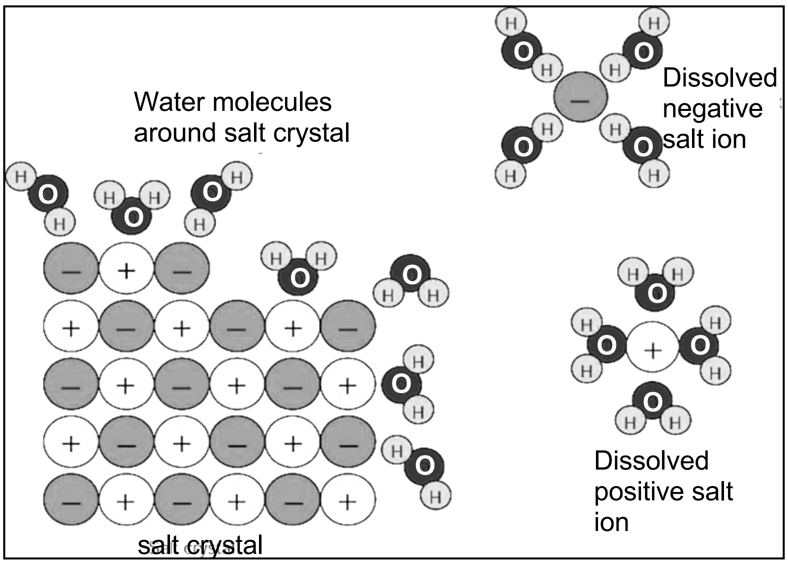
(b) The process of dissolving involves both bond-forming and bond-breaking. The process and description are given below.



When water dissolves a substance, the water molecules attract and "bond" to the particles (molecules or ions) of the substance causing the particles to separate from each other. The "bond" that a water molecule makes is not a covalent or ionic bond. It is a strong force of attraction.

Using information given and your knowledge of bond-breaking and bond-forming, explain why the calculated energy change for dissolving potassium chloride is positive. [2]

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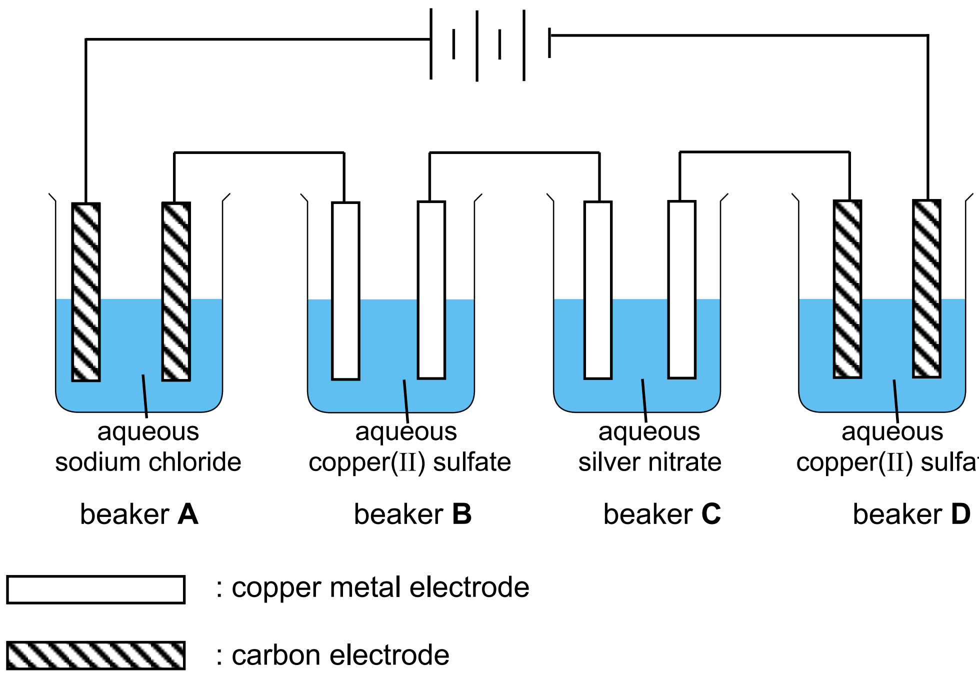
(c) Use the student's results to calculate the enthalpy change when one mole of potassium chloride dissolves in excess water. [3]
Give your answer in kJ/mol, to three significant figures.

A6 The diagram below shows an electrolysis setup.



(a) In the table below, fill in the missing observations of the anode, cathode and electrolyte. [3]

beaker	anode	cathode	electrolyte
A			no visible change
B	decrease in size	increase in size	no visible change
C	decrease in size		
D		increase in size	

(b) After the setup has been running for some time, explain for the observation made on the electrolyte found in

(i) beaker **A,** [1]

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(ii) beaker **B** and [1]

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(iii) beaker **C**? [2]

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(c) Write the half equations, for the reactions at the anode and cathode in beaker **D**. [2]

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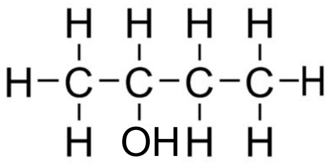
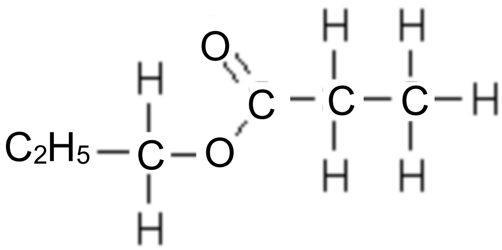
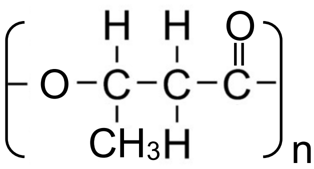
A7 The diagram below shows three different organic compounds, **P**, **Q** and **R**.

compound	
P	
Q	
R	

(a)(i) State whether each statement below is true or false. [2]

statement	True / False
Compound **P** can be made by fermentation.	
Compound **Q** can be made by reacting compound **P** with an organic acid.	
Water is also produced during the formation of compound **Q** and **R**.	

(ii) State and explain one condition used when carrying out fermentation. [1]

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(b)(i) What is the name of compound **Q**? [1]

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(ii) State a possible use for compound **Q**. [1]

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(c) Draw the reactant(s) that is/are used to form compound **R**. [1]

A8 A composite material is a mixture of two different substances. Reinforcing fibres are often used in a plastic to give the plastic extra strength. The table below gives some information about four different fibres that are used to make composite plastics.

fibre	density (kg/m^3)	force needed to break the fibre (N/m^2)
carbon	174	3.1
glass	257	3.7
kevlar	145	3.6
polyester	138	1

(a) Kevlar and carbon fibre composites are used in the building of spacecraft. Suggest reasons why,

(i) polyester fibre composites and [1]

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(ii) glass fibre composites, are not suitable for this purpose. [1]

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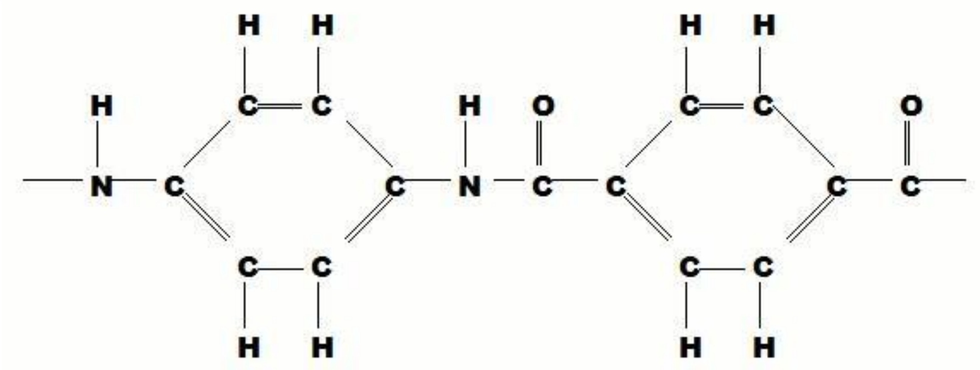
(b) Kevlar has a structure shown below.



Describe two differences between kevlar and polyester. [2]

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(c) Glass is mainly made up of silicon dioxide. Describe another property of glass and explain in terms of bonding and structure for the property described. [2]

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Section B [30 marks]

Answer all **three** questions from this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 Hard water is water that has high mineral content. These minerals may enter the water sources when rain, containing dissolved carbon dioxide, reacts with calcium carbonate and carry calcium ions away with it. Hardness refers to the total concentration of alkaline earth (Group II) ions in water. Due to the much higher concentrations of Ca^{2+} and Mg^{2+} than other alkaline earth ions, hardness can be equated to the concentration of Ca^{2+} and Mg^{2+}. Hardness is commonly expressed as the equivalent number of miligrams of calcium carbonate per dm^3. Thus, if concentration of Ca^{2+} and Mg^{2+} = 1 mmol/dm^3, we would say that hardness is 100 mg calcium carbonate per dm^3 of water as 100 mg of calcium carbonate is equivalent to 1 mmol of calcium carbonate. Water whose hardness is less than 60 mg calcium per dm^3 of water is considered to be "soft". If the hardness is above 270 mg/dm^3, the water is considered to be "hard".

To measure the total hardness, a sample of water is treated with ascorbic acid to reduce Fe^{3+} to Fe^{2+}. Titration with EDTA, a chemical substance, at pH 10 in ammonia solution, would then give the total concentration of Ca^{2+} and Mg^{2+}. The concentration of Ca^{2+} can be determined separately if the titration is carried out at pH 13 without ammonia.

Insoluble carbonates are converted to soluble bicarbonates by excess carbon dioxide:

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$$

Heating converts bicarbonate to carbonate by driving off carbon dioxide and causes calcium carbonate to precipitate.

Hard water reacts with soap ($C_{17}H_{35}CO_2Na$) to form insoluble curds:

$$Ca^{2+} + 2C_{17}H_{35}CO_2^- \rightarrow Ca(C_{17}H_{35}CO_2)_2$$

Enough soap is needed before the soap will lather and be useful for cleaning.

Hard water may be treated by using washing soda (Na_2CO_3) method where sodium carbonate is added into the hard water that contains chlorides and sulfates of calcium and magnesium.

(a) Explain why rain containing dissolved carbon dioxide can react with calcium carbonate. [2]

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(b) Suggest a chemical that can be added to carry out the titration at pH 13. [1]

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(c)(i) It is mentioned above that "enough soap is needed before the soap will lather and be useful for cleaning". Explain why this is so [1]

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(ii) A 500 cm^3 sample of water has a hardness reading of 275 mg/dm^3. [3]
Determine the minimum mass of soap that must be added into the sample of water before the soap will lather and be useful for cleaning.

(d) Explain, with appropriate equation, how the addition of sodium carbonate will help to reduce the hardness of water. [3]
Describe how the treated water can be obtained after the treatment.

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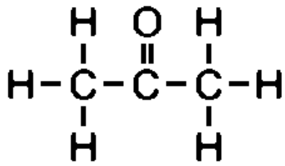
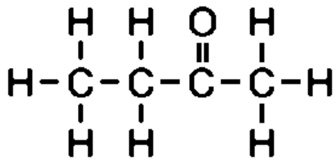
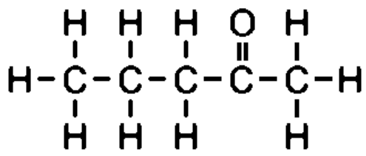
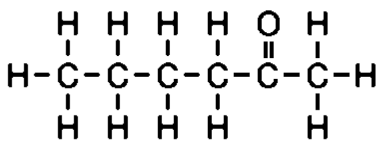
B10 In the table below shows a list of members found in the ketones homologous series.

name	molecular formula	structural formula	boiling point (°C)
propanone	C_3H_6O		56.2
butanone	C_4H_8O		79.6
pentanone	$C_5H_{10}O$		102
hexanone	$C_6H_{12}O$		

(a) Draw the structural formula and write the name of the next member after hexanone. [2]

Name: ……………………………………………

(b) What is the general formula of the ketones homologous series? [1]

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(c) Draw an isomer of butanone. [1]

(d) Suggest the boiling point of hexanone. [3]
Explain your answer in terms of bonding and structure.

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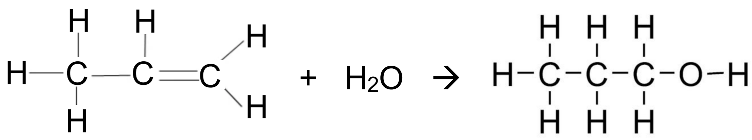
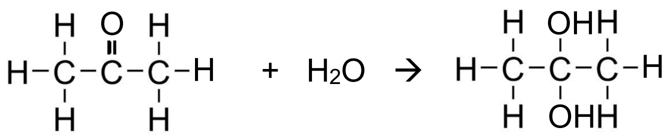
(e) Ketones and alkenes both undergo addition reactions as shown by the structural equations shown below.

Alkene: Propene reaction with water



Ketone: Propanone reaction with water



(i) Describe **two** differences between the two addition reactions shown above. [2]

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(ii) State and explain what would be observed when a few drops of Universal indicator are added into propanone. [1]

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Either

B11 Some metal carbonates, when heated, decompose to produce carbon dioxide.

Fig. 11.1 shows the results from an investigation on the rate of decomposition of four metal carbonates.

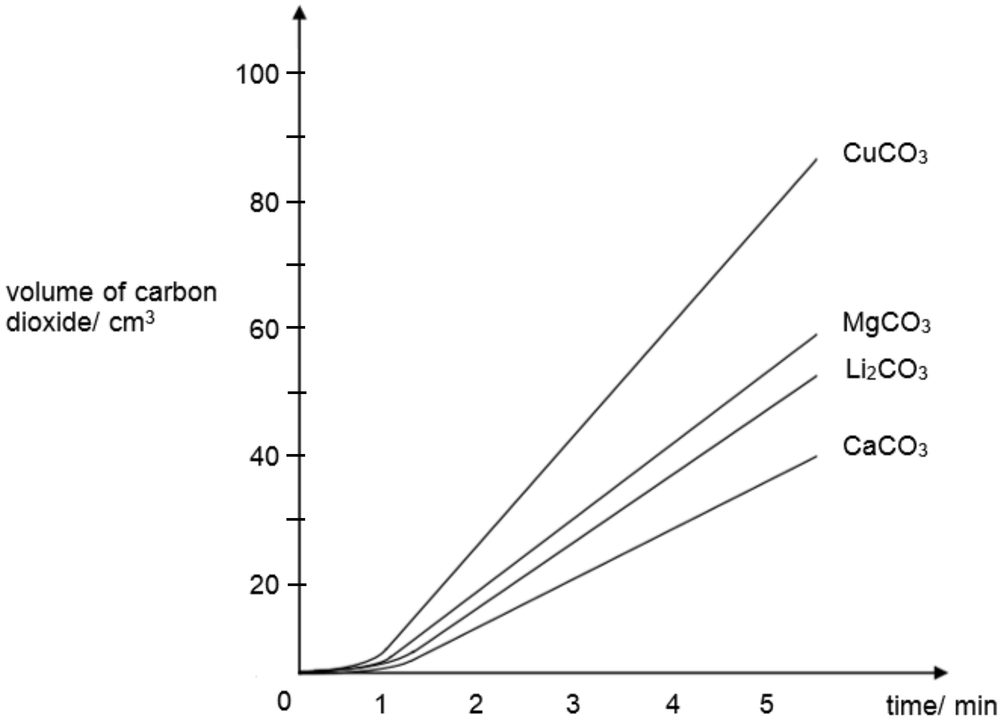

Fig. 11.1

In each experiment, 1.00 g of metal carbonate was heated to the same temperature using flame of the same intensity. The volume of carbon dioxide produced was measured at every minute interval.

(a) Suggest why very little carbon dioxide was collected at the start of each experiment. [1]

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(b) Using the information in **Fig. 11.1**, explain why the decomposition of metal carbonates were **not** completed at the end of the investigation. [1]

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(c)(i) Ignoring the volume of carbon dioxide recorded at time one minute, determine the speed of the decomposition lithium carbonate. [1]

(ii) Hence, determine the time it would take for 1 g of lithium carbonate to be completely decomposed. [3]

(d)(i) Using **only** the information in **Fig. 11.1**, state and explain which metal carbonate decomposed at the fastest rate. [2]

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(ii) Describe and explain how the volume of carbon dioxide will change with time if potassium carbonate was used for the experiment. [2]

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Or

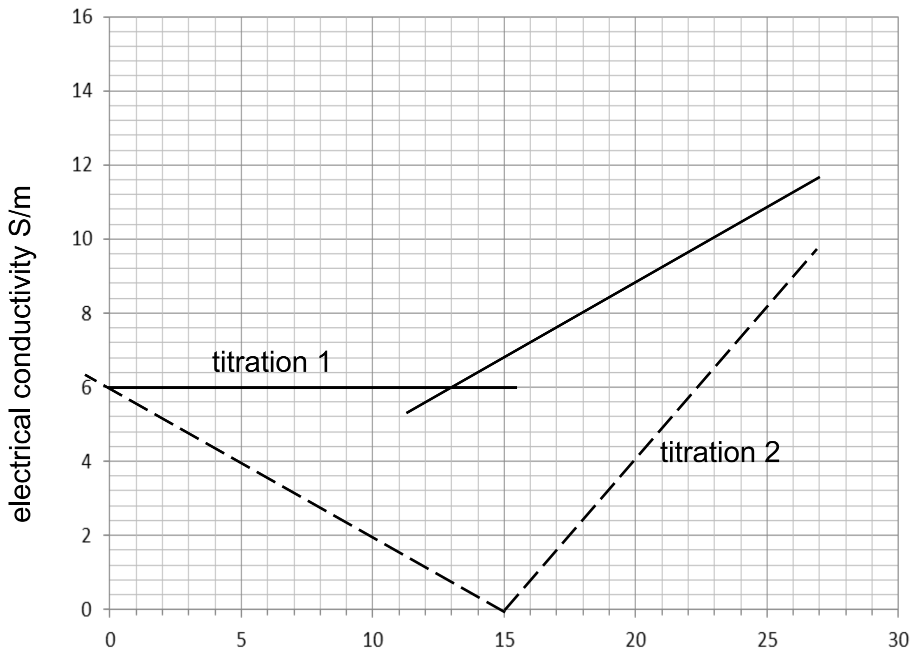
B11 Two titrations were carried with two different sets of solutions.
Titration 1 involved 20.0 cm^3 of sodium hydroxide and iron(II) nitrate solution.

$$2NaOH + Fe(NO_3)_2 \rightarrow Fe(OH)_2 + 2NaNO_3$$

Titration 2 involved 20.0 cm^3 barium hydroxide and sulfuric acid.

$$Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$$

To determine the end-point of a titration, the electrical conductivity of the solution was monitored. With the data collected, graphs were plotted and shown below.



titration 1: volume of aqueous iron(II) nitrate / cm^3
titration 2: volume of sulfuric acid/ cm^3

(a)(i) One difference between the graphs obtained from titration 1 and titration 2 is that the electrical conductivity decreases to 0 S/m for titration 2 but not for titration 1. Explain why this is so. [4]

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(ii) State another difference in the graphs obtained for titration 1 and titration 2. [1]

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(iii) Suggest a reason for the difference in **(a)(ii)**. [2]

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(b) Determine the concentration of sodium hydroxide used in titration 1 given that the concentration of iron(II) nitrate used was 0.563 mol/dm^3. [3]

END OF PAPER

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name: ________________________ Index Number:_______ Class: _______

TEMASEK SECONDARY SCHOOL
Preliminary Examination 2022
Secondary 4 Express

CHEMISTRY **6092/02**

Paper 2 (Section A) **Total duration for Sections A and B: 1 hour 45 minutes**

Question and Answer Booklet

READ THESE INSTRUCTIONS FIRST

Do not open the booklet until you are told to do so.

Hand in this booklet at the end of the paper.

Write your name, index number and class in all the work you hand in.
Write in dark blue or black pen.

Answer all questions in the spaces provided on the question paper.

At the end of the examination, submit **Section A and B separately**.

The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 14.

FOR EXAMINER'S USE	
Section A	/50

Section A
Answer all the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 All nitrates of Group II metal undergo thermal decomposition to form metal oxide, nitrogen dioxide and oxygen.

(a) Describe a test to confirm that decomposition has taken place.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(b) Table 1.1 shows the temperature at which each metal nitrate salt decomposes.

Table 1.1

metal nitrate salt	Temperature at which metal nitrate salt decomposes/ °C
magnesium nitrate	330
calcium nitrate	500
strontium nitrate	570
barium nitrate	650

(i) Using Table 1.1, deduce the order of reactivity of the four metals.

most reactive …………………………………….

…………………………………….

…………………………………….

least reactive ……………………………………. [1]

(ii) Explain your answer in **(b)(i)**.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

A2 Fig. 2.1 shows a mixture of the gases, methane, ammonia and water vapour in a flask. The electrodes provide electric sparks which causes chemical reactions to occur.

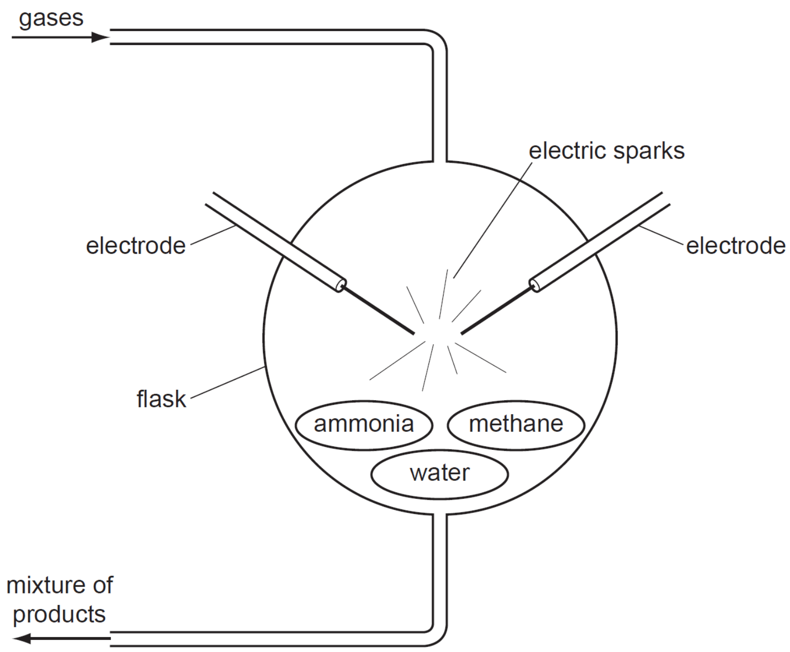


Fig. 2.1

(a) The substances present at the start of the experiment are compounds consisting of small molecules.

Explain what is meant by *molecule*.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(b) After one week, the experiment produced a mixture of products. The mixture of products can be analysed using paper chromatography.

Four known compounds, glycine, alanine, cysteine and lactic acid, were added to the chromatogram for comparison. The chromatogram is shown in Fig. 2.2.

Fig. 2.2 is not drawn to scale.

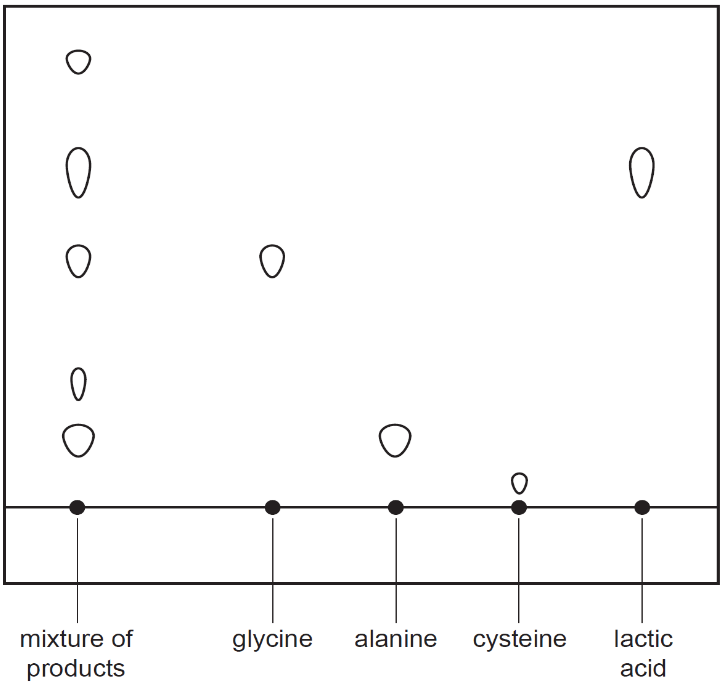


Fig. 2.2

(i) From Fig. 2.2, deduce the identities of the substances present in the mixture of products.

Explain your answer.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

(ii) The solvent front of the chromatogram is 140 mm away from the start line. It is also known that the R_f value of lactic acid ranges from 0.67 to 0.78.

Calculate the range of distances travelled by lactic acid in in the chromatogram.

…………………………………………… mm [2]

A3 Titanium is a transition metal used in the aerospace industry.
It can be extracted by heating titanium(IV) chloride to 2000°C with sodium.

$$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$$

(a) At room temperature and pressure, titanium(IV) chloride exists as a liquid.

Explain why you would not expect titanium(IV) chloride to exist as a liquid at room temperature and pressure.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………[2]

(b) 40 kg of titanium chloride was added to 20 kg of sodium.

Explain why titanium chloride is the limiting reactant. All workings must be shown.

[3]

A4 Aqueous solutions of **barium nitrate, copper(II) sulfate, potassium hydroxide and sodium carbonate** are stored in four bottles labelled A, B, C and D, but not necessarily in this order.

Table 4.1 shows the observations based on the following procedures.

Table 4.1

procedure	observations
Mix A with B, followed by dilute hydrochloric acid	The solution remains colourless. Effervescence seen when dilute hydrochloric is added.
Mix A with C, followed by dilute hydrochloric acid	A green precipitate is observed. Effervescence seen and the precipitate is soluble in dilute hydrochloric acid.
Mix C with D, followed by dilute hydrochloric acid	A white precipitate is formed in a blue solution. The white precipitate remains when dilute hydrochloric acid is added.

Using Table 4.1, identify solutions A, B, C and D.

A …………………………………………………..

B …………………………………………………..

C …………………………………………………..

D …………………………………………………..

[4]

A5 A student investigated the reaction between excess zinc and dilute hydrochloric acid.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

The experiment was conducted twice with the same mass of zinc and same volume, but different concentrations of acid.

(a) Fig. 5.1 shows how volume of hydrogen gas produced changes with time.

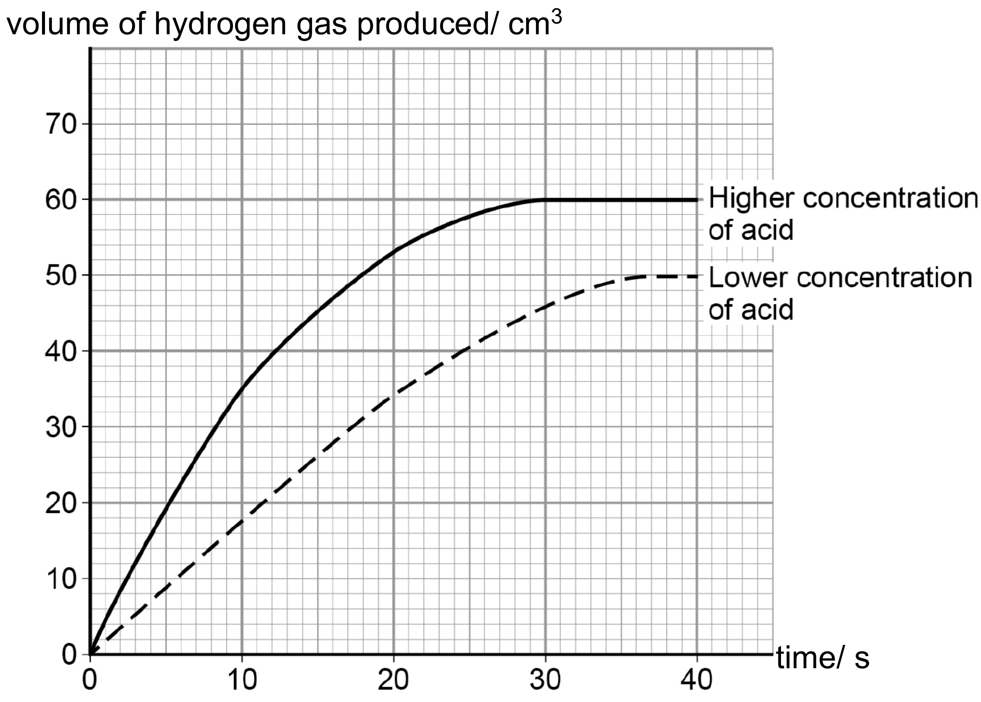


Fig. 5.1

Describe and explain the difference in the shape of the graphs shown in Fig. 5.1.

....

....

....

....[2]

(b) Another set of experiments was conducted using the same number of moles of zinc, magnesium and aluminium with excess hydrochloric acid.

Fig. 5.2 shows the results for this set of experiments.

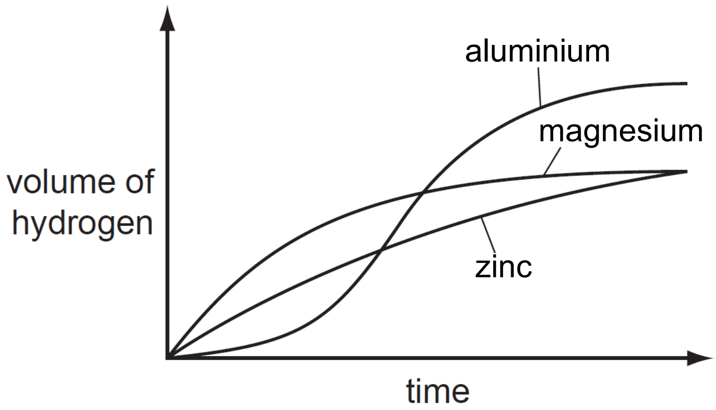


Fig. 5.2

(i) Explain why the volume of hydrogen produced by zinc and magnesium is the same, but that of aluminium is much higher.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

(ii) Compare the speed of reaction for the reaction between aluminium and acid and that of zinc and acid.

Explain your answer.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

A6 To reduce emission of pollutants during the production of electricity, some countries are starting to burn natural gas instead of coal in power stations.

Table 6.1 shows the amount of pollutants formed by each type of fuel.

Table 6.1

type of fuel	**mass of pollutant formed per MJ of electrical energy/ g (1 MJ = 10^6 J)**	
	SO_2	**NO_2**
coal	0.31	0.64
natural gas	0.0015	0.11

The chemical equations of complete combustion of coal and natural gas are shown.

$$\text{coal: } C + O_2 \rightarrow CO_2 \quad \Delta H = -890 \text{ kJ/ mol}$$

$$\text{natural gas: } CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \ \Delta H = -394 \text{ kJ/ mol}$$

(a) Using Table 6.1, state the advantages of using natural gas instead of coal in power stations.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[2]

(b) Calculate the energy released by the complete combustion of 48.0 cm^3 of natural gas.

[2]

(c) Some claim that speed of combustion of natural gas can be increased by reducing the volume of the reaction vessel. All other reaction conditions remain the same.

Do you agree? Explain your answer using collision theory.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………[3]

(d) In terms of bond breaking and bond making, explain why the combustion of coal is exothermic.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………[2]

(e) State and explain whether the combustion of coal is a redox reaction.

……………………………………………………………………………………..

……………………………………………………………………………………..

...…………………………………………………………………………………..[2]

A7 Fig. 7.1 shows an experimental set-up to study the effect of graphite and copper electrodes in the electrolysis of dilute aqueous copper(II) sulfate.

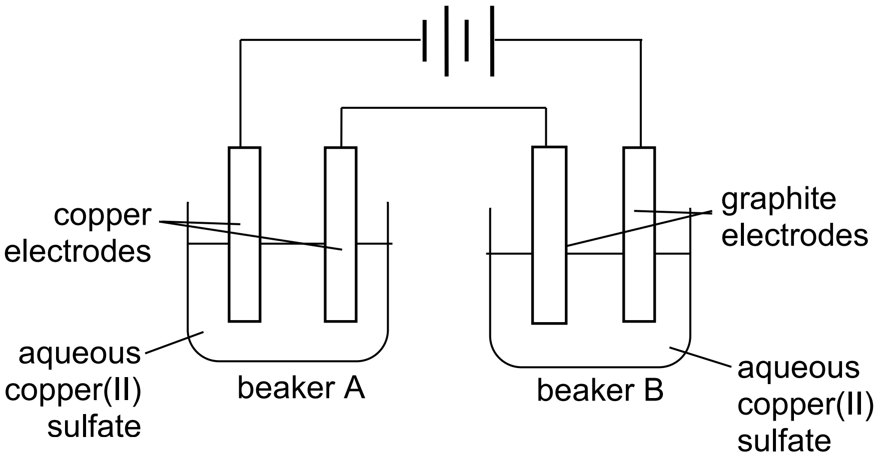


Fig. 7.1

(a) With the aid of half equations, describe one difference in the observation at the anodes in both beakers.

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..[3]

(b) The experiment is repeated by replacing the dilute copper(II) sulfate solution in beaker B with concentrated potassium chloride solution. A few drops of Universal Indicator are also added to beaker B.

Describe two observations in beaker B. Explain your answer.

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

..………………………………………………………………………………..[3]

A8 **(a)** It is believed ancient civilisations generate electricity using clay jars, filled with vinegar solution, with an iron rod placed in a copper cylinder.

Fig. 8.1 shows a representation of the ancient electric cell.

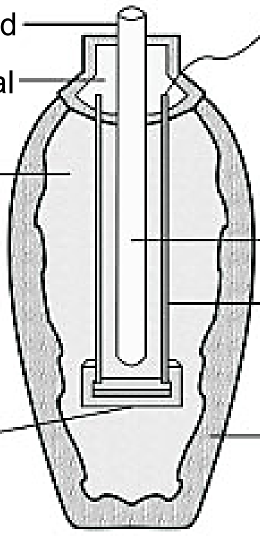


Fig. 8.1

(i) Using Fig. 8.1, state the electrolyte and metals acting as the positive and negative electrode.

electrolyte: ……………………….

positive electrode: ……………………….

negative electrode: ………………………. [2]

(ii) Suggest the observation in the copper cylinder when the electric cell is used. Explain your answer.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………[2]

(iii) Suggest another metal that can be used in place of iron to increase the amount of electrical energy produced by the electric cell.

…………………………………………………………………………………[1]

(b) A modern version of the electric cell is the methanol fuel cell. Electrical energy and heat are produced from a reaction between methanol and oxygen.

The following ionic equations take place at the respective electrodes.

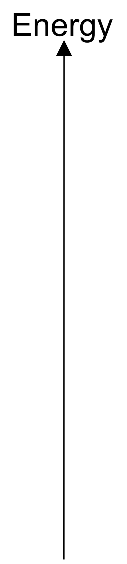
Anode: $CH_3OH\ (aq) + H_2O\ (l) \rightarrow 6\ H^+\ (aq) + CO_2\ (g) + 6e^-$
Cathode: $O_2\ (g) + 4H^+\ (aq) + 4e^- \rightarrow 2\ H_2O\ (l)$

(i) Write a chemical equation for the overall reaction.

…………………………………………………………………………………[1]

(ii) Using your answer in **(b)(i)**, draw an **energy level diagram** for the overall reaction.

Your diagram should label the enthalpy change of reaction, ΔH.



[2]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			**Key** proton (atomic) number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
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lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name: ___________________________ Index Number:________ Class: _______

TEMASEK SECONDARY SCHOOL
Preliminary Examination 2022
Secondary 4 Express

CHEMISTRY **6092/02**

Paper 2 (Section B) **Total duration for Sections A and B: 1 hour 45 minutes**

Question and Answer Booklet

READ THESE INSTRUCTIONS FIRST

Do not open the booklet until you are told to do so.

Hand in this booklet at the end of the paper.

Write your name, index number and class in all the work you hand in.
Write in dark blue or black pen.

Answer **three questions** from this section.
Question B9 is in the form of either/or and only one of the alternatives should be attempted.

Write your answers in the spaces provided.

At the end of the examination, submit **Section A and B separately**.

The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on **page 14** of **Section A**.

FOR EXAMINER'S USE	
Section B	**/30**

This document consists of **10** printed pages.

Section B
Answer three questions from this section.
Question B9 is in the form of either/or and only one of the alternatives should be attempted.
Write your answers in the spaces provided.

B7 Read the information about the history of the Periodic Table.

Chemists spent many years trying to arrange elements in a sensible order.

Johann Döbereiner was one of the first chemists to organise elements by their properties. He found out that some sets of three elements seem to fit together because they have similar properties. He called these sets of elements ‘triads’.

Table 7.1 shows some elements that could be considered to be triads.

Table 7.1

Triad A	lithium	sodium	potassium
Triad B	calcium	strontium	barium
Triad C	chlorine	bromine	iodine
Triad D	carbon	nitrogen	oxygen

Döbereiner looked at the relative atomic masses of the elements in some triads. He noticed that the relative atomic mass of the ‘middle’ element was close to the mean (average) relative atomic mass of the first and third element.

This was a step forward but did not help with all of the other elements that Döbereiner had not put into groups of three. It was left to others to build on Döbereiner’s work.

In 1864, a chemist called John Newlands had an idea of arranging the elements in order, depending on their chemical properties. He called his idea the ‘Law of Octaves’.

Table 7.2 shows Newlands' arrangement of some of the elements.
He put elements with similar properties into the same row of his table.

Table 7.2

Row	**Elements**		
1	^{1}H	^{19}F	$^{35.5}Cl$
2	^{7}Li	^{23}Na	^{39}K
3	^{9}Gl	^{24}Mg	^{40}Ca
4	^{11}Bo	^{27}Al	^{52}Cr
5	^{12}C	^{28}Si	^{48}Ti
6	^{14}N	^{31}P	^{55}Mn
7	^{16}O	^{32}S	^{56}Fe

Newlands based the order of the elements on their relative atomic masses.

The Periodic Table that is used today was developed after Newlands' table.
The symbols that Newlands used for some of the elements are different to those on the Periodic Table today.

(a) Using the triads in **Table 7.1** for this question.

(i) Three of the four triads now fit into Groups in the modern Periodic Table.
Which triad, A, B, C or D does not? Explain your answer.

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………….…………….….[2]

(ii) Use calculations to show that the elements in any one of the four triads obey the atomic mass pattern observed by Döbereiner.
Show your working.

..…………………………………………………………………………..….[2]

(b) Use the data in **Table 7.2** for this question.

(i) Describe the trend in relative atomic masses across Row 1 in Newlands' table.

………………………………………………………………..……………...…[1]

(ii) The numbers shown with each symbol give the atomic mass of each element.

What symbols do we use today for the elements ^{9}Gl and ^{11}Bo in Newlands' table?

^{9}Gl ……………………………… ^{11}Bo …………………………… [2]

(iii) In Newlands' table, the elements in the rows may or may not be all together in the same groups in the modern Periodic Table.

Use elements in different rows to support this statement.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………...…[3]

(iv) Newlands' table does not include any elements from one of the groups in the modern Periodic Table.

Identify the missing group and suggest why Newlands could not include these elements in his table.

……………………………………………………………………………………..

..…………………………………………………………………………...…[2]

B8 **(a)** Esters are compounds which give fruits their flavours. They also provide the scent in flowers.

(i) The ester $CH_3(CH_2)_2COOCH_3$ contributes to the aroma of apples. Draw the full structural formulae of the two starting materials needed to produce this ester.

starting material 1	starting material 2

[2]

(ii) Describe a chemical test to distinguish the two starting materials.

……………………………………………………………………………..…………

…………………………………..…………………………………..…..[2]

(iii) One of the starting materials used for esterification must be freshly prepared and cannot be left to stand in air before the reaction.

State the functional group of this starting material and explain why.

……………………………………………………………………………..…………

…………………………………..…………………………...…………..[2]

(b) Other than esters, leaf alcohol is also commonly used in fragrances as it is responsible for the aroma of freshly cut grass.

Fig. 8.1 shows the structural formula of leaf alcohol.

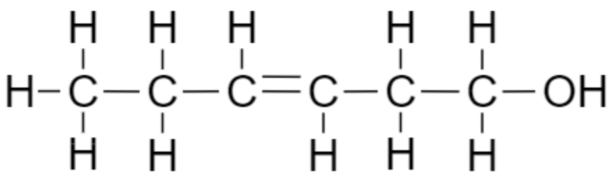

Fig. 8.1

(i) Circle the functional group(s) of leaf alcohol in Figure 8.1 [1]

(ii) When heated at 60 atm and 300°C, in presence of an acid, leaf alcohol reacts to form a product. This molecular mass of this product increased by 18.

Draw the deduced structure of this product.

[1]

(iii) Draw two repeat units of the polymer formed by polymerisation of leaf alcohol.

[2]

Either

B9 **(a)** Fig. 9.1 shows the reaction between di-acyl chloride and diamine to form a polymer.

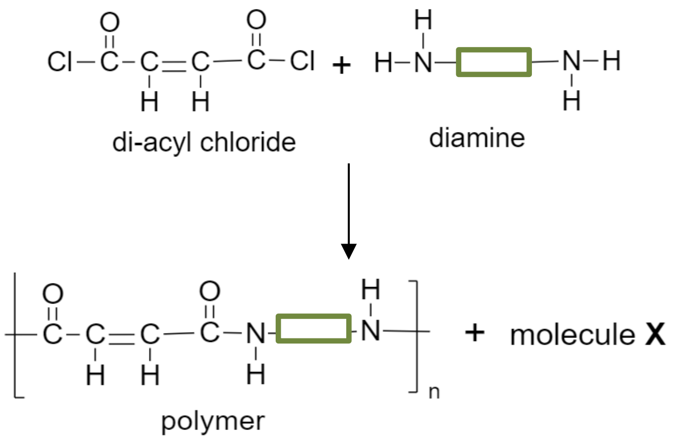

Fig. 9.1

Acyl chlorides reacts with amines in a similar manner as carboxylic acids.

(i) Identify molecule **X** in Figure 9.1.

....[1]

(ii) State the type of polymerisation shown in Figure 9.1. Explain your answer.

....

....[1]

(iii) Name type of linkage present in the polymer formed in Figure 9.1

....[1]

(iv) Explain why polymers such as that shown in Figure 9.1 are increasingly being used in place of natural materials.

....[1]

(v) Some polymers are non-biodegradable in nature.

Explain what is meant by “non-biodegradable” and how improper disposal of these polymers affects the environment.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[1]

(b) An example of a naturally occurring polymer is proteins. Proteins are made up of amino acids.

Fig. 9.2 shows a type of amino acid called alanine.

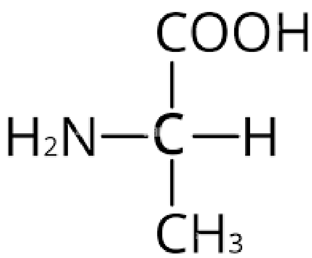

Fig. 9.2

(i) Draw the polymer formed by alanine.

[2]

(ii) With reference to the structure drawn in **(b)(i)**, explain why alanine can undergo polymerization.

……………………………………………………………………………………

……………………………………………………………………………………[1]

Or

B9 Both carbon (graphite) and copper are useful elements.

(a) Compare the **bonding** and **structure** of these two elements.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………[3]

(b) Describe briefly how you could show that carbon is more reactive than copper and less reactive than magnesium.

………………………………………………………………………………………………

………………………………………………………………………………………………

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………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………[2]

(c) When graphite is heated in air, it reacts with oxygen to produce carbon dioxide.
When copper is heated in air, it reacts with oxygen to produce copper(II) oxide.

Compare the physical and chemical properties of the two **oxides**.
Your answer should include a discussion of their

- melting and boiling points,
- electrical conductivity,
- reactions with acids and alkalis.

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....[3]

End of Paper

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TAMPINES SECONDARY SCHOOL
Secondary Four Express
PRELIMINARY EXAMINATIONS 2022

NAME

CLASS | | | | **REGISTER NUMBER** | | |

CHEMISTRY **6092/02**

Paper 2 **25 Aug 2022**

1 h 45 min

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
There are 2 sections in this booklet.

Section A (50 marks)
Answer **all** the questions. Write your answers in the spaces provided.

Section B (30 marks)
Answer **three** questions.
Answer all questions in the spaces provided.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 25.

The use of an approved scientific calculator is expected, where appropriate.

	Marks
Section A (50 marks)	
Section B (30 marks)	
Total (80 marks)	

This document consists of **25** printed pages, including one blank page.

[Turn over

Section A [50 marks]

Answer all the questions in the spaces provided.

A1 The following table summarises the number of subatomic particles in particles **A** to **I**.

particle	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
number of protons	1	6	6	7	8	8	12	17	18
number of electrons	0	6	6	10	8	10	12	17	18
number of neutrons	0	6	7	7	8	8	12	18	22

Which of the above particle(s) is/are

(a) an inert gas,

.... [1]

(b) an atom and an ion of the same element,

.... [1]

(c) cations,

.... [1]

(d) the most reactive metal in the table,

.... [1]

(e) are isotopes?

.... [1]

[Total: 5 marks]

A2 Silver iodide is produced in the reaction between silver nitrate solution and sodium iodide solution.

A student investigated the law of conservation of mass. This is the method used.
1. Pour silver nitrate solution into a beaker labelled A.
2. Pour sodium iodide solution into a beaker labelled B.
3. Measure the masses of both beakers and their contents.
4. Pour the solution from beaker B into beaker A.
5. Measure the masses of both beakers and their contents again.

Table 2.1 shows the student's results.

Table 2.1

	mass before mixing in g	mass after mixing in g
beaker A and contents	78.26	108.22
beaker B and contents	78.50	48.54

(a) Explain, by using calculations, how the results demonstrate the law of conservation of mass.

....

....

....[2]

(b) **(i)** What is observed during the reaction between silver nitrate and sodium iodide?

....

....[1]

(ii) Halide ions can be identified in an unknown solution by adding acidified aqueous silver nitrate. In testing for halide ions, explain why dilute hydrochloric acid cannot be used to acidify the sample.

....

....[1]

(c) The student purified the separated silver iodide with the following steps.

1. Rinse the silver iodide with distilled water.
2. Warm the silver iodide.

(i) Suggest how the student could separate the silver iodide from the mixture at the end of the reaction.

....

....[1]

(ii) State one impurity that was removed by rinsing with water.

....

....[1]

(iii) Suggest why the student warmed the silver iodide.

....

....[1]

[Total: 7 marks]

A3 Carboxylic acids are organic acids that contain a functional group.
Table 3.1 shows information about the first three carboxylic acids in a homologous series.

Table 3.1

name	**formula**	**pH of a 0.01 mol/dm^3 solution**
methanoic acid		2.91
ethanoic acid	CH_3COOH	3.39
	CH_3CH_2COOH	3.44

(a) Complete Table 3.1. [1]

(b) Arrange the three acids in order of increasing rate of reaction.

Explain your answer using information from Table 3.1.

....

....

....[2]

(c) Ethanoic acid ionises in water.

The equation for the reaction is:

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

Describe the acidity of ethanoic acid by referring to the equation.

....

....

....[1]

(d) Fig. 3.1 is a flow diagram showing the reactions of ethanoic acid.

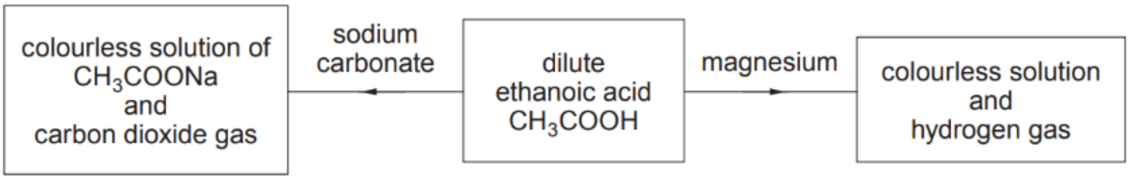


Fig. 3.1

(i) Draw the displayed formula of the anion present in the product with formula CH_3COONa.

[1]

(ii) Write a balanced chemical equation for the reaction between ethanoic acid and magnesium.

....[2]

(e) Fig. 3.2 shows the concentration of ethanoic acid in a bottle of vinegar.

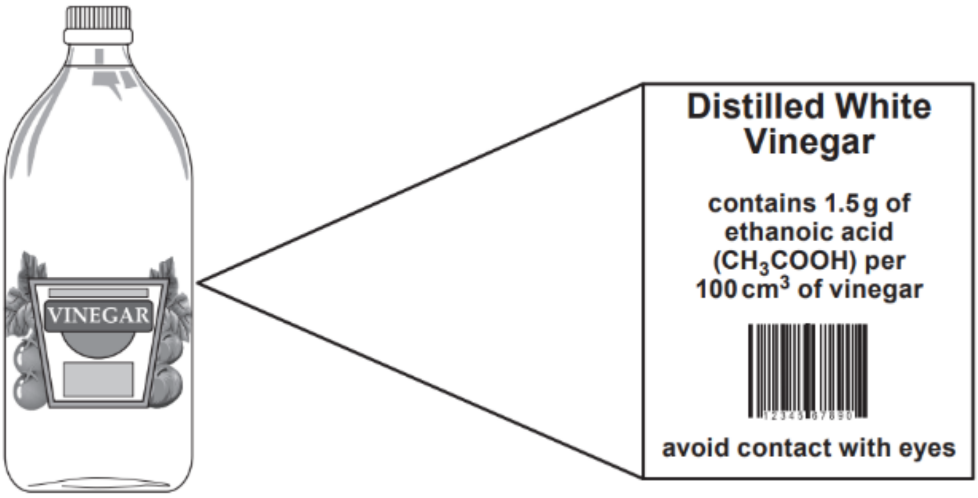


Fig. 3.2

A student reacted 20.0 cm^3 of vinegar with 25.00 cm^3 of 0.20 mol/dm^3 of sodium hydroxide.
Using calculations, show whether the information on the label is correct.

[2]

[Total: 9 marks]

A4 Ammonia is produced by the Haber process.

(a) In the Haber process, nitrogen and hydrogen are mixed in a 1 : 3 ratio by volume.

Explain why the gases are mixed in a 1 : 3 ratio. Include an equation in your answer.

....

....

....[2]

(b) Table 4.1 shows the percentages of each gas in the mixture by volume and by mass.

Table 4.1

	nitrogen	hydrogen
percentage by volume	25	75
percentage by mass	82	18

Explain why the percentages of the gases are different when they are measured by volume and when they are measured by mass.

....

....[1]

(c) The Haber process produces a mixture of the gases ammonia, hydrogen and nitrogen.

Table 4.2 shows boiling points for ammonia, hydrogen and nitrogen.

Table 4.2

gas	boiling point in ^{0}C
ammonia	-33
nitrogen	-196
hydrogen	-260

Use information from the table to explain how ammonia is separated from the mixture.

....

....

....[2]

(d) Ammonia is used to produce hydrazine, N_2H_4.

(i) Draw a dot and cross diagram to show the bonding in hydrazine.

Show outer shell electrons only.

[2]

(ii) Hydrazine, N_2H_4, reacts with oxygen as shown below.

$$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$$

A metal in water corrodes faster than an identical piece of metal in the same volume of water containing dissolved hydrazine.

Use the information to explain how hydrazine slows corrosion.

....

....

....[2]

[Total: 9 marks]

A5 Iron is a transition metal that shows variable oxidation states. Iron can be extracted from haematite in a blast furnace. Haematite is an iron ore which is mainly made up of iron(III) oxide.

(a) There are a number of reactions occurring in the blast furnace.

Write down the equation for

(i) a redox reaction,

……………………………………………………………………………………………….. [1]

(ii) a thermal decomposition reaction.

……………………………………………………………………………………………….. [1]

(b) 2000 kg of haematite was used to produce 1300 kg of iron.

Using your equation from **(a)(i)**, or otherwise, find the percentage purity of iron(III) oxide in haematite.

[3]

(c) Iron(III) ions are an example of transition metal compounds used as catalysts because of their ability to change oxidation state.

The reaction between iron(III) ions and iodide ions is shown in the following equation, which shows the change in oxidation state.

$$2I^{-}(aq) + 2Fe^{3+}(aq) \rightarrow I_2(aq) + 2Fe^{2+}(aq)$$

(i) Explain how iron(III) ions are acting as the oxidising agent in this reaction.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

……………………………………………………………………………………………….. [1]

(ii) Describe a test for iron(III) ions.

test ………………………………………………………………………………………….. [1]

observation ……………………………………………………………………………….

………………………………………………………………………………………………. [1]

[Total: 8 marks]

A6 A student conducted two experiments to investigate the relative reactivity of iron and three other solid metals X, Y and Z. It is known that the sulfates of X, Y and Z are colourless.

In experiment 1, he heated each of the metal oxides in a test-tube and observed if there was any change.

In experiment 2, he tested metals X, Y and Z with aqueous iron(II) sulfate.

He then tabulated the results of both experiments as follows.

experiment 1	oxide of iron	oxide of X	oxide of Y
action of heat	no change	no change	no change

experiment 2	metal X	metal Y	metal Z
addition of metal into aqueous iron(II) sulfate	a reaction occurs	iron deposited, gas evolved from vigorous bubbling	no visible change

(a) Deduce the order of reactivity of iron, X, Y and Z, in terms of increasing reactivity.

.... [1]

(b) When metal X is added into aqueous iron(II) sulfate, a reaction occurs.

Describe and explain all the observations when X is placed in aqeuous iron(II) sulfate in experiment 2.

....

....

....

....

.... [3]

[Total: 4 marks]

A7 Crude oil is a raw material which is processed in an oil refinery. Two of the processes used are fractional distillation and cracking.

Table 7.1 shows the percentage by mass of some fractions in crude oil, as well as the demand for each fraction expressed as a percentage.

Table 7.1

fraction	number of carbon atoms per molecule	percentage in crude oil	percentage needed by oil refinery to supply demand
petroleum gases	1-4	4%	11%
gasoline	5-9	11%	22%
kerosene	10-14	12%	20%
gas oil	14-20	18%	15%
waxes and bitumen	over 20	23%	4%

(a) Use information from Table 7.1 to explain how cracking helps an oil refinery match the supply of gasoline with the demand for gasoline.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

………………………………………………………………………………………………… [2]

(b) The hydrocarbon $C_{15}H_{32}$ can be cracked to make propene and one other hydrocarbon.

(i) Draw the full structural formula of propene.

[1]

(ii) Propene is used to make alcohols.

Write an equation to show how propene can be converted into an alcohol, showing the structural formula of the compounds.

[2]

(iii) One of the hydrocarbons produced contains 90% carbon by mass.

Deduce the empirical formula of this hydrocarbon.

[3]

[Total: 8 marks]

Section B [30 marks]

Answer **three** questions in the spaces provided.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Hydrogen is considered as an alternative source of fuel.

Production of hydrogen

Method 1

It can be manufactured by reacting methane with steam. The reaction takes place in 2 stages.

Stage 1: $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$

Stage 2: $CO(g) + H_2O(g) \rightarrow H_2(g) + CO_2(g)$

Method 2

Hydrogen can also be manufactured by electrolysis. A student investigated how the volume of gases changes with time in the electrolysis of sodium chloride solution. The student measured the volumes of gases collected every minute for 20 minutes.

Fig. 8.1 shows the student's results.

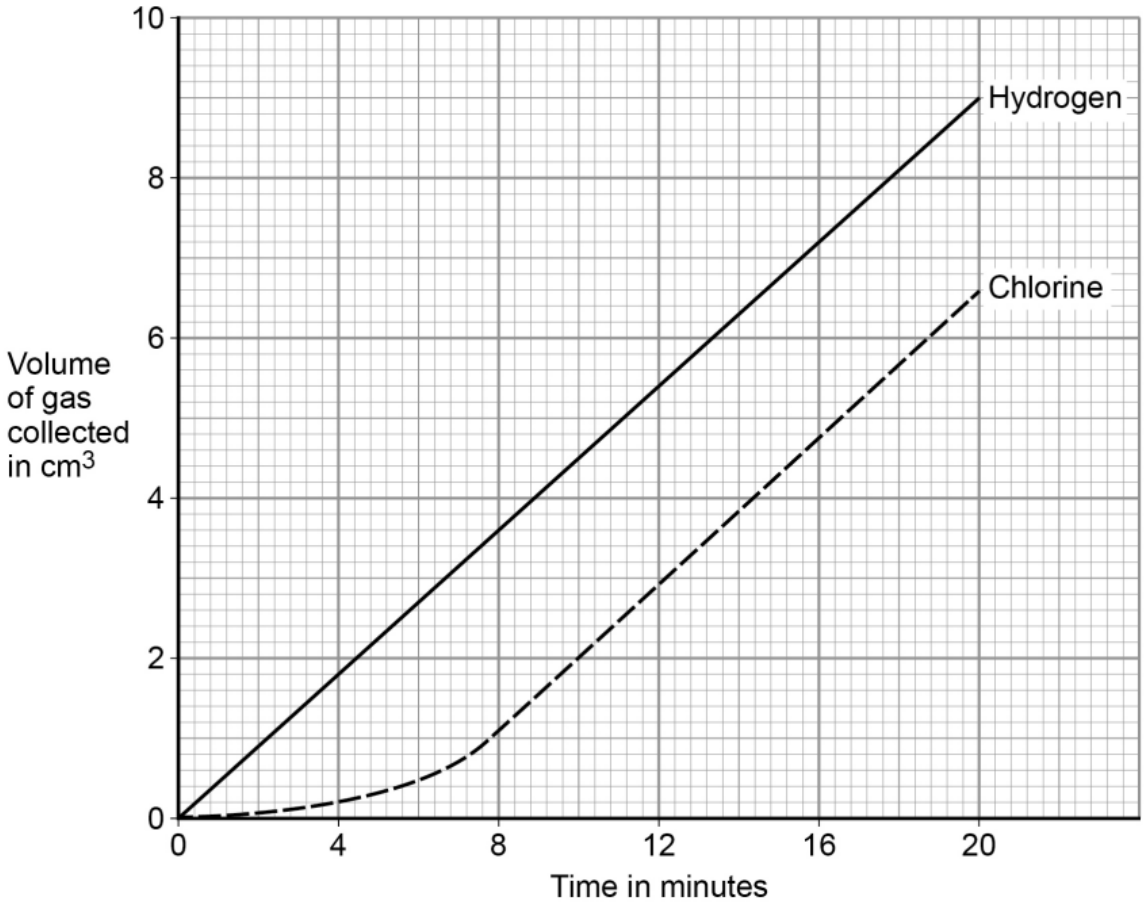


Fig. 8.1

Hydrogen fuel cell

The fuel in a fuel cell is hydrogen. Fig. 8.2 shows a type of fuel cell known as molten carbonate fuel cell.

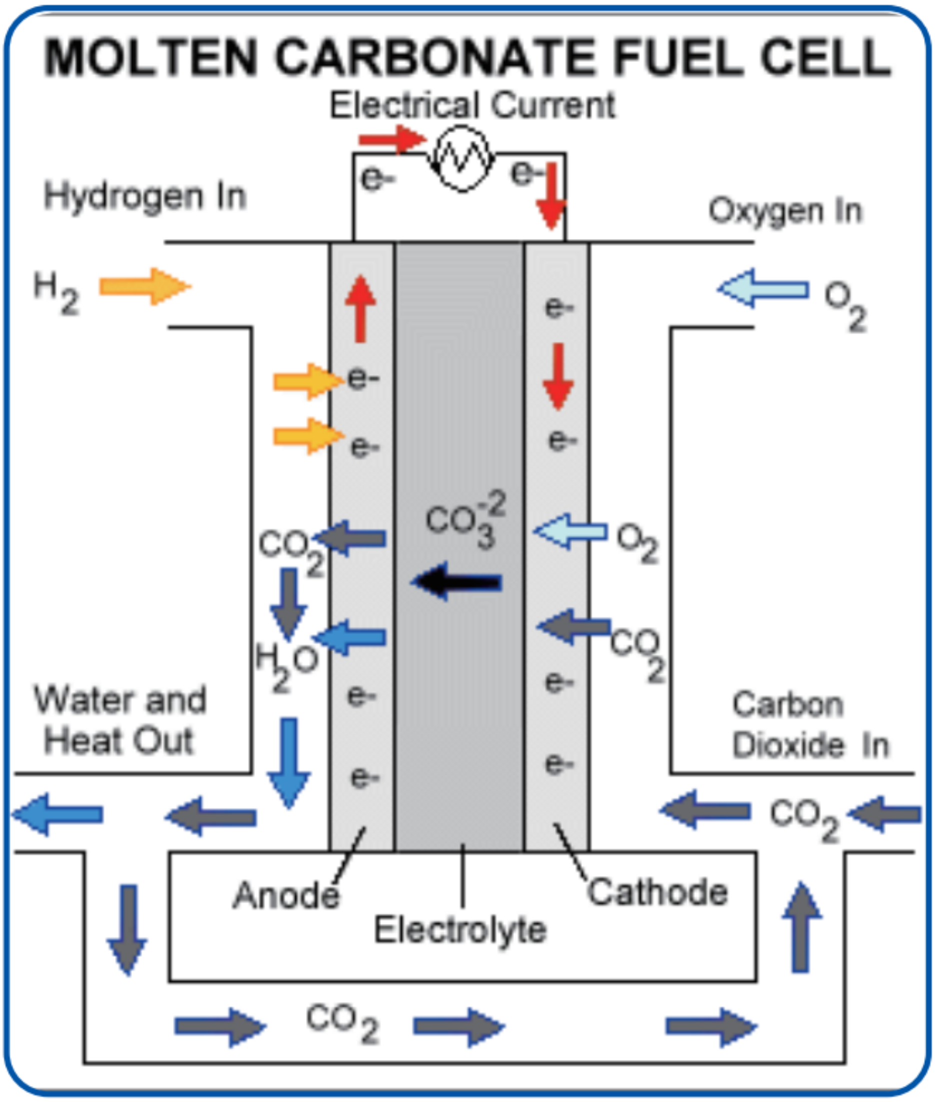


Fig. 8.2

This type of fuel cell uses an electrolyte composed of a molten mixture of lithium carbonate and potassium carbonate. The ions flow from the cathode to the anode where they combine with hydrogen to form water, carbon dioxide and electrons. These electrons move through an external circuit back to the cathode, generating electricity and heat. At the cathode, carbon dioxide reacts with oxygen to form carbonate ions which are released into the electrolyte. Hydrogen fuel cell provides a clean source of energy as it does not produce any environmentally harmful products.

(a) Write an overall equation for the production of hydrogen in method 1.

....[1]

(b) **(i)** Use values from Fig 8.1 and describe the trends shown in the results.

....

....

....

....

....

....[3]

(ii) Suggest why chlorine is collected only after a few minutes in Fig. 8.1.

....

....[1]

(iii) Suggest one reason for the difference in volume of each gas collected in Fig. 8.1.

....

....[1]

(c) The molten carbonate fuel cell in Fig 8.2 operates at 650 ^{0}C. Explain why such an operating temperature is needed for the fuel cell.

....

....[1]

(d) With the use of half equations, explain why the molten carbonate fuel cell in Fig. 8.2 produces no adverse environmental impact during its operation.

....

....

....

....[3]

(e) Some scientists think that the use of hydrogen as a fuel may not be as beneficial for the environment. Suggest two reasons why this may be so..

....

....

....[2]

[Total: 12 marks]

B9 Table 9.1 gives the composition of gases present in the Earth's early atmosphere and today's atmosphere.

Table 9.1

	composition (%)	
gas	**Earth's early atmosphere**	**Today's atmosphere**
carbon dioxide	95	0.04
nitrogen	4	78
oxygen	< 0.01	21
other gases including methane, ammonia, hydrogen and water vapour	0.9	1.06

(a) How different is the composition of gases in Earth's early atmosphere from the atmosphere today?

....

....

....[2]

(b) **(i)** Concentrations of carbon dioxide in the atmosphere are naturally regulated by processes that form the carbon cycle.

Explain how the processes in the carbon cycle control the amount of carbon dioxide in the atmosphere.

....

....

....

....

....

....[3]

(ii) From the information, predict if the surface temperature on early earth is higher or lower than in present day. Give reason(s) to support your answer.

....

....[1]

(c) Ozone occurs in the Earth's atmosphere.

Nitrogen monoxide damages ozone layer in a 2-step reaction.

$NO + O_3 \rightarrow NO_2 + O_2$

$NO_2 + O_3 \rightarrow NO + 2O_2$

One molecule of nitrogen monoxide can destroy hundreds of ozone molecules. Use the equations to explain why.

....

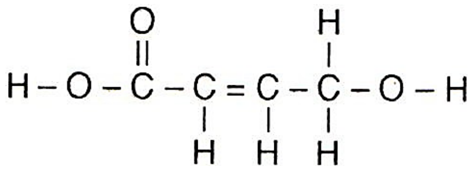
....

....[2]

[Total: 8 marks]

EITHER

B10 An organic compound **X** has the following structural formula:



(a) Describe the chemical tests you could use to identify **any two** functional groups present in compound **X**.

For each chemical test, name the

- the functional group present,
- reagents and conditions used and
- the observations made.

Functional group 1: ....

Reagents and conditions: ....

....

Observations: ....

....

....

Functional group 2: ....

Reagents and conditions: ....

....

Observations: ....

....

....

[6]

(b) Compound **X** is capable of forming polymers.

(i) In the space below, draw the structure of the polymer showing three repeat units made from compound **X** when it undergoes addition polymerisation.

[1]

(ii) If the relative molecular mass of the polymer is 5 100 000, calculate the number of molecules of monomers which combine to form one molecule of this polymer.

[1]

(c) **(i)** Draw the structure of the polymer showing two repeat units made from compound **X** when it undergoes condensation polymerisation.

[1]

(ii) Name a synthetic polymer that possesses the same linkages as the polymer in **(c)(i)**.

.... [1]

[Total: 10 marks]

OR

B10 Iodine and sulfur are elements that can form anions with oxygen. These anions have different chemical properties.

(a) A beaker of aqueous potassium iodide is added into a beaker of aqueous hydrogen peroxide. The reaction is thought to proceed in a two-step mechanism.

Step 1: $H_2O_2\,(aq) + I^-\,(aq) \rightarrow H_2O\,(l) + IO^-\,(aq)$
Step 2: $IO^-\,(aq) + H_2O_2\,(aq) \rightarrow H_2O\,(l) + O_2\,(g) + I^-\,(aq)$

Step 1 occurs very slowly but **step 2** occurs very quickly.

(i) Describe the observations, if any, for **step 1** and **step 2**.

Step 1: ....

....

Step 2: ....

.... [2]

(ii) Identify the catalyst of the reaction. Explain your answer.

....

....

.... [2]

(iii) Describe how the catalyst speeds up the chemical reaction.

....

....

.... [2]

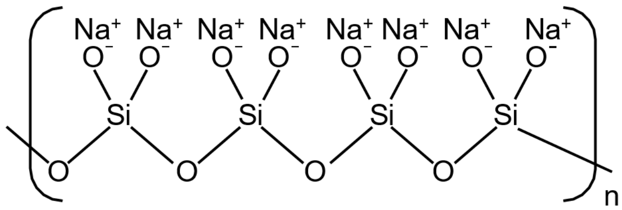
(iv) Describe a way to lower the rate of reaction of **step 2**.

....

.... [1]

(b) Hydrogen peroxide is used as a bleaching agent in paper manufacturing. Sodium silicate is being used to control the metal ions in wood pulp which otherwise will catalyse the decomposition of hydrogen peroxide, reducing the efficiency of the process.

The structure of sodium silicate is shown below.



(i) Describe the bonding in sodium silicate, with reference to the structure and the elements found in sodium silicate.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………………………………………………… [2]

(ii) Copper(II) ions are found in wood pulp.

The copper(II) ions will displace the sodium ions in sodium silicate to form copper silicate.

In the space below, draw a similar diagram to show the structure of copper silicate.

[1]

[Total: 10 marks]

End of Paper

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

	Class	Register Number
Name		

6092/02
CHEMISTRY

22/4P/6092/2

PAPER 2

Tuesday **30 August 2022** **1 hour 45 minutes**

VICTORIA SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

The use of an approved scientific calculator is expected, where appropriate.

A copy of the Periodic Table is printed on page 22.

Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

Deductions	
Presentation	
Significant Figures	
Units	

This question paper consists of 22 printed pages, including the cover page.

[Turn Over

Section A

Answer all the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Select substances from the list to answer the following questions.

You may use each substance once, more than once or not at all.

$CaCl_2$

C

CO_2

$Cu(NO_3)_2$

Na_3PO_4

SO_2

$ZnSO_4$

(a) Which substance is an acidic atmospheric pollutant from volcanic eruptions?

……………………………………………………………………………………………….[1]

(b) Which substance is commonly used as an inert electrode?

……………………………………………………………………………………………….[1]

(c) Which substance dissolves in water to form an aqueous solution that gives an insoluble white precipitate on addition of excess aqueous sodium hydroxide?

……………………………………………………………………………………………….[1]

(d) Which substance is likely to be a good catalyst?

……………………………………………………………………………………………….[1]

(e) Which substance will decolourise when used as an electrolyte in an electrolytic cell with inert electrodes?

……………………………………………………………………………………………….[1]

[Total: 5]

A2 The nuclide notation of hydrogen and deuterium are shown.

$${}^{1}_{1}H \qquad\qquad {}^{2}_{1}D$$

hydrogen deuterium

(a) Suggest a term to indicate the relationship between a hydrogen atom and a deuterium atom.

…………………………………………………………………………………………….[1]

(b) Deuterium reacts with oxygen in the same way as hydrogen. The product of the reaction is known as 'heavy water'.

(i) Using the chemical symbols given above, write the chemical equation for the reaction between deuterium and oxygen.

…………………………………………………………………………………………….[1]

(ii) Explain why deuterium reacts with oxygen in the same way as hydrogen.

…………………………………………………………………………………………….[1]

(iii) Sodium can react with water in the following chemical equation.

$$2H_2O + 2Na \rightarrow 2NaOH + H_2$$

7.2 g of water and 6.9 g of sodium are allowed to react.

Determine the limiting reactant and calculate the volume of hydrogen produced.

[3]

[Total: 6]

A3 Table 3.1 shows the melting and boiling points of some substances.

Table 3.1

substance	melting point / °C	boiling point / °C
lead(II) bromide	370	914
lithium	180	1360
methane	–182	–161
methanimine	–93	–6
X	1610	2230

(a) Explain, using ideas about structure and bonding, why methane and lithium have different boiling points.

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………[2]

(b) A sample of lead(II) bromide was mixed with chlorine gas in a reaction vessel. However, there was no observable change.

Explain why there was no change observed.

………………………………………………………………………………………………...

………………………………………………………………………………………………[1]

(c) Substance **X** is a very hard substance that is commonly used on the tips of drill bits.

(i) Suggest the identity of substance **X**.

……………………………………………………………………………………………[1]

(ii) Explain why the substance has poor electrical conductivity.

……………………………………………………………………………………………...

……………………………………………………………………………………………[1]

(d) Methanimine has the molecular formula, CH_3N.

Draw a 'dot-and-cross' diagram of methanimine.

Show outer electrons only.

[2]

[Total: 7]

A4 Table 4.1 shows part of a revised version of the original Periodic Table first published by Mendeleev in 1869.

Table 4.1

	Period 1	Period 2	Period 3	Period 4		Period 5	
Group I	H	Li	Na	K	Cu	Rb	Ag
Group II		Be	Mg	Ca	Zn	Sr	Cd
Group III		B	Al			Y	In
Group IV		C	Si	Ti		Zr	Sn
Group V		N	P	V	As	Nb	Sb
Group VI		O	S	Cr	Se	Mo	Te
Group VII		F	Cl	Mn	Br		I

(a) Which group of elements in the modern Periodic Table is missing from the Mendeleev Periodic Table?

……………………………………………………………………………………………….[1]

(b) Identify two other differences between Mendeleev's Periodic Table and the modern Periodic Table.

1. ……………………………………………………………………………………………...

……………………………………………………………………………………………...

2. ……………………………………………………………………………………………...

……………………………………………………………………………………………….[2]

(c) Some elements were left out of the Periodic Table as they had not been discovered.

Fill in the chemical symbol of germanium in Table 4.1. [1]

(d) Mendeleev put elements with similar properties in the same Group.

One of the properties he used was the formula of the oxides of the elements.

Table 4.2 shows the different types of oxides formed when Group I metals tarnish in air.

Table 4.2

element	oxides formed	formula
lithium	lithium oxide	Li_2O
sodium	sodium oxide	Na_2O
	sodium peroxide	Na_2O_2
potassium	potassium superoxide	KO_2
rubidium	rubidium superoxide	RbO_2

(i) Do the formulae of the oxides given in the table show clearly that all of the elements belong in the same Group?

Explain your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(ii) Do the formulae of the oxides given in the table show a trend down the Group?

Explain your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(e) What are the formulae of the peroxide and superoxide ions?

peroxide ion ………………………………………

superoxide ion …………………………………… [2]

[Total: 8]

A5 Fig. 5.1 shows the structure of citric acid, one of the polycarboxylic acids commonly present in unripe fruits.

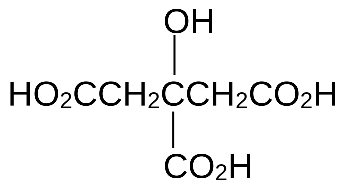


Fig. 5.1

(a) **(i)** Circle the different functional groups present in citric acid. [1]

(ii) The reagents below were added separately to a test-tube containing citric acid.

Record the observations in the table below.

reagent	observation
acidified potassium manganate(VII)	
sodium carbonate	

[2]

(b) Substance **Y**, as shown in Fig. 5.2, undergoes a reaction to produce citric acid.

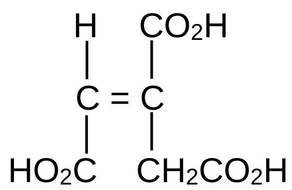


Fig. 5.2

(i) State the reagent and conditions required to produce citric acid from **Y**.

………………………………………………………………………………………..

………………………………………………………………………………………[1]

(ii) Draw the structure of a repeating unit formed by the addition polymerisation of **Y**.

[1]

(c) Another polycarboxylic acid present in unripe fruits exists as a crystalline solid, **Z** with the following composition by mass.

C: 35.8%   H: 4.5%   O: 59.7%

(i) Calculate the empirical formula of **Z**.

[2]

(ii) 1.97 g sample of **Z** (M_r = 134) was dissolved in water and the resulting solution was titrated with 1.00 mol / dm^3 NaOH.

29.4 cm^3 of 1.00 mol / dm^3 NaOH was required for complete neutralisation.

Showing your workings clearly, deduce the number of carboxyl groups present in a molecule of **Z**.

[2]

[Total: 9]

A6 Table 6.1 shows some of the reactions that take place in the blast furnace during the extraction of iron from its ore.

Table 6.1

reaction	equation	ΔH / kJ mol^{-1}
1	$C(s) + O_2(g) \rightarrow CO_2(g)$	-394
2	$C(s) + CO_2(g) \rightarrow 2CO(g)$	+173
3	$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$	-25.5

(a) The temperature at the lower part of the furnace must be hot enough to melt the iron.

Identify the reaction that is responsible for raising the temperature of the furnace.

Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(b) Explain, with the aid of an equation, how silicon dioxide, present as an impurity is removed from the blast furnace.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[3]

(c) Calculated quantities of carbon and other elements are then added to pure iron to produce different types of steel.

Explain why different types of steel are produced.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(d) Scrap steel can be recycled to obtain iron metal.

Explain why it takes less energy to make iron from scrap steel than from iron ore.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(e) Fig. 6.1 shows the reaction between iron and chlorine gas to produce gaseous iron(III) chloride, Fe_2Cl_6.

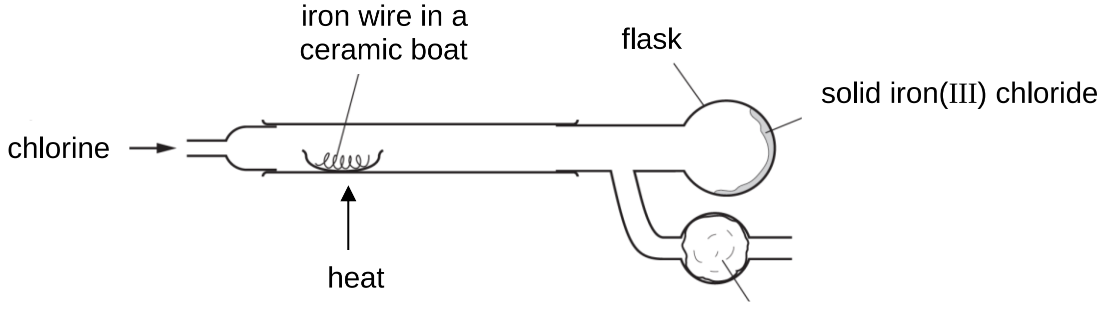


Fig. 6.1

(i) Identify a suitable drying agent for the reaction above.

……………………………………………………………………………………….[1]

(ii) Suggest why the iron(III) chloride is collected in the flask and not in the ceramic boat.

……………………………………………………………………………………….

……………………………………………………………………………………….[1]

[Total: 8]

A7 Butadiene is an organic compound that can be used to produce synthetic rubber.

It is a gas at room temperature and pressure that can be produced via a process known as steam cracking. Fig. 7.1 shows the structure of butadiene.

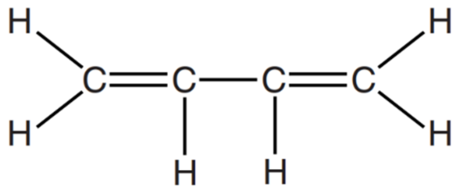


Fig. 7.1

(a) Which petroleum fraction would butadiene be found?

Explain your answer.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

(b) Butadiene is an unsaturated hydrocarbon.

Describe a chemical test to test for an unsaturated hydrocarbon.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(c) Describe the arrangement and motion of the particles in butadiene at room temperature and pressure.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(d) A sample of butadiene undergoes hydrogenation reaction with excess hydrogen.

(i) State the reaction conditions for hydrogenation reaction to take place.

……………………………………………………………………………………………[1]

(ii) Draw the full structural formula of the product formed after the hydrogenation reaction.

[1]

[Total: 7]

Section B

Answer all the questions in this section in the spaces provided.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Hess's Law

Hess's Law is a law of Physical Chemistry, which states that the heat absorbed or evolved in a chemical process is the same regardless of whether the entire chemical process is completed in one or multiple steps.

For example, Fig. 8.1 shows that the total energy change for Reaction 3 is the sum of the energy change for both Reactions 1 and 2.

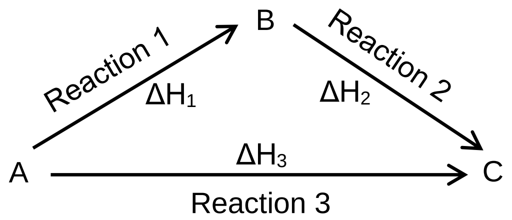


Fig. 8.1

Hess's Law can be used to determine the energy change between the different reactants using the following formula:

$$\Delta H_3 = \Delta H_1 + \Delta H_2$$

Combustion of Methane

Methane is a commonly used fuel in science laboratories to generate heat required for experiments. Methane is channelled through a gas tap to the Bunsen burner, which is lighted up to produce a flame.

The combustion of methane can proceed via two pathways.

Pathway 1: Methane undergoes complete combustion with sufficient oxygen.
Pathway 2: Methane first undergoes incomplete combustion before converting to the final products.

Both pathways are illustrated in Fig. 8.2.

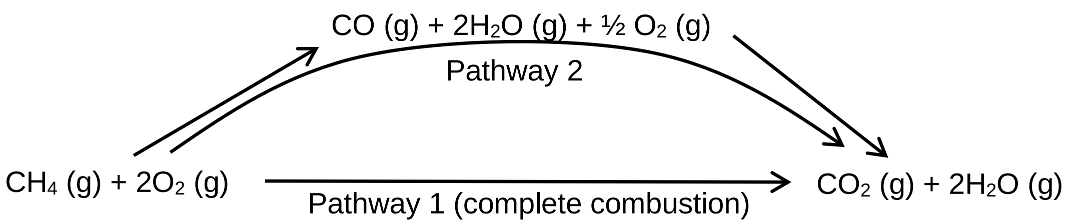


Fig. 8.2

The chemical equations for the respective combustion reactions at 298 K are shown below.

Incomplete combustion:

$$CH_4 (g) + 2O_2 (g) \rightarrow CO (g) + 2H_2O (g) + \tfrac{1}{2} O_2 (g) \qquad \Delta H = -607 \text{ kJ/mol}$$

Complete combustion:

$$CH_4 (g) + 2O_2 (g) \rightarrow CO_2 (g) + 2H_2O (g) \qquad \Delta H = -890 \text{ kJ/mol}$$

Gibbs Free Energy

Gibbs free energy is a thermodynamic potential that uses the enthalpy change of a system to calculate the work done in the system.

The equation $\Delta G = \Delta H - T\Delta S$, can be used to predict if a chemical reaction can take place spontaneously.

ΔG is the Gibbs free energy change in kJ / mol
ΔH is the enthalpy change of the reaction
T is the temperature in Kelvin, K
ΔS is the entropy change of the reaction

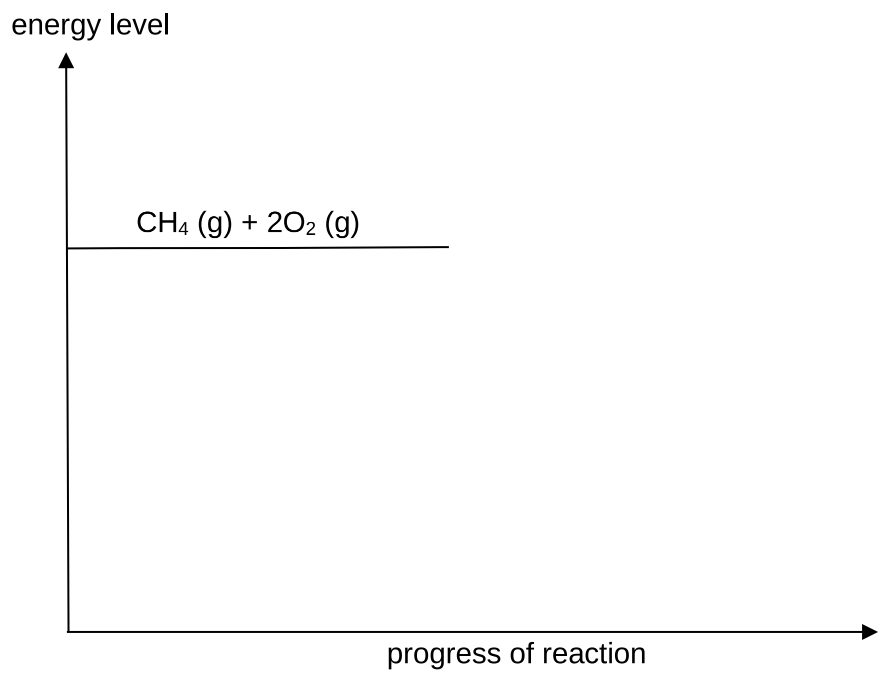
If $\Delta G < 0$, the reaction is able to proceed and will occur naturally.
If $\Delta G > 0$, the reaction is unable to proceed and will not occur naturally.
If $\Delta G = 0$, the reaction is at equilibrium.

(a) Use Hess's Law to calculate the enthalpy change of the formation of the products of complete combustion from the products of the incomplete combustion of methane.

[2]

(b) Complete the energy level diagram for both the complete and incomplete combustion, on the same diagram.

Your diagram should also include the values of the respective energy changes of both pathways for the combustion of methane.



[3]

(c) Suggest reasons why the enthalpy change of combustion of complete combustion is more negative than the enthalpy change of combustion of incomplete combustion.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(d) Explain, in terms of oxidation states, whether the complete combustion of methane is a redox reaction.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(e) **(i)** Given that the ΔS of complete combustion of methane is -0.242 kJ / mol K, calculate the Gibbs free energy change of the complete combustion of methane and predict whether the reaction would take place naturally.

[2]

(ii) The conversion of diamond to graphite at room temperature and pressure is calculated to have a negative Gibbs free energy change.

Suggest why a sample of diamond at room temperature and pressure does not visibly convert to graphite.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

[Total: 12]

B9 The Clark Sensor, as shown in Fig. 9.1, is an electrolytic cell that is used to measure the concentration of oxygen gas dissolved in samples of water such as from rivers and seas.

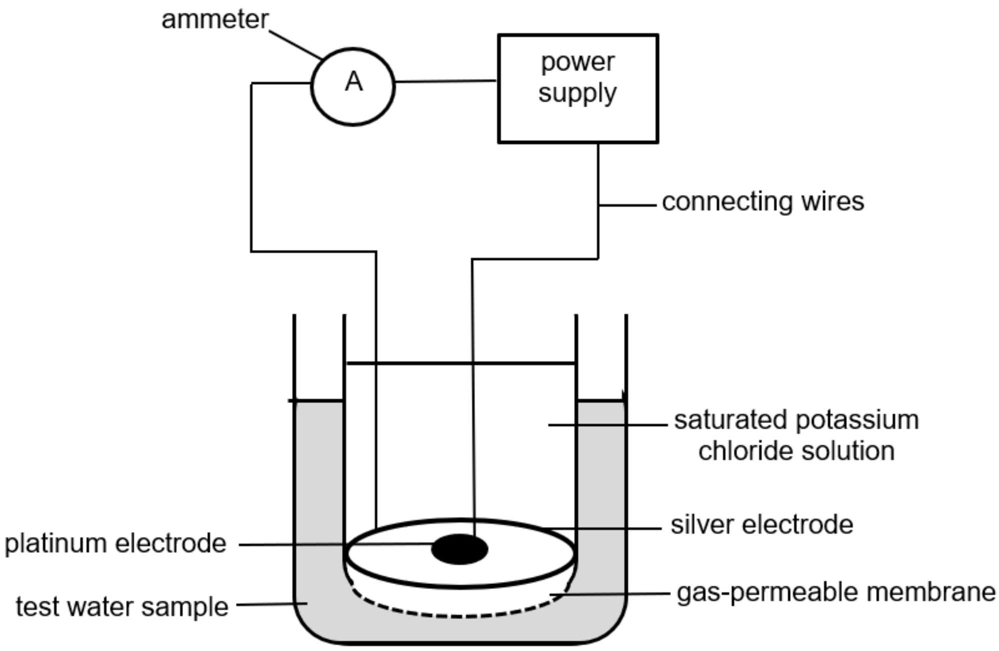


Fig. 9.1

Oxygen gas dissolved in the water sample can diffuse across the gas-permeable membrane.

A constant voltage is applied and the rate of flow of electrons produced is measured by the ammeter. The rate of flow of electrons is proportional to the number of oxygen molecules used up per minute in the water sample.

The half-equations at the electrode reactions are:

$$Ag \rightarrow Ag^{+} + e^{-}$$

$$O_2 + 4H^{+} + 4e^{-} \rightarrow 2H_2O$$

(a) Write the overall equation for the reaction in the electrolytic cell.

....[1]

(b) Identify the direction of electron flow in the cell.

Place a tick (✓) beside the correct option.

platinum to silver	
silver to platinum	

[1]

(c) Given that the number of moles of electrons that flow through the silver electrode per minute is 5.20×10^{-4} mol, calculate the number of oxygen molecules used up per minute.

[2]

(d) Describe a test to identify the presence of oxygen gas.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………[2]

(e) Suggest why the water sample is stirred constantly during the measurement.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………[1]

(f) One of the electrodes needs to be cleaned regularly to remove a white solid which forms during the reaction.

Suggest the identity of the white solid.

……………………………………………………………………………………………………[1]

[Total: 8]

EITHER

B10 The equation below shows the reaction that takes place when solid silver oxide is added to excess aqueous hydrogen peroxide.

$$Ag_2O(s) + H_2O_2(aq) \rightarrow 2Ag(s) + O_2(g) + H_2O(l)$$

(a) State the role of hydrogen peroxide in the equation above.

….. [1]

(b) State two variables that could be measured to monitor the rate of reaction as shown in the equation above.

Describe briefly how these two variables could be measured in a school laboratory.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

.....……………………………………………………………………………..………..…..[2]

(c) **(i)** Use ideas about collisions between particles to explain the effect on the rate of reaction if the experiment was repeated using twice the concentration of aqueous hydrogen peroxide of the same volume.

………...……………………………………………………………………………...

…………………………………………………………………………………………..

.......………………………………..…………………………………………………....[2]

(ii) A student commented that the volume of oxygen gas produced from the experiment in **(c)(i)** would double.

Do you agree with the student? Explain your answer.

…………………………………………………………………………………………..

.......………………………………..…………………………………………………....[1]

(d) Calculate the mass of silver oxide required to produce 1.0 dm^3 of oxygen gas.

[2]

(e) A sample of silver oxide was contaminated with traces of lead(II) oxide.

Describe how a pure and dry sample of silver oxide can be obtained from the mixture.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

.....…………………………………………………………………………..………..…..[2]

[Total: 10]

OR

B10 Aluminium objects have a thin insoluble oxide layer on their surfaces.

The oxide layer can be removed by adding dilute acid to the aluminium object.

Effervescence of colourless gas was observed after some time.

(a) **(i)** Identify the gas produced.

....[1]

(ii) Explain why the effervescence of gas was observed only after some time.

....

....

....[2]

(b) Aluminium objects that have had the aluminium oxide layer removed may then be anodised to reduce corrosion.

Anodising is an electrolytic process which coats the aluminium anode with a thick protective layer of aluminium oxide using acids as electrolyte.

Explain why dilute hydrochloric acid is used as an electrolyte during anodising instead of concentrated hydrochloric acid.

....

....

....[2]

(c) Ammonium perchlorate, NH_4ClO_4, is commonly used as a solid fuel in rocket boosters.

Aluminium reacts with ammonium perchlorate as shown in the equation.

$$\ldots\ Al + \ldots\ NH_4ClO_4 \rightarrow \ldots\ Al_2O_3 + \ldots\ AlCl_3 + \ldots\ NO + \ldots\ H_2O$$

(i) Balance the equation above. [1]

(ii) Describe how a bottle containing aqueous ammonium perchlorate can be identified from another bottle containing aqueous zinc perchlorate.

....

....

....[2]

(iii) A student wrote the following steps in the preparation of ammonium perchlorate.

1. Add excess ammonium carbonate to dilute perchloric acid.
2. Filter the mixture.
3. Heat the filtrate until saturated and allow it to cool.

Do you agree with the student? Explain your answer.

…………………………………………………………………………………………..

.......………………………………..…………………………………………………....[1]

(iv) Identify another reactant that can be added to dilute perchloric acid to make ammonium perchlorate.

.......………………………………..…………………………………………………....[1]

[Total: 10]

End of Paper

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 A*l* aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 C*l* chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 T*l* thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 F*l* flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Name: .... (   )   Class: ....

WOODLANDS SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022

EXPRESS

Level:	Secondary Four Express	Marks:	80
Subject:	Chemistry	Day:	Tuesday
Paper:	6092/02	Date:	23rd August 2022
Duration:	1 hour 45 minutes	Time:	1025 – 1210

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work that you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
Answer **all** questions in Section A in the spaces provided.
Answer all **three** questions from Section B.
The last question is in the form either/or and only one of the alternatives should be attempted.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.
The use of an approved scientific calculator is expected, where appropriate.

<table>
<tr><th colspan="6">FOR EXAMINER'S USE</th></tr>
<tr><th>Paper 1</th><th colspan="3">Paper 2</th><th>Paper 3</th><th>Total</th></tr>
<tr><td rowspan="2">/40</td><td>Section A</td><td>/50</td><td rowspan="2">/80</td><td rowspan="2">/40</td><td rowspan="2">/100</td></tr>
<tr><td>Section B
B9
B10
B11 ....</td><td>/30</td></tr>
</table>

DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO DO SO.
This document consists of **19** printed pages and **1** blank page.

Section A

Answer **all** the questions in this section in the spaces provided.

A1 **(a)** Use the list of substances to answer the questions.

ammonia	**carbon monoxide**
graphite	**lead(II) sulfate**
silicon dioxide	**sodium carbonate**

(i) Which **two** substances exist as simple molecules?

.... [1]

(ii) Which substance conducts electricity in the solid state?

.... [1]

(iii) Which substance does **not** contain an element from Group IV of the Periodic Table?

.... [1]

(iv) Which substance can be prepared by precipitation?

.... [1]

(v) Which substance is produced from reaction between its salts and an alkali?

.... [1]

(b) Which of the statements about carbon dioxide are **true** and which are **false**?
Put a tick (✓) in one box in each row.

	true	**false**
It is an acidic oxide.		
It is a pollutant which leads to skin cancer.		
It is released from catalytic converter in car.		
It changes the colour of potassium manganate(VII) from purple to colourless.		

[2]

[Total: 7]

A2 The ethers are a homologous series.
The table shows some data about the enthalpy change when 1 mol or 1 g of each ether is completely combusted.

name of ether	formula	enthalpy change of combustion (kJ/mol)	enthalpy change of combustion (kJ/g)
Methoxymethane (dimethylether)	CH_3OCH_3	-1460	-31.7
Methoxyethane	$CH_3OC_2H_5$	-2107	-35.1
Ethoxyethane (diethylether)	$C_2H_5OC_2H_5$	-2726	

(a) Calculate the enthalpy change of combustion when 1 g of ethoxyethane burns. Show your working.

[2]

(b) Use ideas about breaking and forming bonds to explain why all of the values in the table are negative.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) The enthalpy change of combustion in kJ/mol increases from methoxymethane to ethoxyethane.
Suggest a reason why.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(d) One characteristic of a homologous series is that properties show a trend. Describe the trends you would expect for **two** properties of the ethers as the molecules increase in size. Enthalpy change of combustion must **not** be one of the properties you choose.

....

....

.... [2]

(e) Ethanol is an isomer of dimethylether.

ethanol dimethylether

The enthalpy changes of combustion for ethanol and dimethylether are different.

isomer	ethanol C_2H_5OH	dimethylether CH_3OCH_3
Enthalpy change of combustion (kJ/mol)	-1371	-1460

(i) The same products are formed when both isomers are completely combusted.
Write a balanced equation to show the complete combustion of ethanol.

.... [1]

(ii) Suggest why the enthalpy changes of combustion for the two isomers are different.

....

....

.... [1]

[Total: 9]

A3 Phosphorus reacts with sodium hydroxide and water to produce sodium hypophosphite and phospine:

$$P_4\,(s) + 3NaOH\,(aq) + 3H_2O\,(l) \rightarrow 3NaH_2PO_2\,(aq) + PH_3\,(g)$$

(a) By calculating the oxidation state of phophorus, show that this is a redox reaction.

....

....

....

....

....

.... [2]

(b) Describe one way the rate of this reaction can be increased. Explain, with reference to the collisions of particles, how this is achieved.

....

....

....

....

.... [3]

[Total: 5]

A4 A white dehydrating solid has percentage composition by mass of 43.7% phosphorus and 56.3% oxygen.

(a) Find the empirical formula of this substance.

[2]

(b) If the relative molecular mass of the substance is 284, determine its molecular formula.

[2]

(c) 1 mole of this substance reacts fully with 6 moles of hot water to produce 4 moles of phosphoric (V) acid. In an experiment, 131.5 g of the substance was dissolved in 50 cm^3 of hot water. The density of hot water is 1 g/cm^3.
Determine the concentration, in mol/dm^3, of the phosphoric (V) acid produced.

[3]

[Total: 7]

A5 **(a)** A student wants to obtain test tubes of hydrogen and chorine gas from a metallic chloride solution using electrolysis.
Draw a labelled diagram to show the apparatus and materials that should be used.

[3]

(b) Write ionic equations for the half reactions at the anode and cathode.

At anode: ……………………………………………………………………………..

At cathode: ……………………………………………………………………… [2]

(c) Use your equations in **(b)** to explain the change you will observed in the electrolyte after the electrolysis has been running for some time.

....

....

.... [2]

(d) Explain how the electrical conductivities of the electrolyte you have labelled in **(a)** can change in different physical states.

....

....

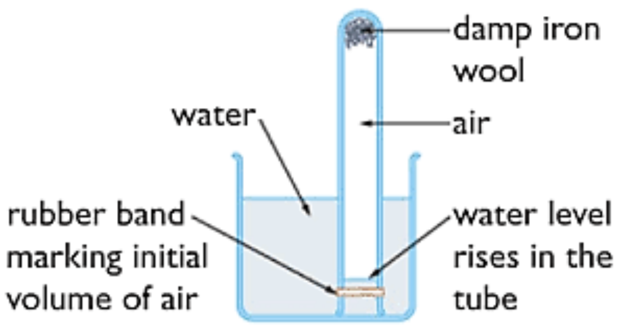
....

....

.... [2]

[Total: 9]

A6 In an experiment as shown below, the water level was observed to rise after 5 days.



(a) Explain why the water level rose after 5 days.

....

.... [1]

(b) If the column of air inside the test tube is 15 cm long, estimate the height that the water will rise to.

.... [1]

(c) Explain what is galvanising, and how it works.

....

.... [2]

[Total: 4]

A7 Use the Periodic Table to answer the following questions.

(a) Explain why argon is often used as an inert atmosphere for dangerous reactions.

....

.... [1]

(b) Name the element

(i) that is found in Group I and Period 3. ....

(ii) that is found in Group VI and Period 2. .... [1]

(c) Name the product(s) formed in the reaction between the element you gave in **(b)(i)** and cold water.

.... [1]

(d) Draw the 'dot and cross' diagram for the compound formed by the two elements you gave in **(b)**.

[2]

[Total: 5]

A8 The experimental procedure below is written by John to prepare a pure sample of magnesium nitrate by the reaction of an acid with a reactive metal.

1) Pour 50 cm^3 of nitric acid into a beaker.
2) Excess magnesium ribbon is added to the acid.
3) The mixture is evaporated till it is saturated.
4) The mixture is filtered to remove the excess solid.
5) Cool to crystallise.
6) Pick out the crystals, and wash them with a little cold deionised water.
7) Dry the crystals by heating with a Bunsen burner.

(a) State **two** mistakes found in John's experimental procedure. Correct his mistakes.

Mistake 1: ……………………………………………………………………………………..

Correction: …………………………………………………………………………….. [1]

Mistake 2: ……………………………………………………………………………………..

Correction: …………………………………………………………………………..... [1]

(b) Calculate the total number of protons, neutrons and electrons found in a nitrate ion.

protons: ……………………..…

neutrons: ……………………

electrons: …………………… [2]

[Total marks: 4]

Section B

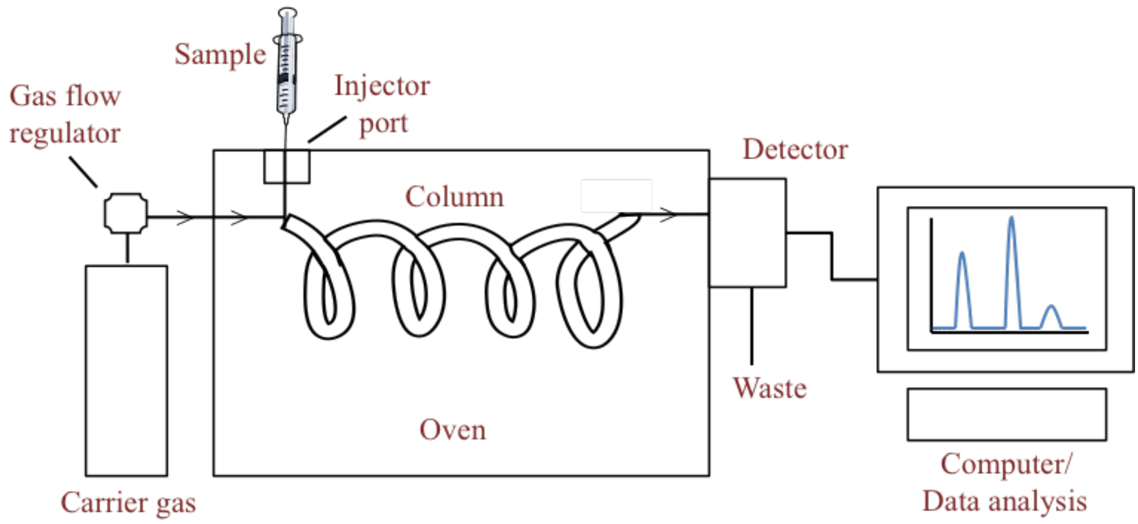
Answer all **three** questions from this section.

The last question is in the form either/or and only one of the alternatives should be attempted.

B9 Gas chromatography (GC) is a common type of chromatography used in analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition.

Typical uses of GC include testing the purity of a particular substance, or separating the different components of a mixture. In preparative chromatography, GC can be used to prepare pure compounds from a mixture.

Gas chromatography is the process of separating compounds in a mixture by injecting a gaseous or liquid sample into a mobile phase, typically called the carrier gas, and passing the gas through a stationary phase.



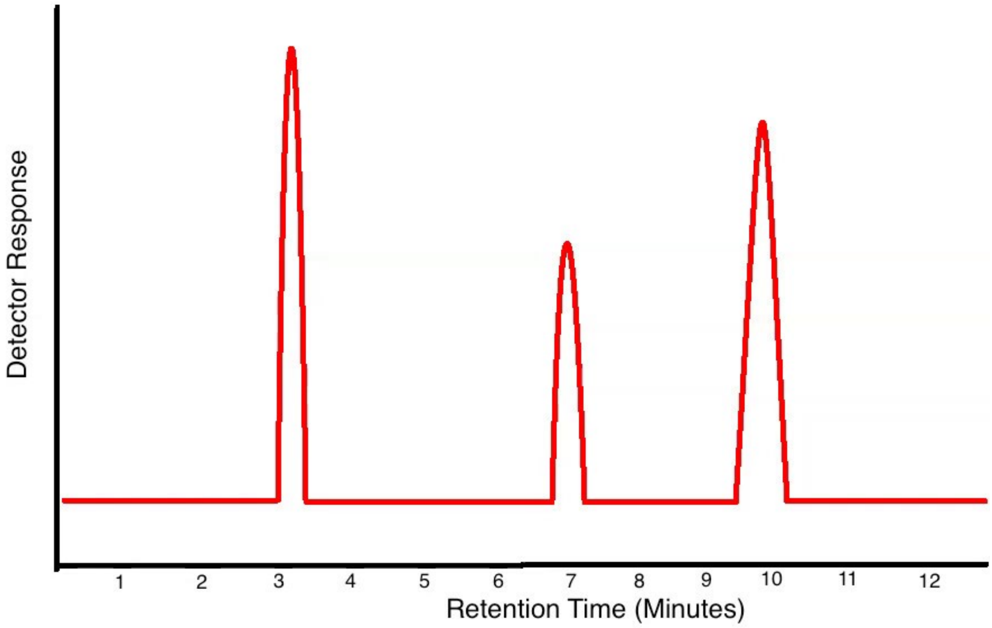
The mobile phase is usually an inert gas such as helium, argon, nitrogen or hydrogen. The stationary phase is a surface of solid particles coated on glass called a column. The substances are separated based on their affinity (attraction) with the mobile phase as compared to the stationary phase. The glass column is placed in an oven where the temperature of the gas can be controlled and the carrier gas coming off the column is monitored by a computerized detector.

Commonly used detectors are the flame ionization detector (FID) and the thermal conductivity detector (TCD). Generally, chromatographic data is presented as a graph of detector response (y-axis) against retention time (x-axis), which is called a chromatogram. This provides a spectrum of peaks for a sample representing the substances present in a sample gas mixture coming off the column at different times.

Retention time can be used to identify substances if the method conditions are constant.

Also, the pattern of peaks will be constant for a sample under constant conditions and can identify complex mixtures of substances. However, in most modern applications, the GC is connected to a mass spectrometer or similar detector that is capable of identifying the substances represented by the peaks. The greater the affinity for the mobile phase, the shorter the retention time.

A mixture was separated using gas chromatography and paper chromatography. The chromatogram obtained from the gas chromatography is shown below.



(a) How many substances are there in the mixture? Explain your answer.

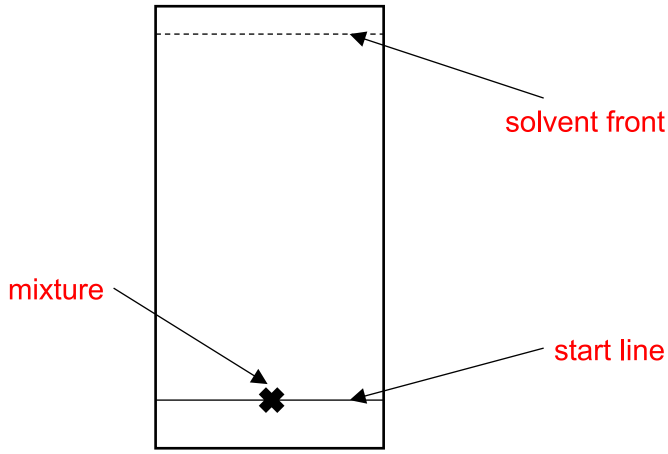
……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(b) In the diagram above, label the substance that has the greatest affinity with the mobile phase. Label it as **P**. [1]

(c) Complete the chromatogram you would expect when the same mixture is separated using paper chromatography.

Label the substance P in this chromatogram too.



[2]

(d) In gas chromatography, the retention time identify the substances present in the mixture.
In paper chromatography, what is used to identify the substances?

.... [1]

(e) In paper chromatography, which material is the mobile phase and which material is the stationary phase?

....

.... [2]

(f) What is one advantage chromatography has over other separation methods?

.... [1]

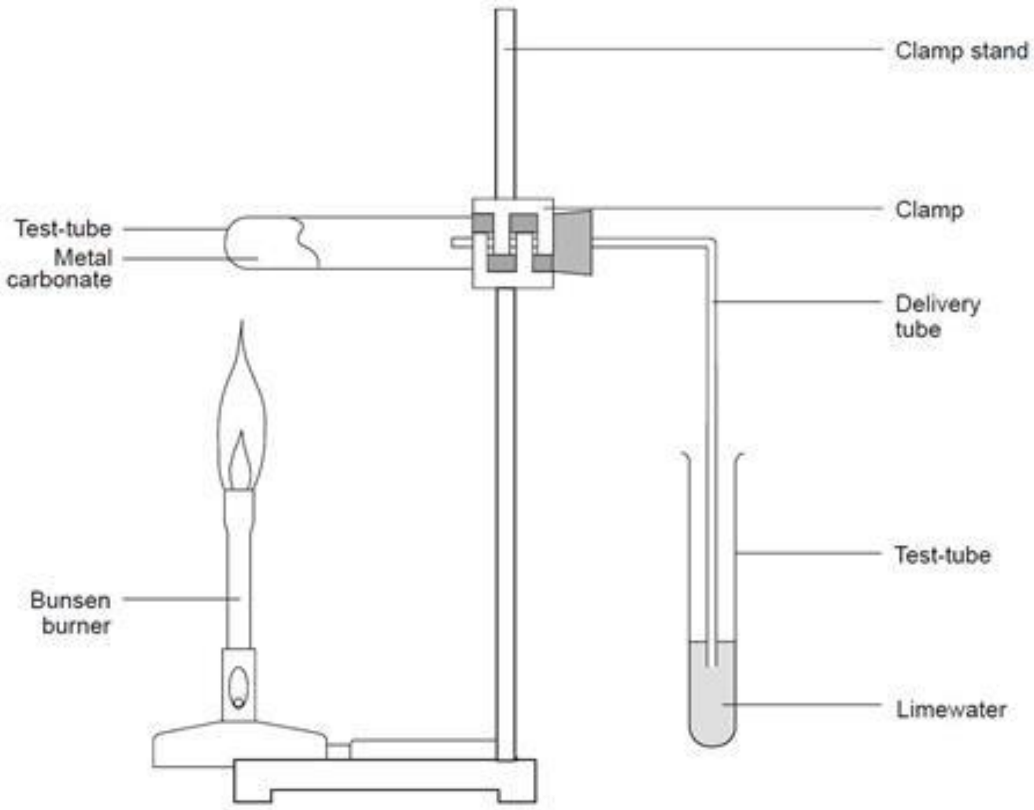
(g) Besides separating the gases in air by gas chromatography, which other separation method can also be used to separate the gases in air.
State the physical property used in the method to separate the gases in air.

....

.... [2]

[Total: **10**]

B10 Three metal carbonates were thermally decomposed to compare their reactivity as shown in the diagram below.



(a) State the dependent variable and 2 variables to control for this experiment.

Independent variable: type of metals

Dependent variable: ……………………………………………………………………………

Control variables: ……………………………………………………………………………

…………………………………………………………………………… [3]

(b) Explain how you may use the reading of the dependent variable to determine the reactivity of the metals.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(c) It was noticed that the total mass of the content in the test tube decreased after the experiment. Suggest a reason for this.

…………………………………………………………………………………………………… [1]

(d) Explain how you may know from the colour change observed that the carbonate thermally decomposed in the test tube is:

(i) zinc carbonate?

.... [1]

(ii) copper(II) carbonate?

.... [1]

(e) Write the balanced equation, with state symbols, of another reaction that will allow you to obtain carbon dioxide from zinc carbonate.

.... [2]

(f) The reactivity of metals can be determined by decomposing metal nitrates by heat too.

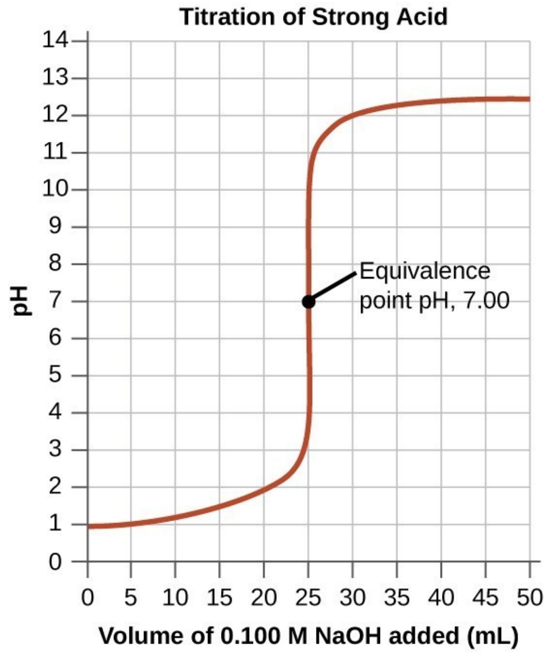
Give the chemical formula of the products of the decomposition of zinc nitrate.

.... [1]

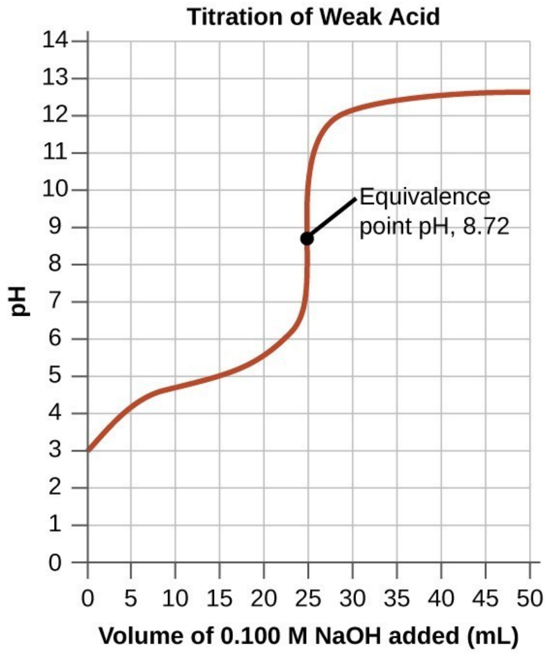
[Total: 10]

EITHER

B11 The graphs below show the change in pH as different types of acid are titrated with a strong alkali. Equivalence point shows the complete neutralization of the acid by the alkali.



(1)



(2)

(a) Which one of the following indicators is suitable for use in titration (1) and (2)?

indicator	low pH colour	pH range in which neutralization occurs	high pH colour
naphtholphthalein	pale-red	7.3-8.8	greenish-blue
phenol red	yellow	6.4-8.0	red
methylene blue	colourless	5.0-9.0	dark blue
bromocresol purple	yellow	5.2-6.8	purple

Titration (a): ....

Titration (b): .... [2]

(b) Which one of the above indicators is suitable for use when titrating a strong acid with a weak alkali? Explain your answer.

....

.... [2]

(c) Explain the difference in nature between a weak and a strong acid.

....

.... [2]

(d) State **two** similarities in physical properties between weak and strong acids.

....

....

.... [2]

(e) Write a balanced chemical equation for the reaction between sodium hydroxide and

(i) a strong acid of your choice.

.... [1]

(ii) a weak acid of your choice.

.... [1]

[Total: 10]

OR

B11 Alkanes is a homologous series of saturated hydrocarbons, whereas alkenes is a homologous series of unsaturated hydrocarbons.

(a) Describe **two** similar gradation in physical properties among the alkanes and the alkenes.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(b) Describe one similarity in the chemical property of the alkanes and the alkenes. In your answer, state clearly the reactant and the products.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(c) Give one difference in the chemical property of the alkanes and the alkenes.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(d) Food can contain saturated fats, monounsaturated fats or polyunsaturated fats. Describe a chemical test you can carry out to determine if a sample of fats is saturated or unsaturated.

Test: ………………………………………………………………………………………………

Results: ……………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(e) Alcohols is another homologous series of organic compounds.

(i) Draw the full structure of the alcohol that oxidises to form propanoic acid.

[1]

(ii) Draw the structure of an isomer of the alcohol in **(i)**.

[1]

(f) The naphtha fractions from the fractional distillation of petroleum is both a resource for use as fuel as well as a feedstock for smaller organic molecules that are needed for manufacturing many industrial goods such as plastics, clothing materials, etc.
Describe the reaction that enable large organic compounds found in naphtha to be broken down into smaller saturated hydrocarbons, unsaturated hydrocarbons or hydrogen gas.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………...[1]

[Total: 10]

End Of Paper

The Periodic Table of Elements

Group

I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key atomic number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

Name: ______________________________ (   ) Class: ____________

WHITLEY SECONDARY SCHOOL

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PRELIMINARY EXAMINATION 2022

SUBJECT	:	Chemistry (6092/02)
LEVEL	:	Secondary 4 Express
DATE	:	22 August 2022
DURATION	:	1 hour 45 minutes
SETTER	:	Ms Ng Soo Hoon
VETTERS	:	Ms Charlene Lye and Mr Ng Mun Leong

READ THESE INSTRUCTIONS FIRST
Write your name, class and index number on all the work you hand in.
Write in dark blue or black ink.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions in the spaces provided.
The last question is in the form of either/or and only **one** of the alternatives should be attempted.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page **19**.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use		
Section **A**		**/50**
Section **B**		**/30**
Total		**/80**

This paper consists of **19** printed pages and **1** blank page.

Section A (50 marks)

Answer all the questions in this section in the spaces provided.

A1 **(a)** Use the list of substances to answer the questions.

copper(II) chloride	carbon
chlorine	helium
sodium carbonate	nitrogen dioxide
phosphorus	

(i) Which substance is unreactive?

……………………………………………………………………………………………[1]

(ii) Which substance is produced at high temperature in car engines?

……………………………………………………………………………………………[1]

(iii) Which substance forms a compound with hydrogen with the formula, $\mathbf{X}H_3$?

……………………………………………………………………………………………[1]

(iv) Which two substances, when mixed together in aqueous forms, would produce a green insoluble salt?

……………………………………………………………………………………………[1]

(v) Which substance reacts with aqueous sodium bromide to produce a reddish-brown solution?

……………………………………………………………………………………………[1]

(b) Which of the statements about the processes in the blast furnace are true and which are false?

Put a tick (√) in one box in each row.

	true	**false**
Carbon in coke reacts with oxygen to form carbon dioxide.		
Carbon monoxide reduces iron(III) oxide in haematite to form molten iron.		
Limestone reacts with sand to form molten slag.		
Molten slag sinks to the bottom of the furnace.		

[2]

[Total: 7]

844

A2 The Haber process is an important process to produce ammonia, which is used as a feedstock to produce fertilisers for agricultural use.

The process is costly as the raw materials, nitrogen and hydrogen need to be obtained by processes that require energy.

The table below shows the bond energies of some bonds.

bond	bond energy/ kJ/mol
H – H	436
O – H	460
N – N	160
N ≡ N	944

(a) Hydrogen reacts with nitrogen to produce ammonia in the equation below.

$$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g) \qquad \Delta H = -\ 91.8\ kJ$$

Calculate the bond energy of the N – H bond in kJ/mol.

[2]

(b) Use ideas about breaking and forming bonds to explain why the enthalpy change for the process is negative.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………… [2]

(c) Finely divided iron is used as a catalyst in the Haber process.

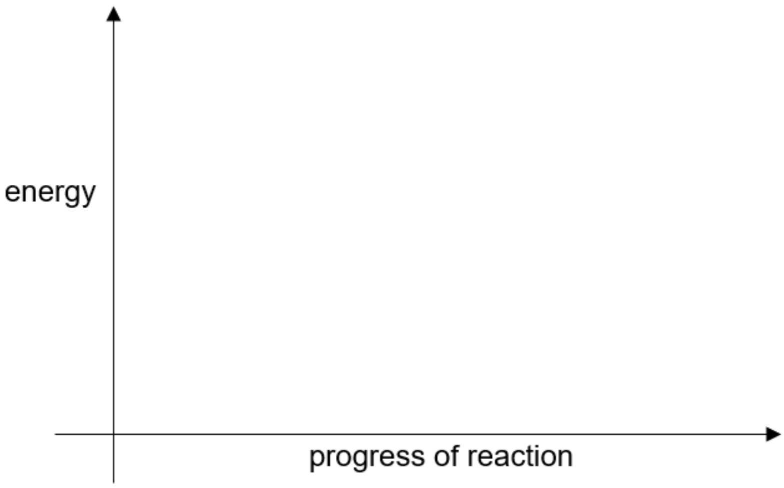
What other essential industry conditions are necessary for making ammonia from nitrogen and hydrogen?

………………………………………………………………………………………………………

……………………………………………………………………………………………………… [1]

(d) Draw an energy profile diagram to show the effect of the catalyst on the Haber process.

Your diagram should show and label
- reactants and products,
- the activation energy for the uncatalysed and catalysed reactions,
- the enthalpy change of reaction.



[3]

(e) Use ideas about collisions between particles to explain, how a catalyst increases the rate of reaction.

……

……

……

………………………………………………………………………………………………….. [2]

(f) Catalysts are expensive to buy but it reduces costs in the long run.

Give a reason to explain why catalysts reduce costs in the long run.

……

………………………………………………………………………………………………….. [1]

[Total: 11]

A3 **(a)** Using the knowledge of the particulate model of matter, describe the changes in the particles in terms of arrangement and motion when dry ice is heated.

arrangement ……………………………………………………………………………………..……..

………

…………………………………………………………………………………...……………… [1]

motion ………………………………………………………………………………………..………..

……………………………………………………………………………………………..…………

……..………………………………………………………………………………………..……… [1]

(b) A student separates four amino acids by paper chromatography using two different solvents.

The solvent front of solvent 1 takes five minutes to reach the end of the chromatogram while the solvent front of solvent 2 takes ten minutes.

The table below shows the R_f values she obtained for these amino acids.

amino acid	R_f in solvent 1	R_f in solvent 2
A	0.2	0.5
B	0.1	0.4
C	0.8	0.9
D	0.3	0.4

(i) Which amino acid travels fastest in both solvents?

…...…………………………………………………………………………………………….. [1]

(ii) The student wrote the following paragraph about the chromatography experiment that she has conducted.

'It is better to use solvent 2 as it allows me to find out the identity of the 4 amino acids. One source of error in this experiment is that the duration of chromatography for solvent 2 is longer than for solvent 1, thus it is an unfair experiment.'

Do you agree with the student? Explain your reasoning.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………..…… [2]

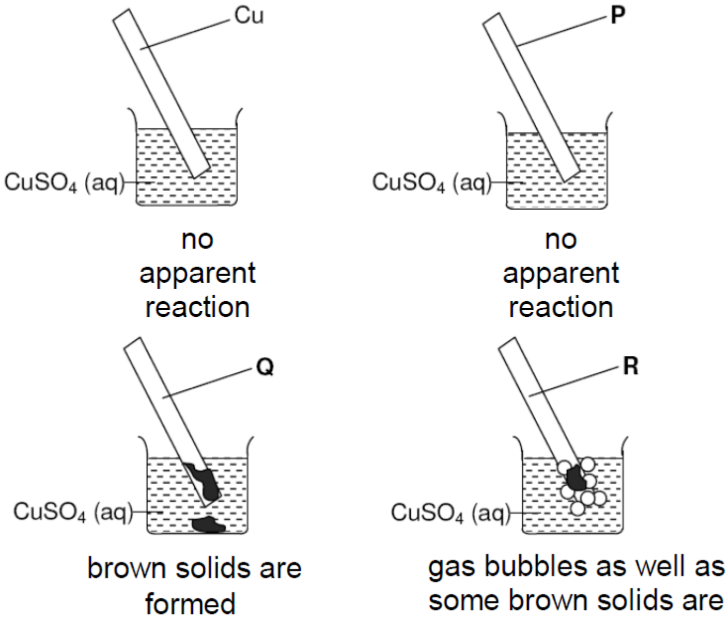
[Total: 5]

A4 **(a)** The following experiments were conducted to determine the order of reactivity of four metals, copper, **P**, **Q** and **R**.

In the first experiment, the oxides of the four metals were heated. The results are shown in the Table below.

metal oxide	CuO	$\mathbf{P}_2O$	**Q**O	**R**O
observation	no reaction	metal **P** is formed	no reaction	no reaction

In the second experiment, copper, **P**, **Q** and **R** are added separately to copper(II) sulfate solution. The observations are shown below.



(i) For the reaction between **Q** and copper(II) sulfate solution, give another observation that could be seen. Explain the observation.

....

....

.... [2]

(ii) Explain the formation of bubbles in the reaction between **R** and copper(II) sulfate solution. Write the chemical equation for this reaction.

....

....

.... [2]

(iii) Arrange the four metals in increasing order of reactivity.

.... [1]

848

(b) Fungicide, which is used to prevent the growth of fungi, contains aqueous copper(II) sulfate.

(i) Galvanised iron is a steel coated with a layer of zinc. Explain why fungicide should **not** be stored in cans made from galvanized iron.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) Write an ionic equation, with state symbols, for the reaction that happens in **(i)**.

…………………………………………………………………………………………… [2]

[Total: 9]

A5 The condensed formula of two carboxylic acids **X** and **Y** are $C_{24}H_{49}COOH$ and $C_{24}H_{41}COOH$ respectively.

(a) State one difference between the structural formulae of the two acids that gives them different chemical properties.

…………………………………………………………………………………………… [1]

(b) Describe a simple test to show which is **X** and which is **Y**.

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) Equal masses of carboxylic acids **Y** and **Z** are separately dissolved in an organic solvent. A few drops of aqueous bromine are added to each solution and the mixtures are shaken. The table shows the results.

carboxylic acid	colour of mixture
Y	yellow
Z	orange

Give a possible condensed formula of carboxylic acid **Z.**

…………………………………………………………………………………………… [1]

[Total: 4]

A6 **(a)** An oxyacid is a compound that contains hydrogen, oxygen and at least one other element. Iodine forms several types of oxyacids.

Complete the table below to show the oxidation states of iodine in the respective oxyacids.

name of oxyacid acid	chemical formula	oxidation state of iodine
periodic acid	HIO_4	
iodic acid	HIO_3	
hypoiodous acid	HIO	

[2]

(b) Iodic acid is produced when iodine is mixed with water and chlorine, as shown in the equation below.

$$I_2 + 6H_2O + 5Cl_2 \rightleftharpoons 2HIO_3 + 10HCl$$

Explain, in terms of oxidation states, why this is a redox reaction.

………

………

………

…………………………………………………………………………………………………… [2]

(c) Oxalic acid is made up of carbon, oxygen and hydrogen and it contains 26.7 % carbon and 2.20 % hydrogen by mass.

(i) Determine the empirical formula of oxalic acid.

[2]

(ii) The relative molecular mass of oxalic acid is 90.
Determine the molecular formula of oxalic acid.

[1]

[Total: 7]

A7 The Alhambra is a beautiful monument in Granada, Spain. It comprises of buildings made of limestone, $CaCO_3$, with a river filled with aquatic life near it.

The life of this monument can be preserved by treatment with an aqueous mixture of barium hydroxide and urea, $CO(NH_2)_2$. As this aqueous mixture soaks into the porous limestone structures, the urea slowly reacts with water to form ammonia and carbon dioxide. The carbon dioxide that is released reacts with aqueous barium hydroxide, forming barium carbonate.

The solubility of the sulfates and carbonates of calcium and barium are shown below.

substance	$CaCO_3$	$CaSO_4$	$BaCO_3$	$BaSO_4$
solubility in water / mol dm^{-3}	1.5×10^{-4}	4.6×10^{-2}	9.0×10^{-5}	9.4×10^{-6}

(a) **(i)** Use information from the table to explain why having a layer of barium carbonate on the monument will help to preserve the life of the limestone monument.

....

.... [1]

(ii) The layer of barium carbonate on the surface of the treated monument can react with sulfur dioxide in the air to form a layer of barium sulfate and carbon dioxide.

Will the above reaction speed up or slow down corrosion of the monument?

Use information from the table to explain your answer.

....

.... [2]

(b) Urea reacts with water to form ammonia and carbon dioxide.

(i) Write the equation for this reaction.

.... [1]

(ii) Environmentalists are concerned when ammonia and carbon dioxide are produced near the river.

Explain why.

....

....

....

....

.... [3]

[Total: 7]

Section B (30 marks)

Answer all three questions in this section.

The last question is in the form of an either / or and only one of the alternatives should be attempted.

B8 A fuel cell is a chemical cell in which reactants are continuously supplied to produce electricity.

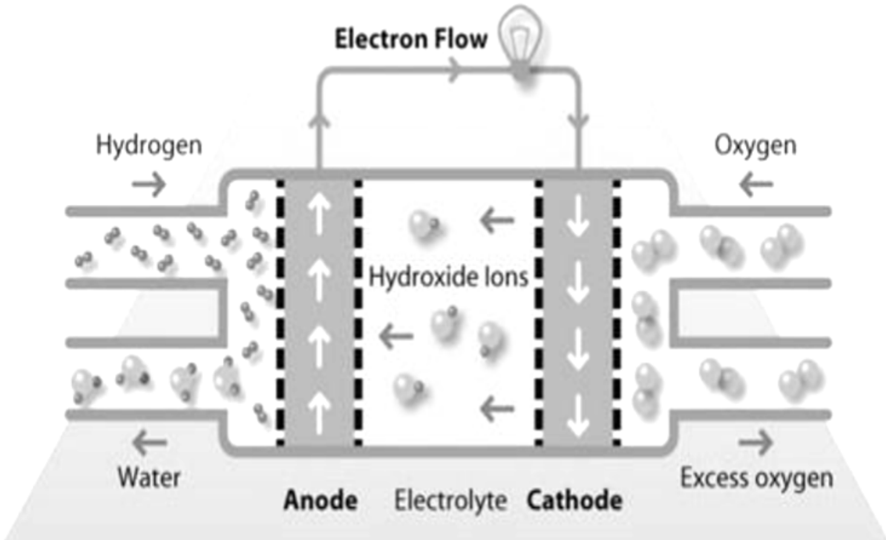
Two such cells are the ***Alkaline Fuel Cell (AFC)*** and the ***Proton Exchange Membrane Fuel Cell (PEMFC)***

Alkaline Fuel Cell

AFCs use an alkaline electrolyte such as potassium hydroxide in water and are generally fuelled with pure hydrogen. Typical operating temperatures are around 70 ^{o}C. As a result of the low operating temperature, a variety of non-precious metals can be used as catalysts to speed up the reactions occurring at the anode and cathode.

At the anode, the hydrogen gas reacts with the hydroxide ions to form water. The water then travels through the membrane to the cathode side of the cell where they then react with oxygen to form hydroxide ions. The electrons travel in an external circuit, generating the electrical output of the cell.

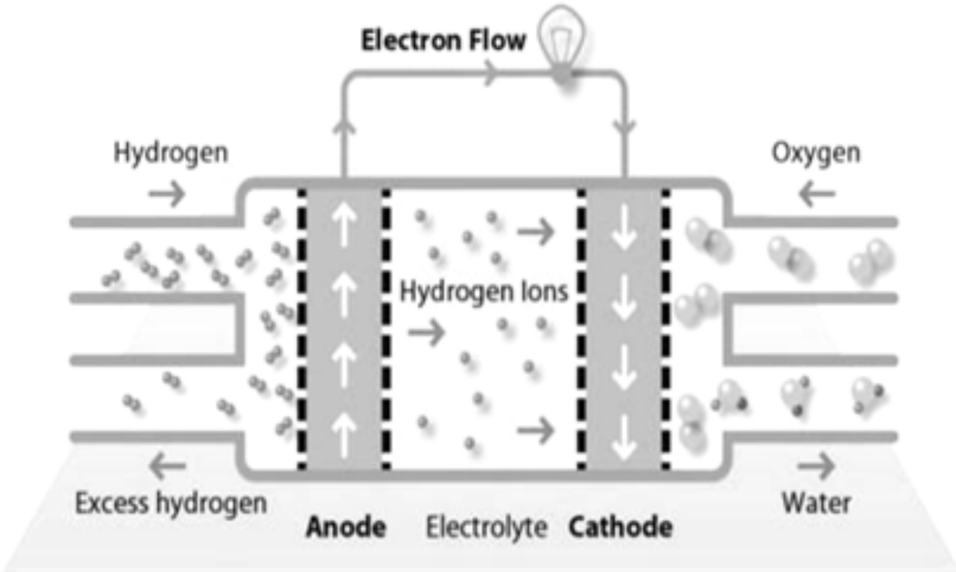
AFC cell type is easily poisoned by carbon dioxide (CO_2). In fact, even the small amount of CO_2 in the air can affect this cell's operation, making it necessary to purify both the hydrogen and oxygen used in the cell. This purification process is costly.



Proton Exchange Membrane Fuel Cell

The ***PEMFC*** uses a water-based, acidic polymer membrane as its electrolyte, with platinum-based electrodes. PEMFC cells operate at relatively low temperatures (below 100 ^oC). Due to the use of precious metal-based electrodes, these cells must operate on pure hydrogen.

Hydrogen gas is processed at the anode where electrons are separated to form hydrogen ions on the surface of a platinum-based catalyst. The hydrogen ions pass through the membrane to the cathode side of the cell where they then react with oxygen to form water. The electrons travel in an external circuit, generating the electrical output of the cell.



(a) Compare the reactions at the electrodes for ***AFC*** and ***PEMFC***. Complete the table below with the relevant half-equations.

	cathode	anode
AFC		
PEMFC		

[4]

(b) Write the overall equation, with state symbols, for both cells.

…………………………………………………………………………….……………….……...… [2]

(c) Explain, with reference to the nature of CO_2, why it poisons ***AFC***. Write an equation to support your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(d) Suggest one reason why the operation of ***AFC*** is more economical than that of ***PEMFC***.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(e) Most of the hydrogen produced today is made via steam-methane reforming. In this process, high temperature steam reacts with methane (CH_4), in the presence of a catalyst to produce hydrogen and carbon monoxide.

(i) Hydrogen fuel cells are environmentally-friendly.

Explain why.

…………………………………………………………………………………………… [1]

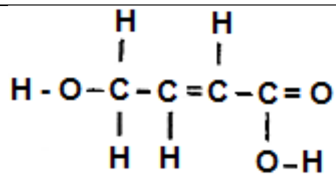
(ii) Suggest why some environmentalists argue against the use of hydrogen fuel cells.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

[Total: 11]

B9 Some of the following organic compounds can be converted to one another using various chemical processes.

Compound **A**	C_3H_8O
Compound **B**	propene
Compound **C**	CH_3CH_2COOH
Compound **D**	

(a) **(i)** **A** has a few isomers. One of the isomers of **A** can be converted into **C**. Draw the full structural formula of this isomer.

[1]

(ii) Describe how the isomer drawn in **(a)(i)** can be converted to **C**. State the observations you would see in this conversion.

....

.... [2]

(iii) Calculate the percentage yield if 30 tonnes of **C** was obtained from 45 tonnes of the isomer drawn in **(a)(i)**.

[2]

(b) **B** and **D** can undergo the same type of polymerisation.

Draw the structural formula of the polymer formed when **D** undergoes this type of polymerisation.

[1]

(c) Name a synthetic polymer that has the same linkage as the polymer formed when **D** undergoes condensation polymerisation.

.... [1]

(d) **C** can be converted into a sweet smelling liquid **X** with 4 carbon atoms.

(i) Name liquid **X**.

.... [1]

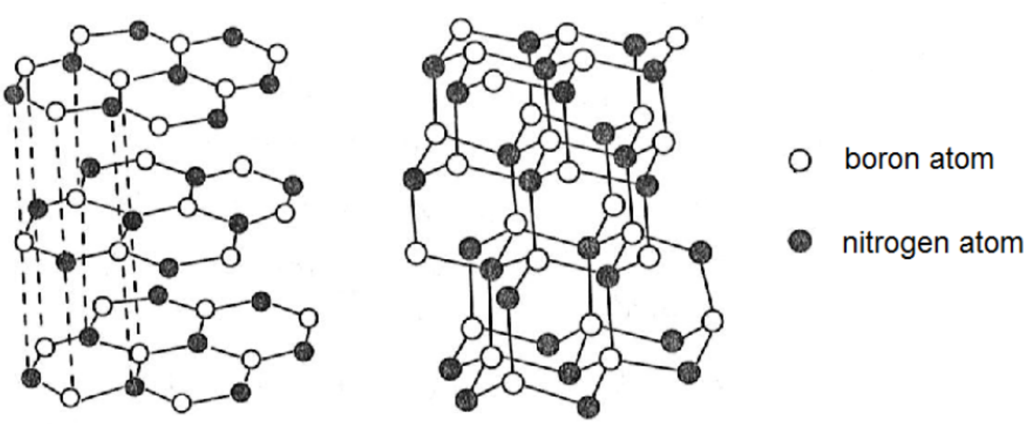
(ii) Draw the full structural formula of an isomer of liquid **X**. This compound drawn must have different chemical properties from liquid **X**.

[1]

[Total: 9]

EITHER

B10 Boron nitride is found to exist in two possible forms, hexagonal boron nitride and cubic boron nitride as shown below.



Hexagonal boron nitride Cubic boron nitride

(a) Carbon can also be found in two different forms (allotropes). Name the allotropes of carbon which has a similar structure as

(i) hexagonal boron nitride ………………………………………………………………

(ii) cubic boron nitride ………………………………………………………………… [1]

(b) Based on the structures shown, explain the difference in one physical property of hexagonal and cubic boron nitride other than electrical conductivity.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [3]

(c) The melting points of hexagonal boron nitride and two other compounds of nitrogen are given below.

compound	melting point/ °C
hexagonal boron nitride	2973
aluminium nitride (AlN)	2200
hydrazine (N_2H_4)	2

(i) Draw the 'dot and cross' diagram to represent the bonding in hydrazine. Show all electrons.

[2]

(ii) Draw the 'dot and cross' diagram to represent the bonding in aluminium nitride. Show only valence electrons.

[2]

(iii) Both hexagonal boron nitride and aluminium nitride have very high melting points. Explain why in terms of the structures present in both substances.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

[Total: 10]

OR

B10 A student investigated the rate of reaction when dilute acid reacts with excess magnesium ribbon.

He used the same volume of acid for each experiment. He measured the time taken to collect 10 cm^3 of gas at room temperature and pressure. He also measured the total volume of gas at the end of the experiment at room temperature and pressure.

The table below shows his results.

experiment	acid	concentration In mol/dm^3	time taken to collect 10 cm^3 of gas / s	total volume of gas / cm^3
1	nitric acid	0.5	15	150
2	nitric acid	1.0	6	300
3	nitric acid	0.5	7	150
4	hydrochloric acid	0.5	15	150

(a) Give the formula for the salt which forms in experiment 1.

……………………………………………………………………………………………[1]

(b) **(i)** The student carried out three experiments using acid at room temperature and one experiment using acid at a higher temperature.

Which experiment was carried out at a higher temperature?

Explain your reasoning.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) Explain, in terms of collisions between reacting particles, why a higher temperature affects the rate of reaction.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(c) The student carried out two further experiments at room temperature using 0.5 mol/dm^3 ethanoic acid and 0.5 mol/dm^3 sulfuric acid.

He used the same volume of acids as in the previous experiments with excess magnesium ribbon.

The table below shows his results.

Complete the table to predict what results he should expect and explain how you arrived at your answers.

experiment	acid	concentration in mol/dm^3	time taken to collect 10 cm^3 of gas /s	total volume of gas /cm^3
5	ethanoic	0.5		
6	sulfuric	0.5		

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [4]

[Total: 10]

- End of Paper -

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			proton (atomic) number atomic symbol name relative atomic mass								5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

West Spring Secondary School
Preliminary Examination 2022

CHEMISTRY **6092/02**
Paper 2

SECONDARY 4 EXPRESS

Name ________________________________ (   ) **Date** **26 August 2022**

Class __________ **Duration** **1 hour 45 minutes**

Additional materials: Laminated Periodic Table

READ THESE INSTRUCTIONS FIRST

Write your index number, class and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is provided separately.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

This document consists of **20** printed pages including the cover page.

Setter: Mdm Sharena **[Turn over**

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Choose from the following reactions/processes to fill in the blanks. Each reaction/process may be used once, more than once or not at all.

Precipitation	Displacement	Reduction	Decomposition
Neutralisation	Combustion	Oxidation	Dissociation

(a) When potassium hydroxide and carbonic acid reacts, ……………………………….. occurs. [1]

(b) Iron undergoes ……………………………….. during rusting. [1]

(c) Copper(II) carbonate undergoes ……………………………….. to form copper(II) oxide and carbon dioxide. [1]

(d) Copper(II) oxide can undergo ……………………………….. to form copper, by reacting with hydrogen. [1]

(e) Methane undergoes ……………………………….. when it reacts with air to produce carbon dioxide and water vapour. [1]

[Total: 5]

A2 Chromatography can be used to separate components of a mixture.

A student used paper chromatography to analyse a black food colouring.

The student placed spots of known food colours, A, B, C, D and E, and the black food colouring on a sheet of chromatography paper and carried out paper chromatography using ethanol as the solvent.

The results are shown on the chromatogram in Figure 2.1.

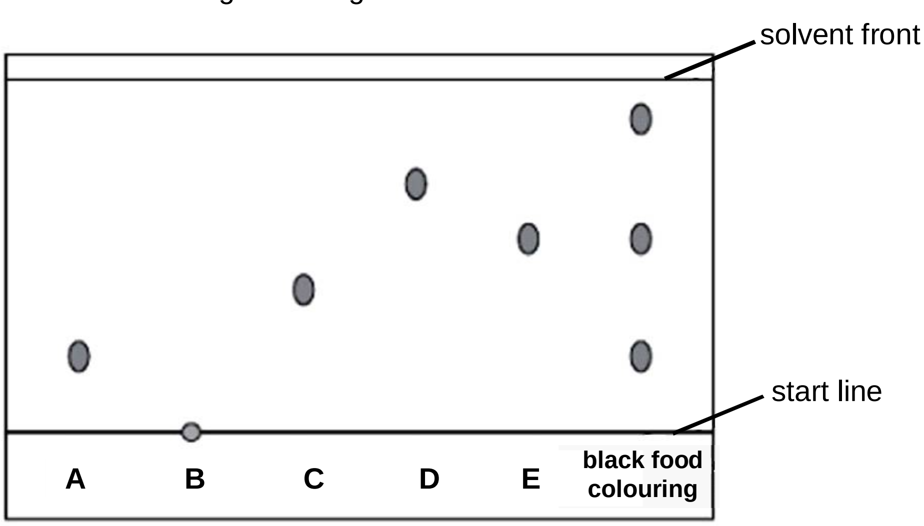


Fig. 2.1

(a) Which of the known food colours is insoluble in ethanol? …………………………. [1]

(b) What does the chromatogram tell you about the composition of the black food colouring?

……..

……………………………………………………………………………………………..……………..[2]

(c) Table 2.1 gives the results of chromatography experiments that were carried out on some known food colours, using ethanol as the solvent.

Table 2.1

name of food colour	distance from start line to solvent front in mm	distance moved by food colour in mm	R_f value
Ponceau 4R	62	59	0.95
Carmoisine	74	45	0.61
Fast red	67	27	0.40
Erythrosine	58	17	0.29

Using Figure 2.1 and the information in Table 2.1, calculate the R_f value of food colour C to determine which of the food colours in the table could be food colour C?

Use the formula,

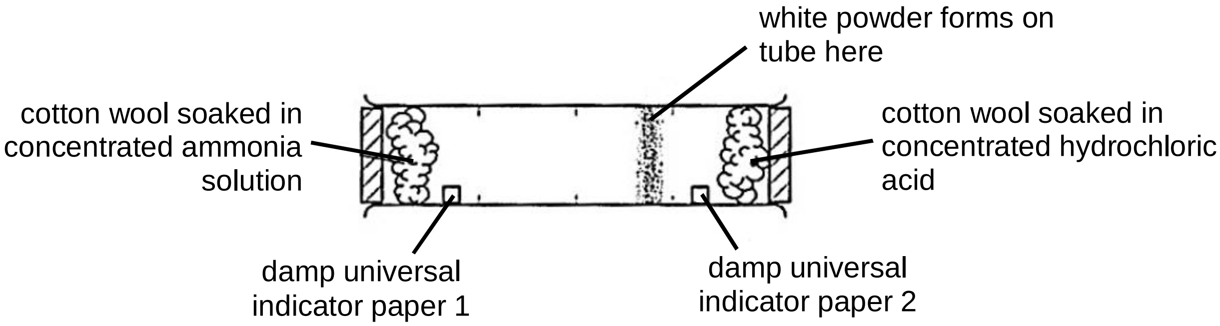
$$R_f \text{ value} = \frac{\text{distance travelled by food colour C}}{\text{distance travelled by the solvent}}$$

Food colour C is …………………………………………..

[2]

[Total: 5]

A3 An experiment was set up to investigate the movement of gaseous ammonia and gaseous hydrogen chloride.



(a) The white powder forms on the tube due to the reaction between gaseous ammonia and gaseous hydrogen chloride to produce solid ammonium chloride.

Insert the correct symbol in the equation to show that this reaction is reversible.

$NH_3 + HCl \; \boxed{} \; NH_4Cl$ [1]

(b) The tube contains two pieces of Universal Indicator paper.

Complete Table 3.1 to show the colours and pH values of each piece of paper at the end of the experiment.

Table 3.1

Universal Indicator paper	colour	pH
1		
2		

[2]

(c) Explain why the white powder does not form at the centre of the tube.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..[3]

[Total: 6]

A4 Strontium-88 has three other isotopes.

Figure 4.1 is the mass spectrum that shows the relative abundance of each isotope.

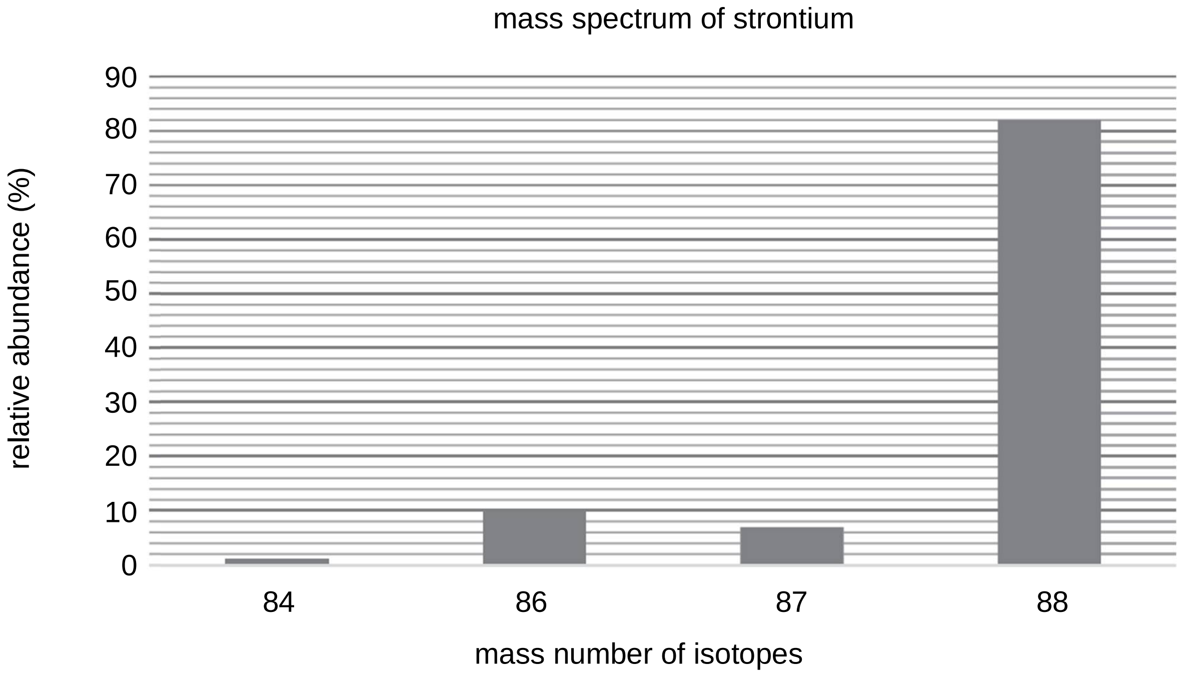


Fig. 4.1

(a) Calculate the relative atomic mass of strontium.

Show your working clearly.

[2]

(b) 180 g of strontium-88 burns in oxygen to form 245 g of strontium peroxide.

Show that the empirical formula of strontium peroxide is SrO_2.

[2]

(c) The reaction between strontium and oxygen is a redox reaction.

$$Sr + O_2 \rightarrow SrO_2$$

Oxygen acts as an oxidising agent in the reaction.

Use ideas about oxidation state to explain that the statement is true.

……

……

……[2]

(d) Strontium also forms strontium superoxide, $Sr(O_2)_2$, with oxygen.

Determine the formula for a superoxide ion.

……[1]

[Total: 7]

A5 Astatine, At, is an element in Group VII of the Periodic Table.

It exists as diatomic molecules similar to the other elements in the same Group.

Two isotopes of astatine are known to exist : astatine-210 and astatine-211.

It reacts with calcium (Ca) to form the compound calcium astatide.

symbol	number of protons	number of neutrons	number of electrons
$^{85}_{210}At$			
$^{85}_{211}At$			

(a) Complete the table above. [2]

(b) Using astatine-210 and astatine-211 as examples, describe **one** similarity and **one** difference in terms of the particles in their nucleus.

……

……

……[2]

(c) Draw the ‘dot-and-cross’ diagram for astatine.

Show outer electrons only.

[1]

(d) Draw the “dot-and-cross” diagram of calcium astatide.

Show outer electrons only.

Hence, write the chemical formula of this compound.

Chemical formula of calcium astatide : …………………………. [3]

(e) Suggest whether the melting and boiling point of calcium astatide will be higher or lower than that of astatine.

Explain your answer.

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

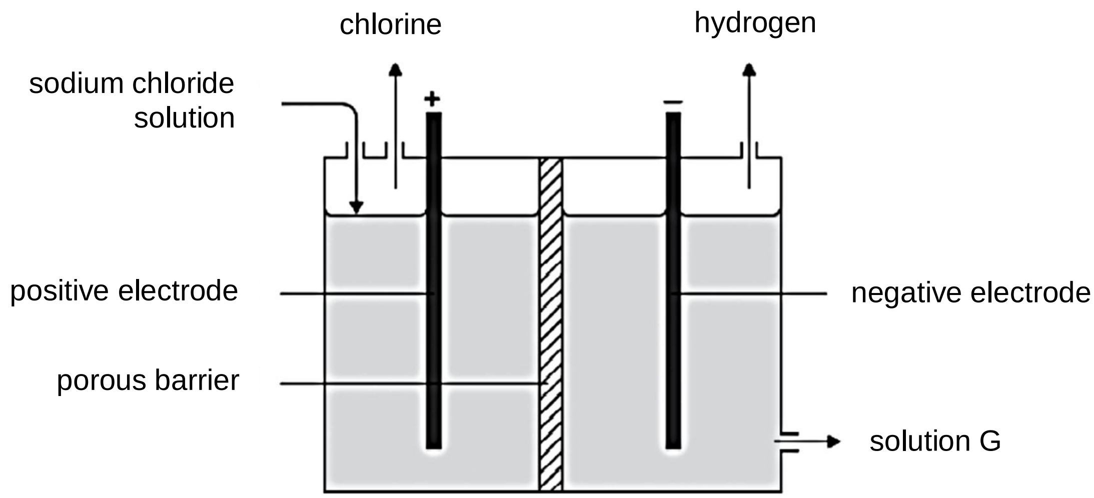
…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

……………………………………………………………………………………………………[3]

[Total: 11]

A6 The electrolysis of concentrated sodium chloride solution is an industrial process which produces three products: chlorine, hydrogen and solution G.



(a) Graphite electrodes are used in the electrolysis.

Explain, in terms of bonding, why graphite conducts electricity.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….[2]

(b) Solution G is alkaline.

Name solution G and explain how it is produced in the electrolysis.

Solution G is ……………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….[2]

[Total: 4]

A7 In the early 19th century, a chemist, Frederich Wohler, was the first to isolate aluminium metal.

At a high temperature, potassium was reacted with aluminium chloride to form potassium chloride and aluminium.

Today's chemists would classify this reaction as a redox reaction.

(a) Construct a balanced chemical equation for the reaction.

……………………………………………………………………………………………………[1]

(b) Explain why this reaction is classified as a redox reaction, in terms of electron transfer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

(c) Suggest if sodium can be used in place of potassium. Give a reason for your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

[Total: 5]

A8 **(a)** Methanol, ethanol and propanol are organic compounds.

Table 8.1 shows the enthalpy change of combustion (ΔH) when 1 mole of each compound is completely burnt in oxygen.

Table 8.1

compound	molecular formula	boiling point / °C	ΔH / $kJmol^{-1}$
methanol	CH_4O	65	– 700
ethanol	C_2H_6O	78	– 1350
propanol	C_3H_8O	97	– 2000

(i) State **two** pieces of evidence from the table which show that methanol, ethanol and propanol belong to the same homologous series of alcohols.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(ii) Butanol is the fourth member of the alcohol homologous series.

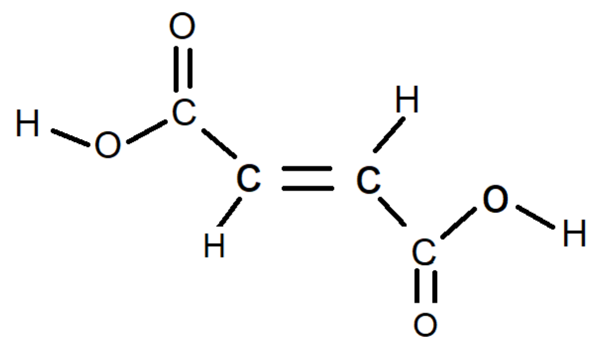
Predict the amount of energy released when 1 mole of butanol is completely burnt, giving evidence in your answer.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..[1]

(b) Fumaric acid is a colourless solid which can be extracted from plants.

The full structural formula of fumaric acid is shown below.



(i) Describe how a sample of fumaric acid can be differentiated from ethanol.

…………………………………………………………………………………………………….

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..[2]

(ii) Draw the structural formula of a repeating unit of the polymer which is made when fumaric acid reacts with ethane-1,2 diamine, $H_2N(CH_2)_2NH_2$.

Name the linkage formed.

Name of linkage = …………………………………..[2]

[Total: 7]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 **Solubility of Compounds**

The solubility of a compound, at a certain temperature, is the maximum number of grams of the compound which dissolve in 100 grams of water at that temperature. The relationship between solubility and temperature can be expressed by a solubility curve. The solubility curves of some compounds are shown in Figure 9.1.

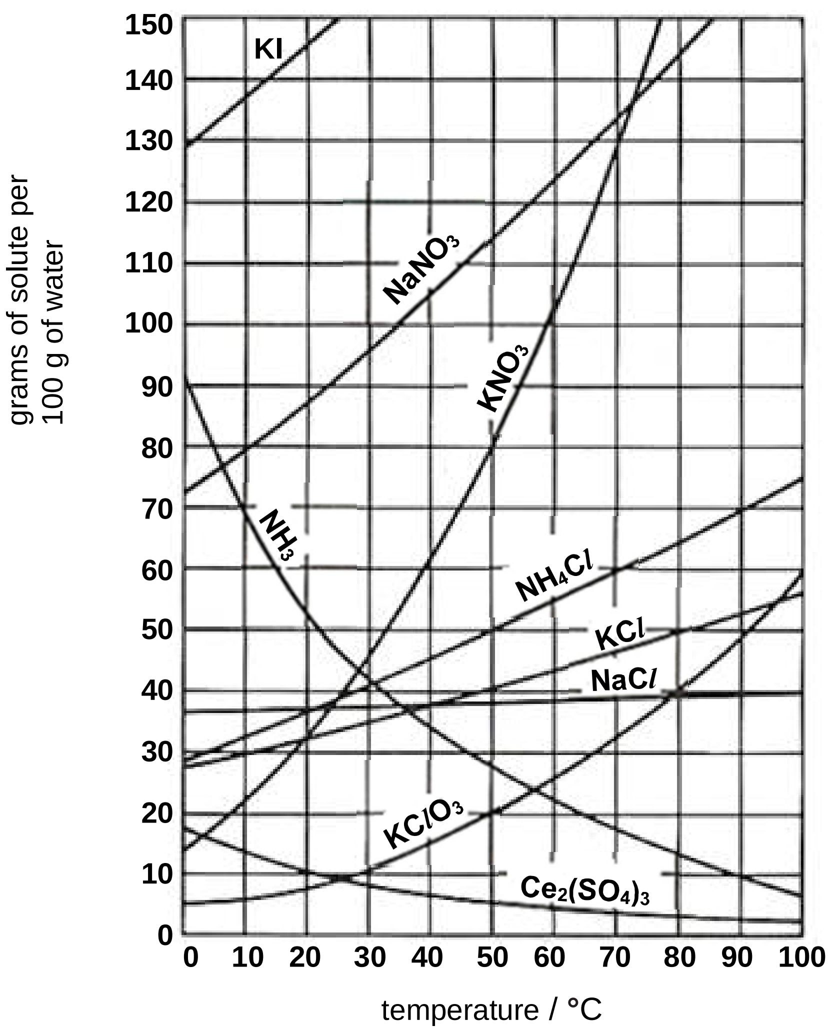


Fig. 9.1

Sparingly Soluble Ionic Compounds

The dissolving and precipitating of ionic compounds are phenomena that occur both within us and around us. For example, the dissolving of enamel on teeth in acidic solutions causes tooth decay; the precipitation of certain salts in our kidneys produces kidney stones; the precipitation of calcium carbonate from underground water forms stalactites and stalagmites inside caves. Although solids of ionic compounds are generally known to be soluble in water, some ionic solids have low solubility. Such ionic compounds are said to be sparingly soluble in water.

Ionic compounds such as sodium chloride, NaC*l*, are generally soluble in water. Some ionic solids such as silver chloride, AgC*l*, are only sparingly soluble (soluble to a small extent) in water.

The solubility of ionic compounds depends on two factors.

1 The forces of attraction between the water molecules and the ions of the solid;

2 The forces of attraction between the cations and anions of the solid.

If factor 1 is greater than factor 2, the ionic compound will dissolve in water.

Figure 9.2 shows what happens when sodium chloride dissolves in water.

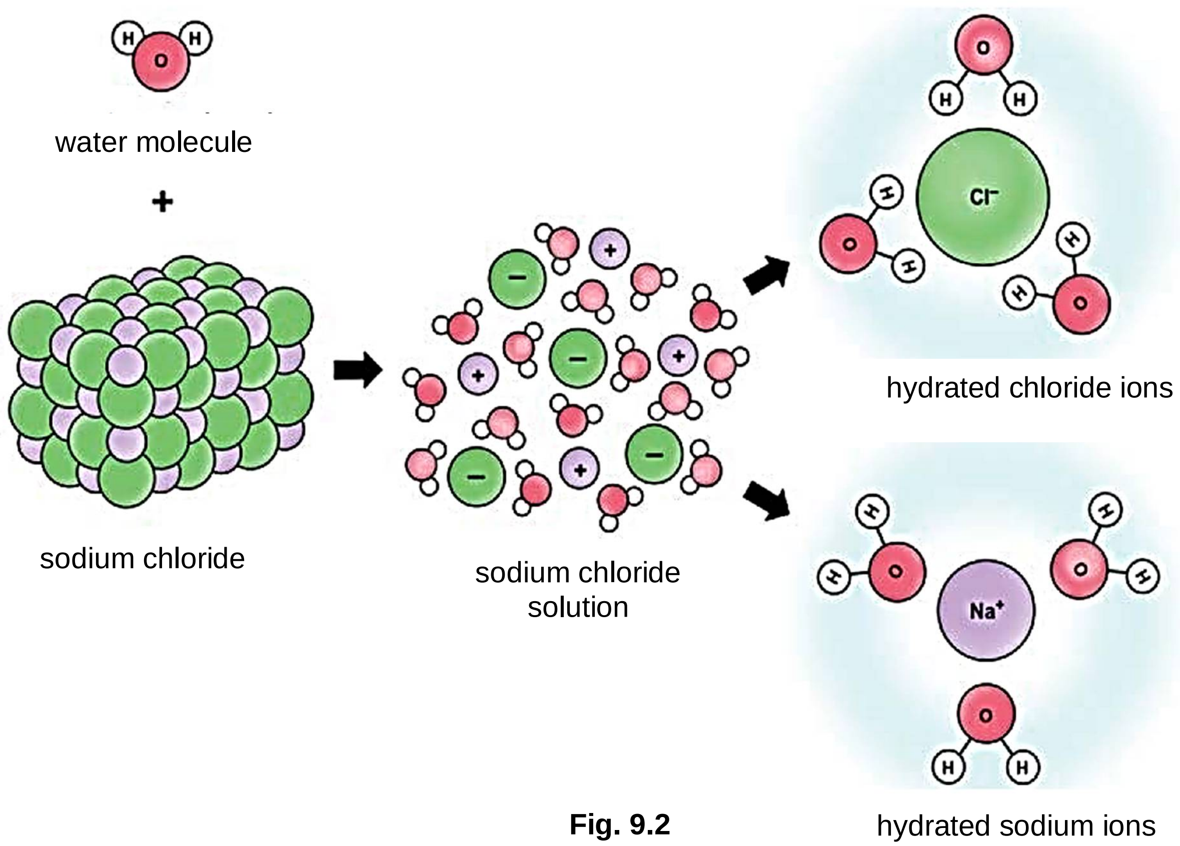


Fig. 9.2

The solubility of sparingly soluble ionic compounds can be estimated from its solubility product, K_{sp}, which is only affected by temperature. The higher the K_{sp} value, the more soluble the compound will be.

Table 9.1 below shows the K_{sp} values of some common ionic compounds.

Table 9.1

compound	chemical formula	K_{sp} (mol^2/dm^6) at 25°C
barium sulfate	$BaSO_4$	1×10^{-10}
calcium carbonate	$CaCO_3$	5×10^{-9}
calcium sulfate	$CaSO_4$	2×10^{-5}
silver chloride	AgC*l*	2×10^{-10}

Predicting Precipitation

By comparing the K_{sp} value and **ionic product** of a compound, we can predict whether precipitation of a certain compound will occur when two solutions are mixed together.

The **ionic product** is the product of the concentration of cation and anion present in the mixed solution.

For instance, when a sparingly soluble salt like barium sulfate dissolves in water, it dissociates into Ba^{2+} and SO_4^{2-} according to the equation below.

$$BaSO_4\,(s) \rightarrow Ba^{2+}\,(aq) + SO_4^{2-}\,(aq)$$

Ionic product = [concentration of Ba^{2+} ions in solution] x [concentration of SO_4^{2-} ions in solution]

Table 9.2 below shows whether precipitation will occur when comparing ionic product and K_{sp} of a compound.

Table 9.2

Types of solution	**Outcome**
ionic product = K_{sp}	No precipitation. Solution is saturated. No more solute can dissolve.
ionic product < K_{sp}	No precipitation. More solute can dissolve.
ionic product > K_{sp}	Precipitation occurs

(a) **(i)** In Figure 9.1, why do the solubility curves not go beyond 100 °C?

....[1]

(ii) From the solubility curves in Figure 9.1, identify the compound which is the least soluble at 90°C.

....[1]

(iii) If 200 g of a saturated solution of potassium nitrate at 50 °C was evaporated to dryness, what mass of potassium nitrate would remain?

[2]

(b) By comparing the two factors affecting solubility as described in the question, explain why sodium chloride is very soluble in water while silver chloride is only sparingly soluble.

……

……

……

……

……

……

……[2]

(c) Sodium sulfate is another soluble ionic compound.

By referring to Figure 9.2, draw a similar diagram to the hydrated sodium ion or hydrated chloride ion to show a hydrated sulfate ion.

[1]

(d) Predict the relationship between temperature and K_{sp} value of an ionic compound.

……

……[1]

(e) 0.02 mol/dm^3 of calcium nitrate solution is added to the same volume of 0.005 mol/dm^3 sodium sulfate solution at 25 °C.

(i) Name the sparingly soluble compound that is formed.

…………………………………………………………………………………………………[1]

(ii) Using the information from Table 9.1 and Table 9.2, determine, by calculation of the ionic product in **part (e)(i)**, if precipitation will occur.

[2]

(f) Without further addition of any reagent, suggest how the amount of solid precipitated out from a saturated solution can be increased.

………………………………………………………………………………………………………..….[1]

[Total: 12]

B10 Water can be broken down into hydrogen and oxygen by electrolysis. The equation is shown below.

$$2H_2O\ (l) \rightarrow 2H_2\ (g) + O_2\ (g) \qquad \Delta H = +\ 484\ kJ/mol$$

(a) Complete the energy profile diagram for the electrolysis of water.

Your diagram should include :

- the reactants and products.
- the activation energy.
- the enthalpy change.

[4]

(b) Complete the table.

Fuel	enthalpy change when 1 mol of H_2 is completely burned in kJ/mol	enthalpy change when 1 kg of H_2 is completely burned in kJ/kg
Hydrogen, H_2		

[2]

(c) Some people think hydrogen is a clean fuel.

Do you agree with the statement? Explain your answer.

………..

………..[2]

[Total: 8]

Either

B11 The rate of reaction between a metal and bromine can be studied using the apparatus in Figure 11.1.

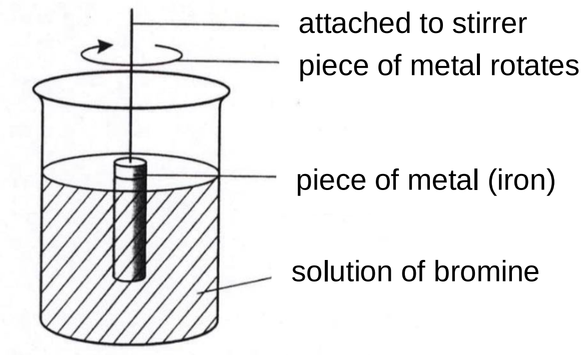


Fig. 11.1

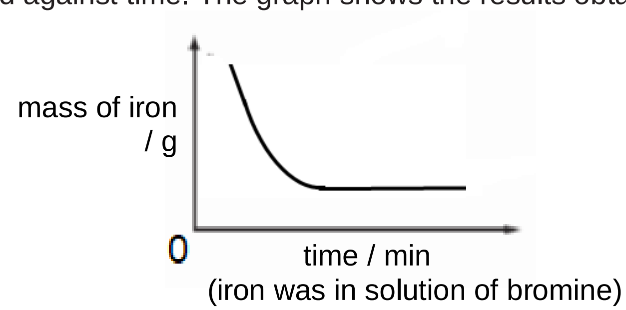
A cylindrical piece of iron, was weighed and placed in the solution as shown above.

The iron was removed at regular intervals and the stopwatch was paused.

The piece of iron was washed, dried, weighed and then placed in the solution again.

The stopwatch was restarted and the reaction continued.

The mass of iron was plotted against time. The graph shows the results obtained.



(a) Explain the shape of the graph.

……

……

……

…………………………………………………………………………………………………..[3]

(b) How would the rate of reaction change if the cylindrical piece of iron was hammered to form a flat sheet of iron and placed in the bromine solution?

Explain your answer.

……

…………………………………………………………………………………………………..[2]

(c) The experiment was conducted using two solutions of bromine of equal volume but different concentration.

A piece of iron with equal mass was placed in each solution.

The mass of the iron was measured at one minute intervals.

Table 11.1 shows the loss in mass of the iron after one minute.

Table 11.1

experiment	concentration of bromine solution	loss in mass of iron after one minute
1	0.05 mol/dm^3	10 mg
2	0.10 mol/dm^3	20 mg

Explain, in terms of collisions between particles, the difference in the results obtained.

……..

……..

……..[2]

(d) Iron also reacts with iodine solution.

Predict the loss in mass of iron after one minute if 0.05 mol/dm^3 of iodine solution of equal volume was used instead of bromine solution.

Suggest a reason for your answer.

Loss in mass of iron = ………..……… mg

……

……..[1]

(e) Iron is heated with bromine gas to form iron(III) bromide.

$$2Fe + 3Br_2 \rightarrow 2FeBr_3$$

Calculate the minimum mass of iron required to react completely with 12 dm^3 of bromine gas.

[2]

[Total: 10]

Or

B11 One of the components in crude oil is undecane, $C_{11}H_{24}$.

This molecule may be broken down to give 2 molecules of butene and one other product.

The reaction is carried out in the oil refinery.

(a) What is the name of this type of reaction?

………..[1]

(b) Construct a balanced chemical equation for this reaction.

………..[1]

(c) Name the other product formed, besides butene.

………..[1]

(d) When the reaction is carried out, 1.00 mol of undecane gives 50.4 g of butene.

Calculate the percentage yield of butene.

[2]

(e) Butene can exist as 3 isomers. One isomer of butene is shown in Figure 11.1.

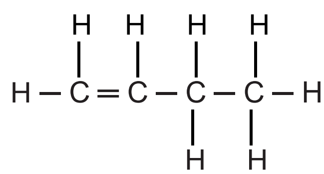


Fig. 11.1

Draw the structures of the other **two** isomers of butene.

[1]	[1]

(f) The isomers of butene can undergo addition polymerisation.

Draw the structure of the polymer formed by any **one** of the isomers in **part (e)**, showing three repeating units.

[1]

(g) Butanol is manufactured by the reaction between steam and butene.

Two isomers of butanol are formed at the same time.

These two isomers are miscible (can mix).

Suggest, with reason, a method suitable for separating the components of the mixture of products

method : ……………………………………………………………………………………………………

reason : ……………………………………………………………………………………………………

………[2]

[Total: 10]

END OF PAPER

For Examiner's Use

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Select elements from the list to answer the following questions.

You may use each element once, more than once or not at all.

aluminium

argon

carbon

copper

iodine

iron

lead

nitrogen

oxygen

sulfur

(a) Which element has an ion which, in aqueous solution, reacts with aqueous sodium hydroxide to give a red-brown precipitate?

.... [1]

(b) Which element has an atom with an electronic configuration with only five electron shells?

.... [1]

(c) Which **two** elements form amphoteric oxides?

.... [1]

(d) Which element is used as a catalyst in the Haber Process?

.... [1]

(e) Which element provides an inert atmosphere in the manufacture of steel?

.... [1]

(f) Which element produces ammonia when it is warmed with an aqueous mixture of sodium nitrate and sodium hydroxide?

.... [1]

[Total: 6]

A2 Ammonium iodide, NH_4I, is a white solid which decomposes when heated.

$$NH_4I(s) \rightarrow NH_3(g) + HI(g)$$

(a) A small sample of ammonium iodide is heated in a test-tube.

Describe how you would know when all the ammonium iodide has decomposed.

....

.... [1]

(b) Calculate the **total** volume of gas, measured at room temperature and pressure, formed when 2.90 g of ammonium iodide is completely decomposed.

[3]

(b) Aqueous ammonium iodide reacts with three halogens, fluorine, chlorine and bromine, but not with astatine.

(i) Write a general equation to show the reaction of ammonium iodide with a halogen. Use X_2 as the symbol for the halogen.

.... [1]

(ii) Explain why aqueous ammonium iodide has no reaction with astatine.

.... [1]

(c) Solid ammonium iodide does not conduct electricity.
Aqueous ammonium iodide conducts electricity.

Explain these observations.

....

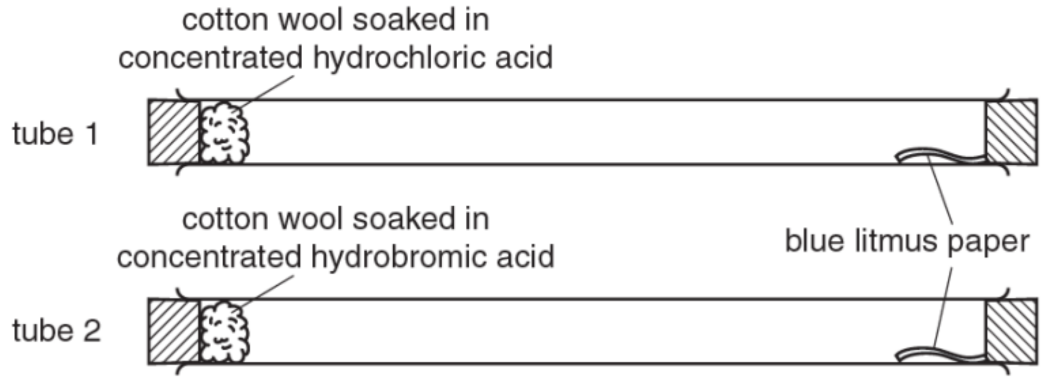
....

.... [2]

[Total: 8]

For Examiner's Use

A3 **(a)** Two students set up an experiment to investigate the rate of diffusion of gases.



Concentrated hydrochloric acid produces fumes of hydrogen chloride, HCl.
Concentrated hydrobromic acid produces fumes of hydrogen bromide. HBr.

The students made the following observations:

Four minutes after setting up the experiment, the litmus paper in tube 1 turns red.
Seven minutes after setting up the experiment, the litmus paper in tube 2 turns red.

One of the students makes this conclusion:

'The rate of diffusion is inversely proportional to the relative molecular mass of each gas.'

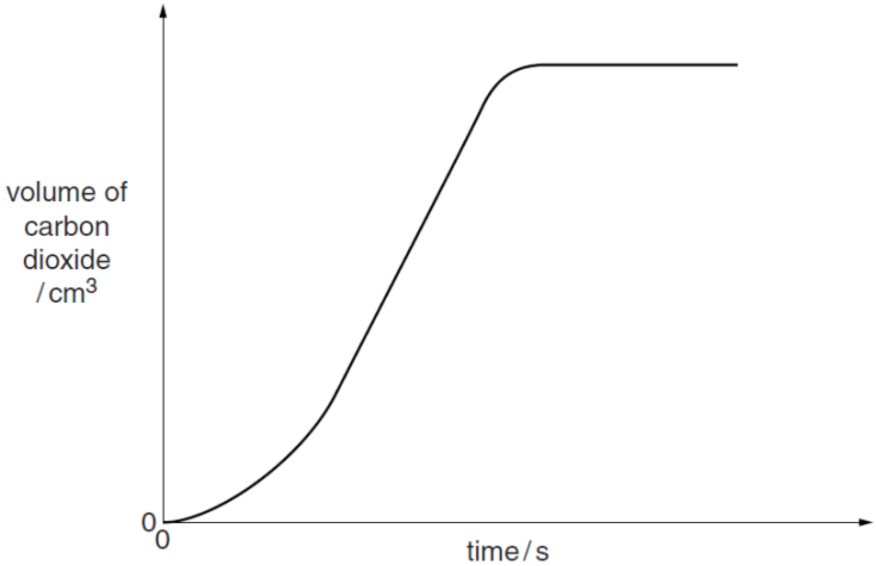
Do the observations support this conclusion? Show by means of a calculation.

[3]

(b) The students conducted another experiment to investigate the rate of decomposition of three metal carbonates, $CaCO_3$, $FeCO_3$ and $ZnCO_3$.

An equal mole of each metal carbonate is heated in a test-tube. The total volume of carbon dioxide formed is measured every 10 seconds, and the results are plotted.

The diagram shows the **typical** shape of the graph for all the metal carbonates.



(i) Suggest why the volume of carbon dioxide does not increase by very much when each metal carbonate is first heated.

.... [1]

(ii) How is the graph used to find out when the decomposition has finished?

.... [1]

The table shows the results.

metal carbonate	time taken for complete decomposition / s
$CaCO_3$	360
$FeCO_3$	60
$ZnCO_3$	70

(iii) Predict and explain the time it would take $MgCO_3$ and $PbCO_3$ to fully decompose.

$MgCO_3$ .... s

$PbCO_3$ .... s

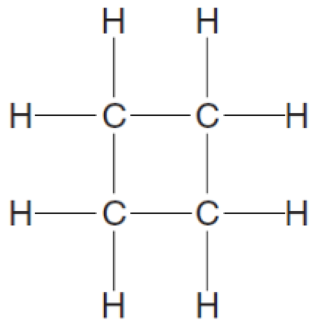
explanation ....

.... [3]

[Total: 8]

For Examiner's Use

A4 **(a)** Cyclobutane is an organic compound with the following structure.



The complete combustion of one mole of cyclobutane releases 2702 kJ of heat energy.

(i) Calculate the heat energy released when 600 dm^3 of cyclobutane, at room temperature, and pressure, is completely combusted.

[2]

(ii) Explain, in terms of the energy changes associated with bond breaking and bond making, why the combustion of cyclobutane is exothermic.

....

....

....

.... [2]

(iii) Cyclobutane has several isomers which are alkenes.

Draw the structure of **one** of these isomers.

[1]

(b) Sorrel is a small green plant.

Sorrel plants contain a poisonous carboxylic acid **Y.**

(i) What can be deduced about the chemistry of **Y** from each of the following pieces of information?

When **Y** is warmed with acidified potassium manganate(VII), the solution changes from pink to colourless.

……………………………………………………………………………………

……………………………………………………………………………………

A 0.1 mol/dm^3 solution of **Y** has a pH of 5 whereas a 0.1 mol/dm^3 hydrochloric acid solution has a pH of 1.

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Analysis of 10.0 g of carboxylic acid **Y** shows that it contains 2.67 g carbon, 0.220 g hydrogen and 7.11 g oxygen.

The relative molecular mass of **Y** is 90.

Deduce the empirical formula and the molecular formula of **Y**.

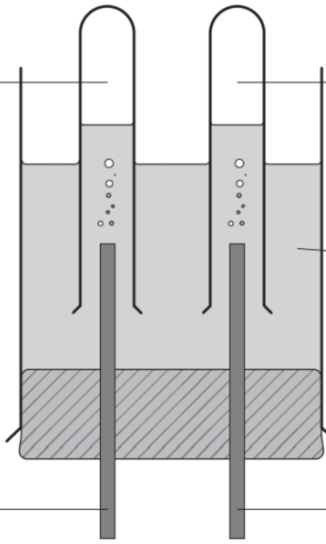
empirical formula …………………………….

molecular formula ……………………………. [3]

[Total: 10]

For Examiner's Use

A5 (a) The diagram shows the apparatus that a student sets up for the electrolysis of **concentrated** sodium chloride solution.



Explain why

(i) hydrogen, and **not** sodium, is formed at the cathode.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) equal volumes of chlorine and hydrogen gas are produced.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

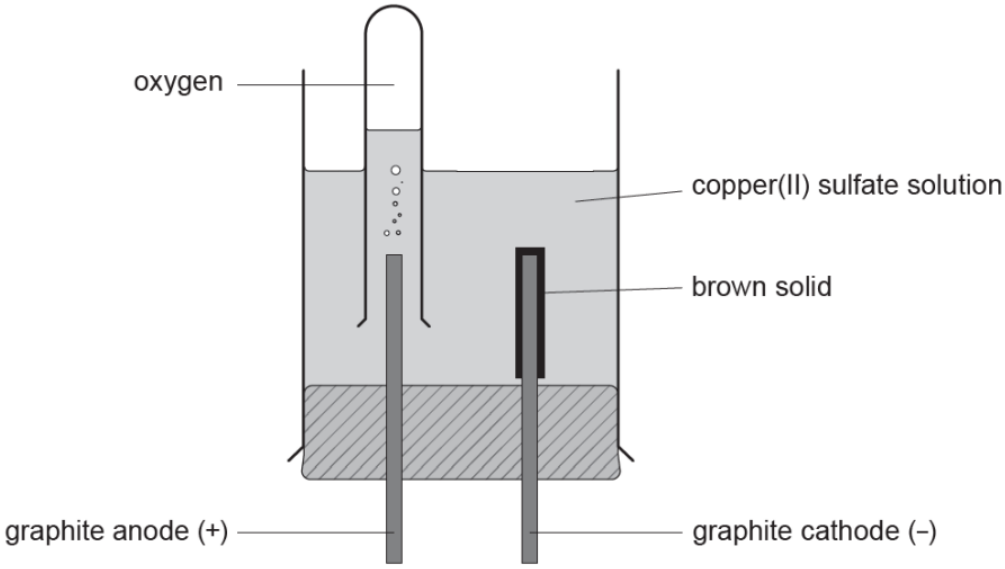
(iii) the Universal Indicator turns purple during the electrolysis.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

For Examiner's Use

(b) The student modifies the apparatus for the electrolysis of copper(II) sulfate solution.



(i) Explain, using the reaction occurring at the cathode, the meaning of the term *reduction*.

.... [1]

(ii) Over time, the electrolyte turns from blue to colourless. State one change the student could make to the apparatus so that the electrolyte remains blue during the electrolysis. Give a reason for your answer.

....

....

....

.... [2]

[Total: 6]

For Examiner's Use

A6 **(a)** Global warming is believed to be mainly the result of increasing levels of carbon dioxide in the atmosphere.

(i) How is the balance of carbon dioxide and oxygen maintained in the atmosphere? Explain why levels of carbon dioxide are increasing and how this leads to global warming.

……………………………………………………………………………………………

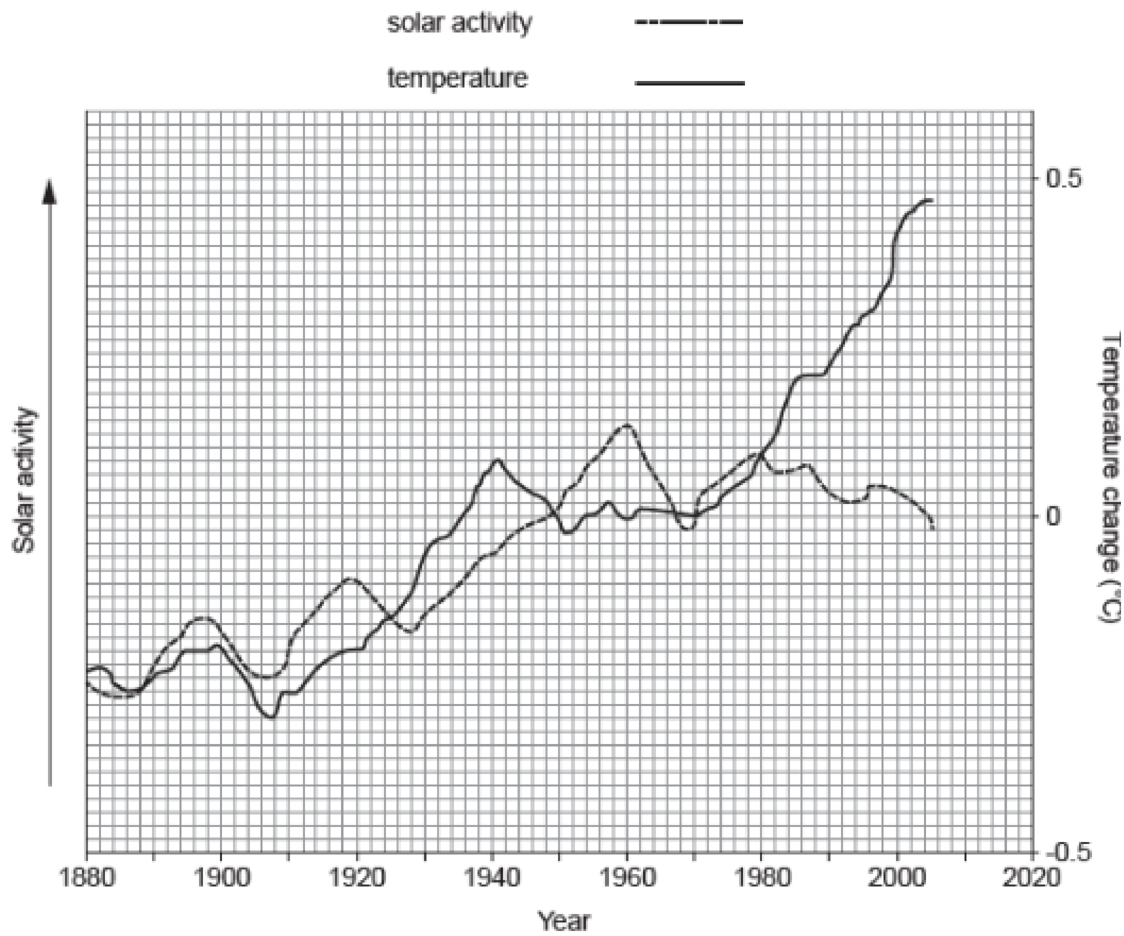
……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(ii) Some scientists believe that it is changes in solar activity (i.e. changes in the brightness and warmth of the sun) that causes global warming. The graphs below show the changes in solar activity and atmospheric temperature from 1880 to 2020.



Using the information from the graphs, describe how well the evidence supports the argument that solar activity is the cause of global warming.

……………………………………………………………………………………………

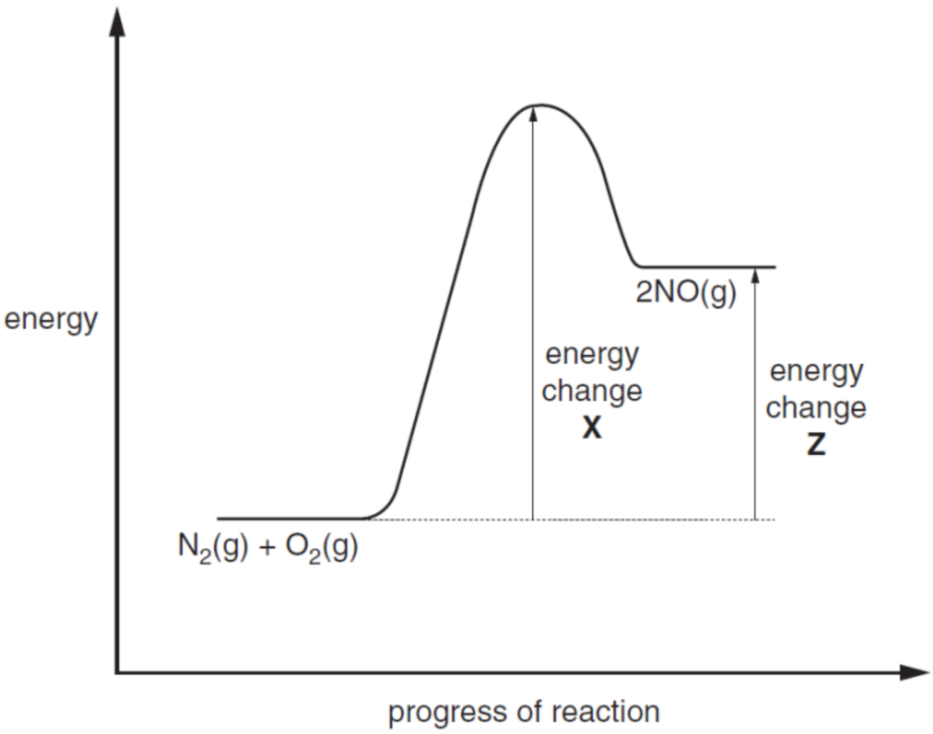
…………………………………………………………………………………………… [2]

For Examiner's Use

(b) Oxides of nitrogen are atmospheric pollutants. Nitrogen monoxide, NO, is formed in an internal combustion engine when nitrogen and oxygen react together.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

The diagram shows the energy profile for this reaction.



(i) Identify the energy changes **X** and **Z**.

X is ……………………………………………

Z is …………………………………………… [2]

(ii) Explain how you can tell from the diagram that the reaction is endothermic.

………………………………………………………………………………………

……………………………………………………………………………………… [1]

For Examiner's Use

(c) The exhaust system of a motor car is fitted with a catalytic converter.

When nitrogen monoxide passes through the converter, it reacts with carbon monoxide.

$$2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$$

The catalyst increases the rate of this reaction.

(i) Explain how the catalyst in the converter increases the rate of this reaction.

.... [1]

(ii) During the course of a journey, 2.4 dm^3 of nitrogen monoxide was produced by the engine.

Calculate the volume of nitrogen gas produced if all the nitrogen monoxide reacted in the converter.

[1]

(iii) In reality, only 1.0 dm^3 of nitrogen was produced after the gases had passed over the catalytic converter. Calculate the percentage of nitrogen monoxide that had reacted.

[2]

[Total: 12]

Section B

Answer all **three** questions from this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

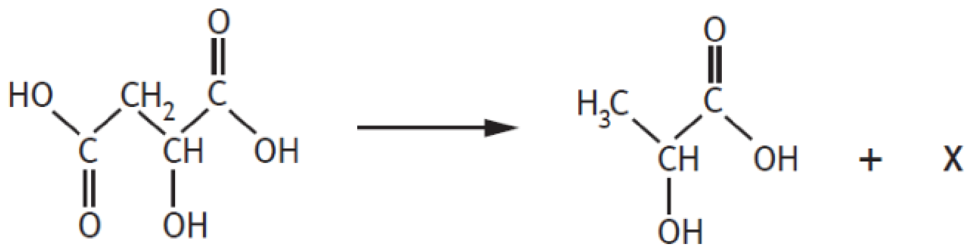
B7 Cider is made from apples in a process that involves crushing and pressing the apples, converting the sugars into alcohol, maturing and bottling.

Brewers add yeast, which contains enzymes to convert the glucose in the apples into an alcohol and carbon dioxide.

The alcohol content in the cider can be calculated using the formula:

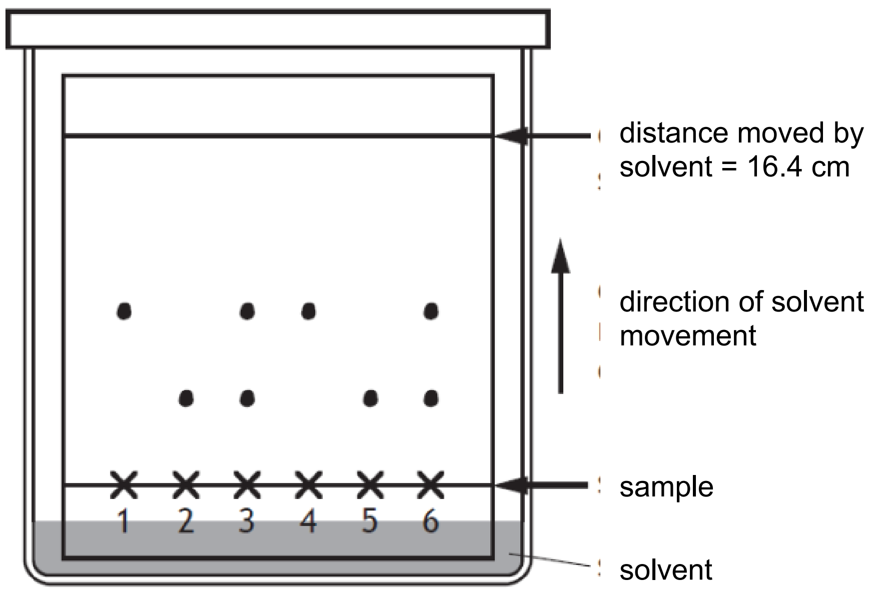
$$\%\,\text{mass of alcohol} = \frac{\text{mass of alcohol}}{\text{mass of cider}} \times 100$$

During the maturing process, malic acid in the apples is converted to lactic acid and another product, X.



The maturing process is complete when all of the malic acid has been converted to lactic acid, and the cider is now ready to be bottled.

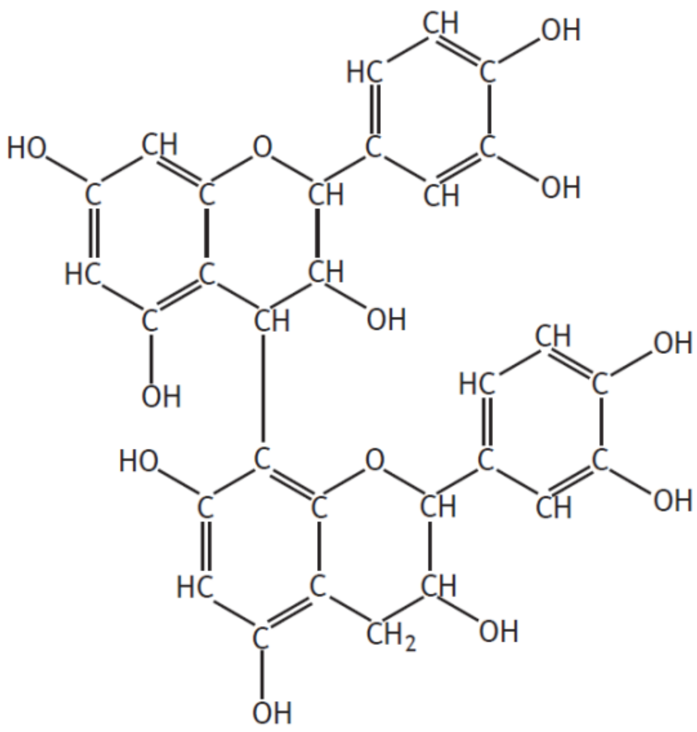
The maturing process in cider samples can be monitored using thin layer chromatography. Samples of lactic acid, malic acid and four ciders A, B, C, and D are applied on a silica plate and the solvent allowed to travel up the plate. The chromatogram obtained is shown.



For Examiner's Use

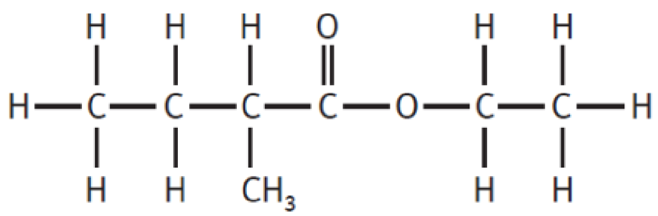
number	sample applied	distance travelled by spot(s) in cm
1	lactic acid	8.2
2	malic acid	4.1
3	cider A	4.1, 8.2
4	cider B	8.2
5	cider C	4.1
6	cider D	4.1, 8.2

Cider contains many naturally occurring compounds that affect taste and aroma. Procyanidin B2 provides a bitter taste to cider.



procyanidin B2

Cider smells of apples because it contains ethyl 2-methylbutanoate.



ethyl 2-methylbutanoate

For Examiner's Use

(a) Brewers add yeast, which contains enzymes to convert the glucose in the apples into an alcohol and carbon dioxide.

What is another role of the enzymes?

.... [1]

(b) A 50·0 cm^3 sample of cider was found to contain 3.05 g of alcohol.
1·0 cm^3 of the cider weighed 1.36 g.

Use this data and the formula in the passage to calculate the alcohol content in the cider.

[1]

(c) During the maturing process, malic acid is converted to lactic acid and another product, X. Identify X.

.... [1]

(d) **(i)** Calculate the R_f value of malic acid, to 2 decimal places.

[1]

(ii) Use the data in the passage to determine which cider, A to D, is ready to be bottled.

Give your reasoning.

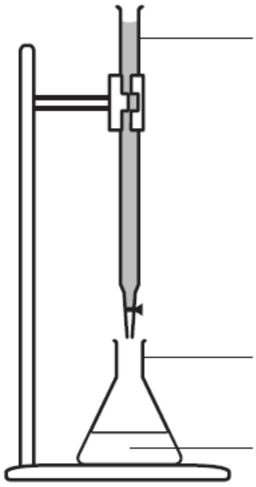
....

....

.... [2]

For Examiner's Use

(e) The following apparatus can be used to compare the level of bitter taste in ciders A to D.



Describe and explain how the comparison can be made, stating any assumption you make.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [4]

(f) Draw the structural formula of the alcohol and the carboxylic acid used to make ethyl 2-methylbutanoate.

alcohol

carboxylic acid

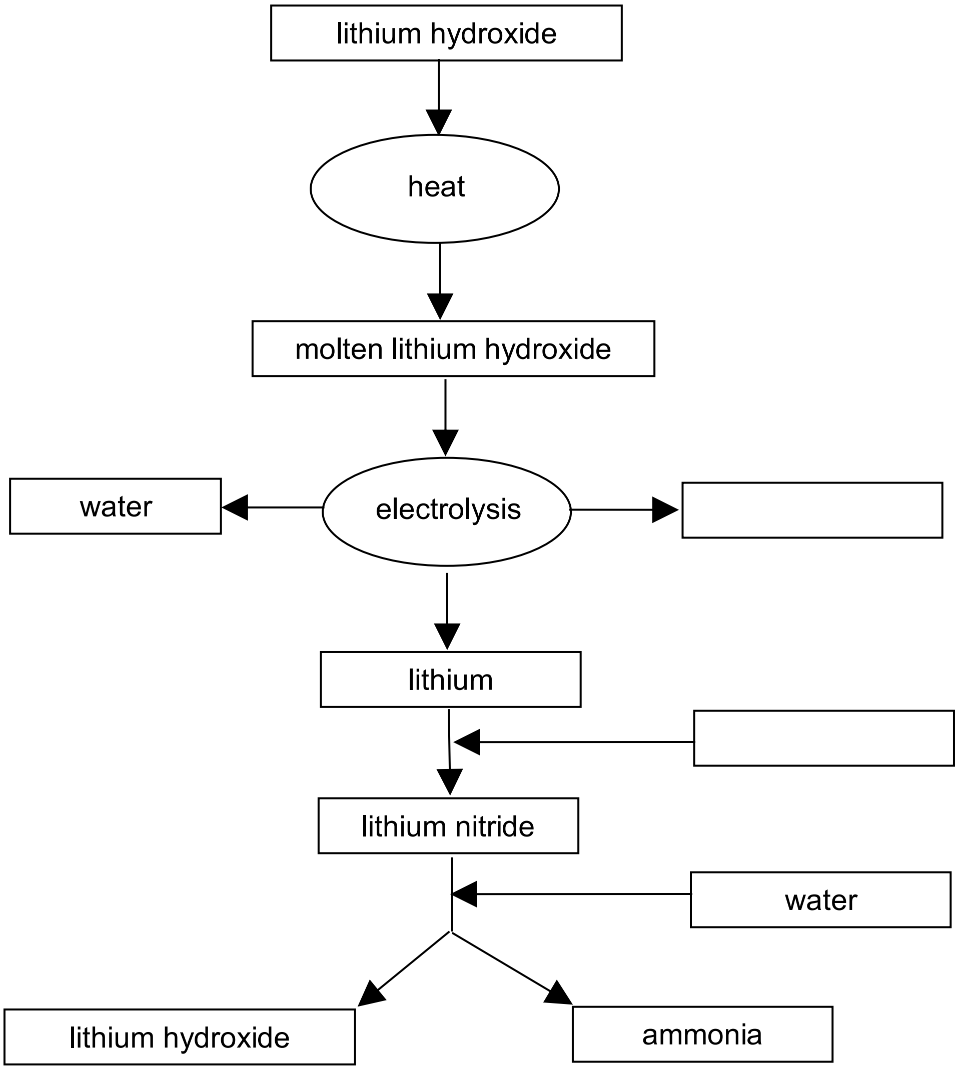
[2]

[Total: 12]

For Examiner's Use

B8 Scientists are developing an alternative industrial process to produce ammonia, which is more efficient than the Haber process.

This process involves the electrolysis of molten lithium hydroxide to produce lithium, water and oxygen. Lithium is then reacted with nitrogen gas, which is obtained from air, to produce lithium nitride (Li_3N). Ammonia and lithium hydroxide are produced when lithium nitride reacts with water.



(a) Complete the **two** boxes in the flow chart using the information provided. [1]

(b) Write an ionic equation for the **cathode** in the electrolysis of molten lithium hydroxide.

.... [1]

For Examiner's Use

(c) Draw 'dot-and-cross' diagrams to show the bonding in lithium nitride (Li_3N) and nitrogen (N_2).

Show outer electrons only.

[4]

(d) Write a chemical equation for the making of ammonia from the reaction between lithium nitride and water.

…………………………………………………………………………………………..…. [1]

(e) By drawing an arrow on the flow chart, suggest how the process is managed to keep waste products to a minimum. [1]

[Total: 8]

For Examiner's Use

EITHER

B9 **(a)** Oil tankers transport crude oil.

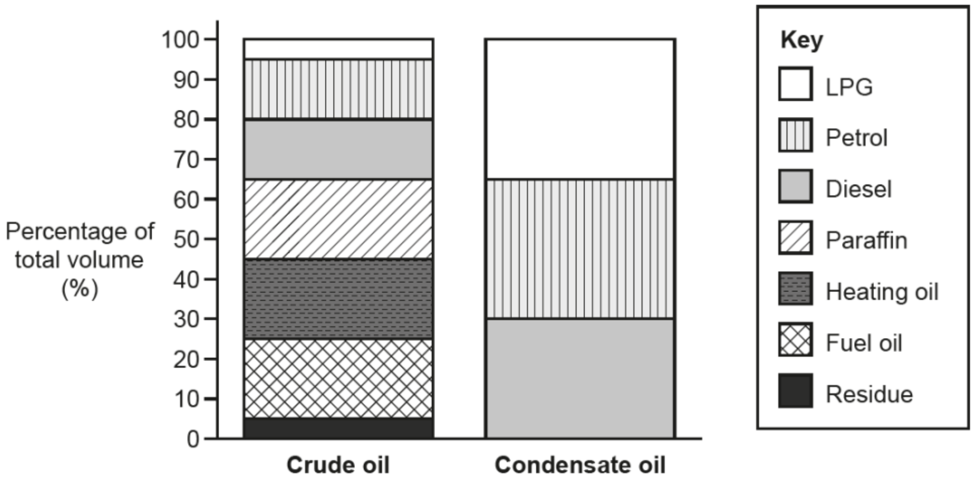
Occasionally they may be involved in an accident and catch fire as shown.

Explain why the burning hydrocarbons in the oil produce thick black smoke.

....

.... [2]

(b) Some ships carry condensate oil, rather than crude oil.
The figure shows the composition of fractions in crude oil and condensate oil.



Outline **one** similarity and **one** difference between crude oil and condensate oil.

....

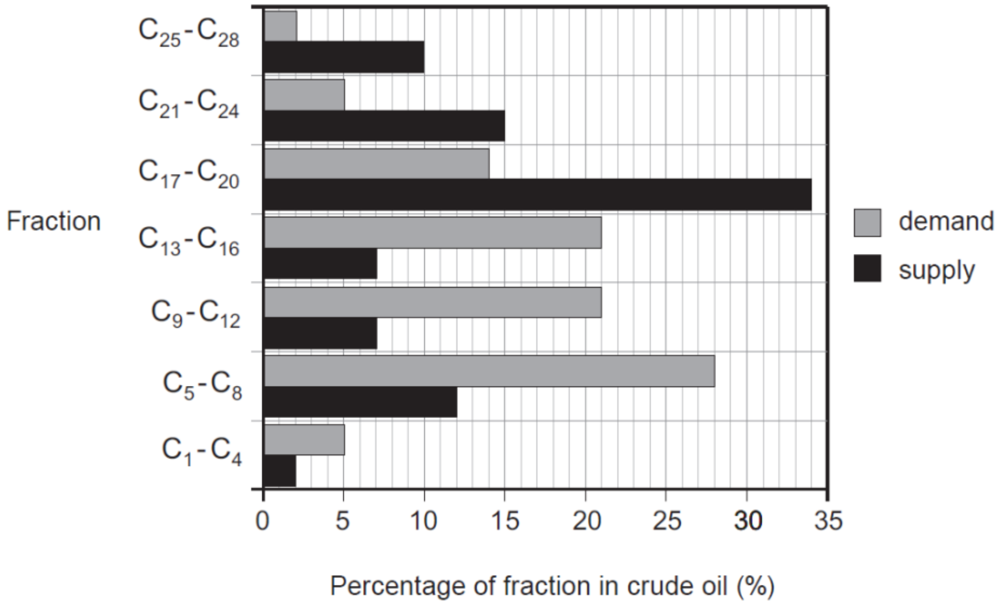
....

....

.... [2]

For Examiner's Use

(c) The bar chart shows the relative supply and demand for some fractions obtained from crude oil.



Use the bar chart to describe how the **difference** between supply and demand of the fractions changes as chain length of the molecules increases.

....

....

.... [2]

(d) Oil companies have solved the problem of the over-supply of some fractions by cracking.

$C_{14}H_{30}$ can be cracked to form C_6H_{12}, butane and ethene in a cracking tower.

(i) Construct a **balanced** equation for this reaction.

.... [1]

(ii) 1.00 tonne of $C_{14}H_{30}$ entered a cracking tower.

After the reaction, 0.212 tonne of ethene had been made. Show that the percentage yield of ethene is 75%. (1 tonne = 10^6 g)

[3]

[Total: 10]

For Examiner's Use

OR

B9 **(a)** On Anglesey, an island off the north-west coast of Wales, there is a large copper mine called Parys Mountain. Unwanted rock from the mining process has been dumped forming waste tips. As rainwater passes through the waste tips it dissolves copper salts. One of the salts is copper(II) sulfate.

During the 18th century large shallow pits were dug all over the mountain. These filled with rainwater. Scrap iron was placed into the water and after a few months, the pits were drained and a copper-rich solid sludge was collected.

Describe and explain the reaction taking place in the pits. Include a relevant **ionic** equation and use your equation to explain which is the reducing agent.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [4]

(b) Many metal ores contain sulfides. Chalcocite is an important copper ore which contains copper(I) sulfide, Cu_2S.

Copper can be obtained from the ore by heating in air.

A reaction takes place as follows.

$$Cu_2S + O_2 \rightarrow 2Cu + SO_2$$

When the extraction process was carried out with 20.5 tonnes of chalcocite, only 12.3 tonnes of copper was formed.

For Examiner's Use

(i) Show that the percentage purity by mass of copper(I) sulfide in the ore is 75%. (1 tonne = 10^6 g)

[4]

(ii) Describe an atmospheric pollution problem associated with this method of copper extraction.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

[Total: 10]

End of Paper

YISHUN SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
SECONDARY 4 EXPRESS

CANDIDATE NAME				
CLASS		INDEX NUMBER		

CHEMISTRY **6092/02**
Paper 2 **29 August 2022**
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either/or.
Write your answers in the spaces provided.

Electronic calculators may be used.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page **20**.

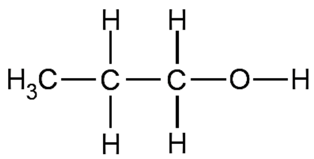
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **20** printed pages.

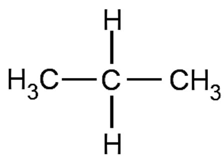
Section A

Answer **all** questions in this section in the space provided.
The total mark for this section is 50.

A1 The diagrams can be used to represent the structures of some organic compounds.



A



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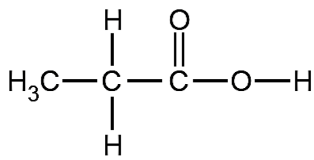

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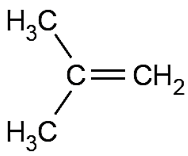

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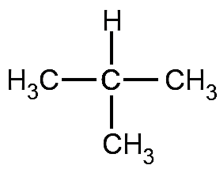

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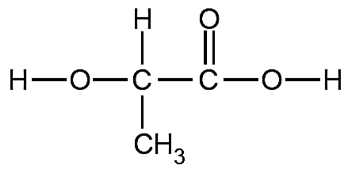
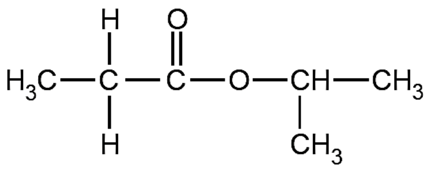


F



G

Each compound may be used once, more than once or not at all.

(a) State which compound:

(i) has a molecule with only 14 atoms

....[1]

(ii) can be oxidised to form propanoic acid

....[1]

(iii) is an isomer of butane

....[1]

(iv) reacts with steam to make an alcohol

....[1]

(b) State which **two** compounds in aqueous solution turn blue litmus red.

....[1]

[total: 5]

A2 This question is about ammonia.

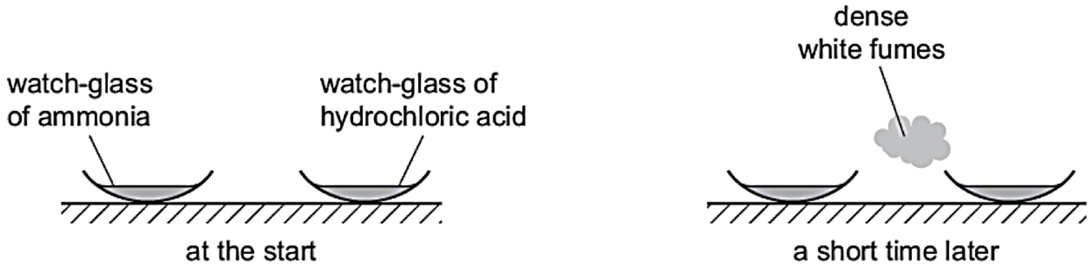
(a) When ammonia gas reacts with hydrogen chloride gas, white fumes of ammonium chloride are formed.

$$NH_3 + HCl \rightleftharpoons NH_4Cl$$

Watch-glasses of aqueous ammonia and concentrated hydrochloric acid were placed near each other on a table.

At first no white fumes were seen.

After a short time, white fumes were seen between the watch-glasses.



Explain these observations using kinetic particle theory.

....

....

....

....

....

....[3]

(b) Ammonia is produced by reacting nitrogen gas and hydrogen gas during the Haber process.

(i) State the conditions required for the Haber process.

....[1]

(ii) Since nitrogen is the most abundant gas in air, explain why air is **not** used as a raw material during the Haber process.

....

....

....

....[2]

(c) Concentrated aqueous ammonia is used to make fertilisers such as ammonium sulfate, $(NH_4)_2SO_4$.

Aqueous ammonia reacts with dilute sulfuric acid.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_2(aq)$$

A student titrates 20.0 cm^3 of aqueous ammonia with 0.150 mol/dm^3 sulfuric acid.

10.5 cm^3 of sulfuric acid is required to neutralise the aqueous ammonia.

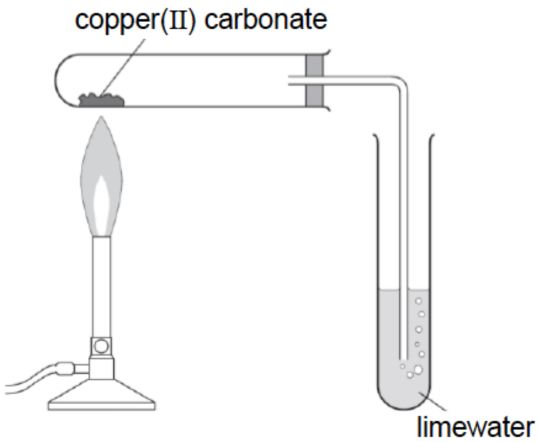
Calculate the concentration, in mol/dm^3, of the aqueous ammonia.

[3]

[total: 9]

A3 A student investigated the rate of a reaction using the apparatus and materials as shown.

He also noted observations at regular time interval during heating.



time interval / min	observations
0 – 1	A slow release of bubbles. No change observed in limewater. The solid in the test tube was green.
1 – 2	A fast release of bubbles. A change was observed in limewater at 1 minute 10 seconds. The solid turned black.
2 – 3	No release of bubbles. The solid in the test tube remained black after cooled.

(a) Explain the student's observation between

(i) zero and first minute

………

……[1]

(ii) first and second minute

………

………

……[2]

(iii) second and third minute

………

………

……[2]

(b) Explain how the observations would differ from the decomposition of copper(II) carbonate if the same number of moles of calcium carbonate is heated.

………

………

………

………

……[3]

[total: 8]

A4 Table 4.1 shows some properties of *oxyacids* of chlorine.

Table 4.1

name of acid	chemical formula	reaction with magnesium (all acids have the same concentration)	oxidation state of chlorine
hypochlorous acid	$HClO$	only a few bubbles seen	
chlorous acid	$HClO_2$	reacts readily	
chloric acid	$HClO_3$	vigorous	
perchloric acid	$HClO_4$	very vigorous	

(a) Suggest why these acids are known as *oxyacids*.

....

....[2]

(b) Complete the table by filling in the oxidation states of chlorine. [2]

(c) State the relationship between the oxidation state of chlorine in the formula and the strength of the acid. Justify your answers with reference to Table 4.1

....

....

....

....[2]

(d) Suggest a method, beside observations, the student could use to follow the rate of the reaction.

....

....[2]

[total: 8]

A5 Oxides of nitrogen are atmospheric pollutants. Nitrogen monoxide, NO, is formed in combustion engines when nitrogen and oxygen react together.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

Fig. 5.1 shows the energy profile for this reaction.

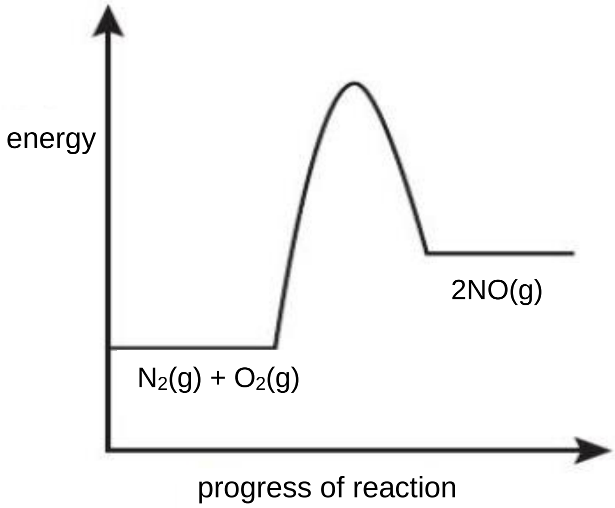


Fig. 5.1

(a) Label clearly on Fig. 5.1 the reaction enthalpy change and the activation energy on the energy profile diagram. [2]

(b) The reaction between nitrogen and oxygen is endothermic.

(i) Explain how you can tell from the diagram that the reaction is endothermic.

....[1]

(ii) The year 2019 proved to be one of the hottest years on record in Singapore, with the annual mean temperature hitting 28.4 °C.
Describe and explain how a hotter day affects the activation energy of the formation of nitrogen monoxide in combustion engines.

....

....

....

....[2]

(c) Cars have catalytic converters fitted to reduce pollution problems caused by some of the exhaust gases.

Write an equation to show one exhaust gas is converted to a harmless substance within the catalytic converter.

…………………………………………………………………………………………………...…[1]

[total: 6]

A6 Two metal electrodes and an electrolyte can be used to produce electrical energy.

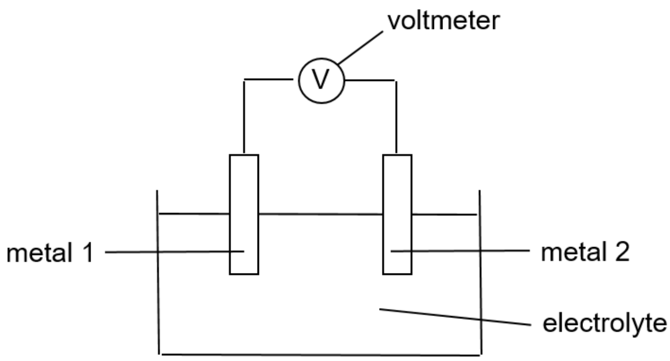


Table 6.1 shows the voltage produced by some cells when different metals are used.

Table 6.1

cell	metal 1	metal 2	voltage / V
1	copper	zinc	1.10
2	copper	magnesium	2.72
3	silver	zinc	1.56
4	silver	iron	1.25

(a) In which direction does the electrons flow in the external wire of cell 3?

……………………………………………………………………………………………………..[1]

(b) In terms of the reactions that take place in the cells, explain why the voltage of cell 2 is higher than cell 1.

……………………………………………………………………………………………………......

……………………………………………………………………………………………………......

……………………………………………………………………………………………………......

……………………………………………………………………………………………………..[2]

(c) Suggest the voltages that will be produced when the following metals are used.

metal 1	metal 2	predicted voltage / V
copper	iron	
silver	magnesium	

[2]

(d) In cell 1, the student observed that the mass of zinc electrode decreases while the mass of copper remains when the electrolyte used is sodium chloride. However, when the electrolyte is changed to copper(II) chloride, the mass of copper electrode increases. Explain these observations.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………..[3]

[total: 8]

A7 Table 7.1 shows the R_f values of pure substances, **A**, **B**, **C**, **D** and **E**. where chromatography was carried out in separate experiments using two different solvents, **X** and **Y**.

Table 7.1

	Substance				
Solvent	**A**	**B**	**C**	**D**	**E**
X	0.50	0.78	0.15	0.50	0.32
Y	0.98	0.00	0.50	0.65	0.32

(a) State which of the substances is insoluble in solvent **Y**. Explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………..[2]

(b) Using chromatography, a mixture was found to contain substances **A**, **D** and **E**.
Suggest which solvent was used to obtain the results. Explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………..[1]

[Turn over

(c) A chromatography of five substances was carried on the same chromatogram with both solvents **X** and **Y**.

The chromatogram was first run using solvent **X**. It was then turned 90° on its side where a second chromatogram using solvent **Y** was run.

On the chromatogram on Fig. 7.1,

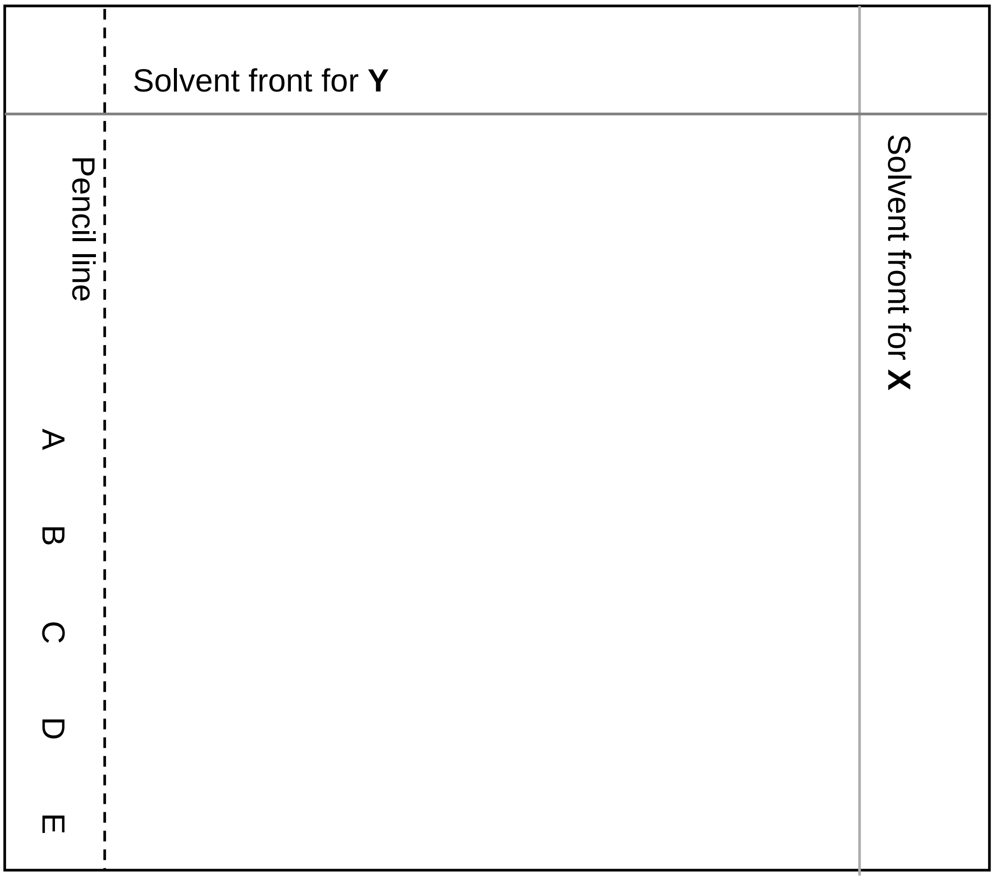


Fig. 7.1

(i) Mark with a "**B**" where you would find the final spot formed by substance **B**. [1]

(ii) Mark "**E**' where you would find the final spot formed by substance **E**. [1]

(d) The use of a locating agent was required in the chromatography experiments.

Explain why a locating agent is used.

....

....[1]

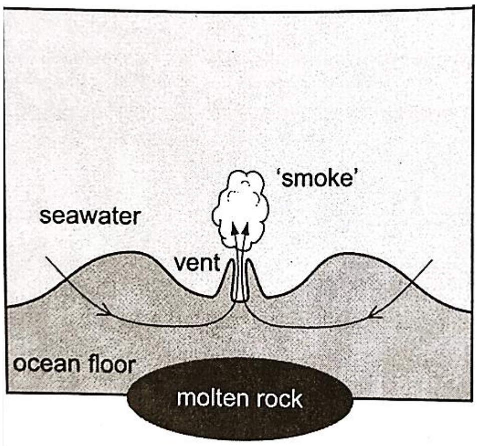
[total: 6]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 This question is about the chemistry of reactions occurring in hydrothermal vents that are found on the ocean floor.



The diagram shows a hydrothermal vent. Seawater flows through the rocks in the ocean floor and is heated by molten rock below the surface. It then flows back out into the ocean through the hydrothermal vent, producing a cloud of 'smoke' consisting of precipitated solids.

The chemical composition of the water coming out of the vents is different from normal seawater.

Table 8.1 shows a typical composition of both types of water.

Table 8.1

	normal seawater	hydrothermal vent water
temperature / ^{o}C	2	350
pH	7.8	4.3
concentration of ions / x 10^{-3} mol/dm^3		
Cl^-	531	539
Na^+	450	419
Mg^{2+}	51.2	0.0
SO_4^{2-}	27.1	0.0
HCO_3^-	2.3	5.7
Ca^{2+}	9.9	15.1
K^+	9.5	22.5
Fe^{2+}	0.0	1.62
Mn^{2+}	0.0	0.93
Cu^{2+}	0.0	0.03
NH_4^+	0.0	0.03
concentration of gases / x 10^{-3} mol/dm^3		
O_2	0.1	0.0
HCl	0.0	7.1
H_2S	0.0	1.7
CH_4	0.0	0.1
He	0.0	2 x 10^{-6}

[Turn over

(a) **(i)** State which ions are removed from the seawater by the hydrothermal vent.

……………………………………………………………………………………………………[1]

(ii) State which transition metal ions have been added to the water by the process.

……………………………………………………………………………………………………[1]

(b) An environmentalist made the following statement: "The decrease in the concentration of the hydrogen ions is only due to the increase in the temperature of the water."

Using relevant data from Table 8.1, explain why the statement made by the environmentalist is incorrect.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

(c) The 'smoke' contains a variety of metal sulfides, which are precipitated when the hot hydrothermal vent water meets the cold seawater.

In one reaction, iron(II) disulfide, FeS_2, is formed in a redox reaction from iron(II) ions and hydrogen sulfide.

$$Fe^{2+}(aq) + 2H_2S(aq) \rightarrow FeS_2(s) + H_2(g) + 2H^+(aq)$$

(i) Deduce which element is oxidised and which is reduced in this reaction.

oxidised …………………………. reduced …………………………….. [1]

(ii) Draw a 'dot-and-cross' diagram of hydrogen sulfide, showing the outer shell electrons only.

[2]

(d) Normal seawater contains the salt sodium hydrogen carbonate which can be prepared in the science laboratory as shown below.

In the first experiment, 25.00 cm^3 of 2.00 mol/dm^3 dilute hydrochloric acid solution is added to completely react with 25.0 of 1.00 mol/dm^3 aqueous sodium carbonate in a conical flask to produce sodium chloride, water and carbon dioxide gas as shown in the reaction.

$$2\,HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(g) + CO_2(g)$$

The above reaction is said to proceed via these two steps:

step 1	$HCl(aq) + Na_2CO_3(aq) \rightarrow NaHCO_3(aq) + NaCl(aq)$
step 2	$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2O(g) + CO_2(g)$

In a second experiment, 25.0 cm^3 of the same dilute hydrochloric acid solution is placed inside a conical flask.

You are given the same aqueous sodium carbonate that was used in the first experiment.

State the minimum volume of aqueous sodium carbonate to be added in order to produce maximum number of moles of sodium hydrogen carbonate.

....[1]

(e) The gas from a hydrothermal vent contains helium with a slightly lower relative atomic mass than is normally found in the Earth's atmosphere.

(i) Define the term *relative atomic mass*.

....

....[1]

(ii) The relative atomic mass of the helium from a particular vent is exactly 4.0025959.

The two naturally occurring isotopes of helium have the precise relative isotopic masses as shown in Table 8.2.

Table 8.2

isotope	relative isotopic mass
^{3}He	3.0160293
^{4}He	4.0026033

Calculate the percentage of ^{3}He in the mixture.

[2]

[total: 12]

B9 A precipitation reaction refers to the formation of an insoluble salt when two soluble salt solutions react. The insoluble salt that is produced is known as the precipitate. Barium hydroxide is an alkali solution which can be used in precipitation reaction. It has the following structure:

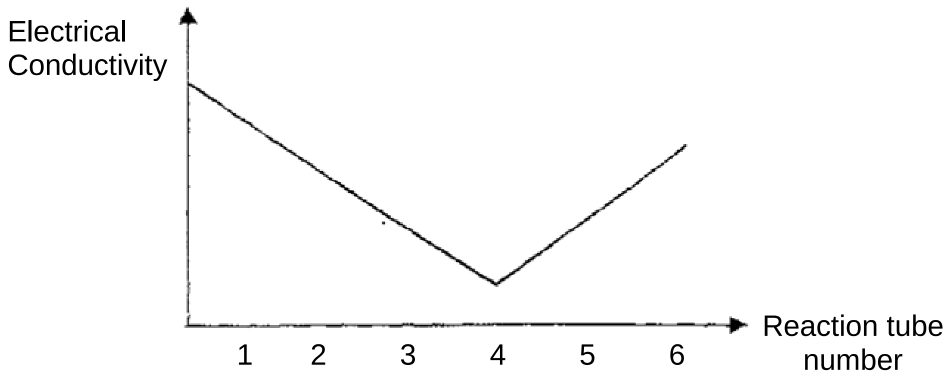
$$Ba^{2+}\ [H{-}O]^{-}\ [H{-}O]^{-}$$

A study of a precipitation reaction between barium hydroxide and dilute sulfuric acid was conducted. The reaction tubes containing different volumes of barium hydroxide and dilute sulfuric acid. Precipitation occurs in all the reaction tubes and after 20 minutes, the height of the precipitate in each tube is measured and recorded in Table 9.1.

Table 9.1

reaction tube	1	2	3	4	5	6
volume of 0.25 mol/dm^3 barium hydroxide used / cm^3	5.0	5.0	5.0	5.0	5.0	5.0
volume of 0.50 mol/dm^3 dilute sulfuric acid used / cm^3	1.0	1.5	2.0	2.5	3.0	3.5
height of precipitate / cm	2.5	3.0	3.5	4.0	4.0	?

The electrical conductivity of each reaction tube is recorded and shown in the graph.



(a) Write an ionic equation to represent the precipitation reaction.

…….[1]

(b) Draw a 'dot-and-cross' diagram to show the bonding in a hydroxide ion, showing the outer shell electrons only.

[2]

(c) Predict, with reason, the height of the precipitate and the colour of the Universal Indicator when added to reaction tube 6 after 20 minutes.

height of the precipitate ………………………………………………………………………..

colour of Universal Indicator ……………………………………………………………………..

reason ………………………………………………………………………………………………..

…………………………………………………………………………………………………...[2]

(d) Describe and explain the shape of the electrical conductivity graph.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………...[3]

[total: 8]

B10 Either

Table 10.1 shows some information on different types of plastics that are commonly used.

Table 10.1

	tensile strength (MPa)	density (g/cm^3)	number of years to break down the plastic
biopolymers	36	1.24	0.5
clear polystyrene	25	1.04	approximately 100
polycarbonates	55 – 75	1.20	1

Note: Tensile strength measures the resistance of a material to breaking under tension.

(a) **(i)** Explain why biopolymers and polycarbonate have been used to replace polystyrene as plastics.

....

....

....

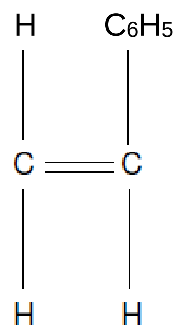
....[2]

(ii) Give one disadvantage of using biopolymers as a plastic container to store food.

....

....[1]

(b) Polystyrene is manufactured from phenylethene. The structure of phenylethene is shown.



(i) Explain how polystyrene could be obtained from phenylethene.

....

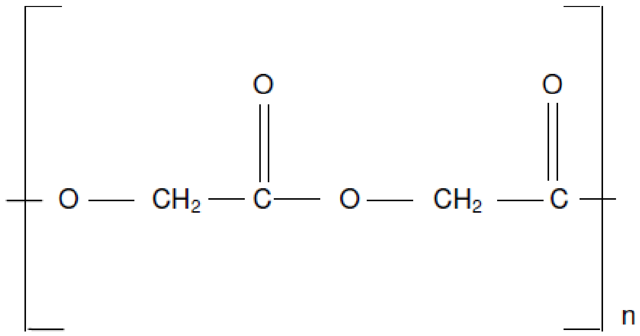
....

....[3]

(ii) Draw the structural formula of polystyrene, showing two repeat units.

[1]

(c) Biopolymers are renewable plastic materials manufactured from biomass such as corn, wheat, sugar cane and potatoes. An example of the structure of a type of biopolymer is shown below:



(i) With reference to the linkage, what type of polymer is this biopolymer?

……………………………………………………………………………………………[1]

(ii) Name one synthetic polymer that has a similar structure as this biopolymer.

……………………………………………………………………………………………[1]

(iii) The biopolymer in **(c)** can be broken down easily to its monomer.
Draw the structural formula of the monomer after the biopolymer is broken down.

[1]

[total: 10]

B10 **Or**

Both copper and magnesium are metals.

(a) Explain why magnesium reacts with hydrochloric acid but copper does not.

....

....[1]

(b) Brass is an alloy of copper and zinc. Table 10.2 shows how the composition of brass influences its relative strength.

Table 10.2

composition of brass		relative strength
% copper	% zinc	
90	10	2.6
80	20	3.0
70	30	3.3
60	40	3.6

How does the composition of brass affect its strength?

....

....[1]

(c) Use your knowledge of the structure of metals to explain why brass is stronger than pure copper. You may include a labelled diagram in your answer.

....

....

....

....[3]

(d) A 11.09 g sample of an oxide of copper contains 9,86 g of copper.
Deduce the empirical formula of this oxide of copper.

empirical formula ....[2]

(e) Water draining from the waste heaps around a copper mine is often blue due to the presence of hydrated copper(II) ions.

Describe and explain what would be observed if an iron bar is placed into a container filled with water containing hydrated copper(II) ions.

....

....

....

....

....

....[3]

[total: 10]

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

YUYING SECONDARY SCHOOL
PRELIMINARY EXAMINATION
Secondary 4 Express

NAME

CLASS 　　　　**REG. NO**

CHEMISTRY 6092/2

Paper 2

25 August 2022

1 hour 45 minutes

Setter: Mr Danny Louis

Candidates answer on the Question Paper.
Additional Materials: Nil

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on this question booklet.
Write in dark blue or black pen on both sides of the paper.
You may use a pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions in the spaces provided on the Question Paper.

Section B

Answer **all** the questions in this section in the spaces provided.
The last question is in the form either/or and only **one** of the alternatives should be attempted.
Write your answers in the spaces provided on the Question Paper.

The use of an approved calculator is expected, where appropriate.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 19.

For Examiner's Use	
Total	80

This document consists of **19** printed pages.

Section A

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 A list of gases is given below.

A	CO
B	NO
C	CH_4
D	SO_2
E	NH_3
F	CO_2

Use the letters **A**, **B**, **C**, **D**, **E** and **F** to answer the following questions. Each letter may be used once, more than once or not at all. [5]

(a) Which gas can be formed by lightning activity in the atmosphere? ____________

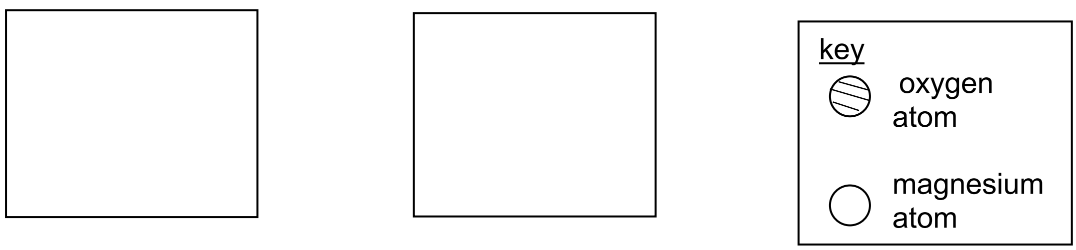
(b) Which is the lightest gas? ____________

(c) Which gas is formed by the decay of organic matter? ____________

(d) Which gas is used to reduce iron(**III**) oxide in the blast furnace? ____________

(e) Which gas turns damp red litmus paper blue? ____________

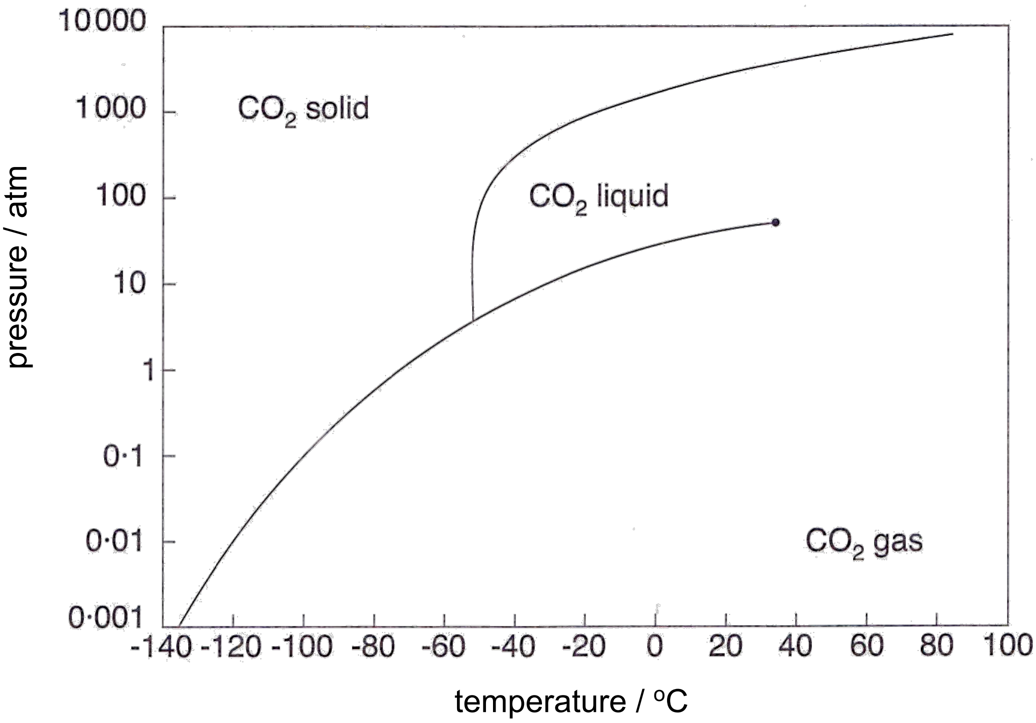
A2 A block of magnesium is burnt in oxygen to form magnesium oxide. Complete the diagrams below to show the arrangement of particles before and after the reaction. [2]



magnesium magnesium oxide

A3 The triple point of a pure substance is the temperature at which the substance can exist as a solid, liquid and gas at the same time.

The figure below shows the triple point of carbon dioxide.



(a) Mark the triple point of carbon dioxide on the figure with an 'X'. [1]

(b) A student is given carbon dioxide gas at room conditions (25 °C and 1 atm). Suggest how liquid carbon dioxide can be obtained by changing **one** of the conditions. [1]

___

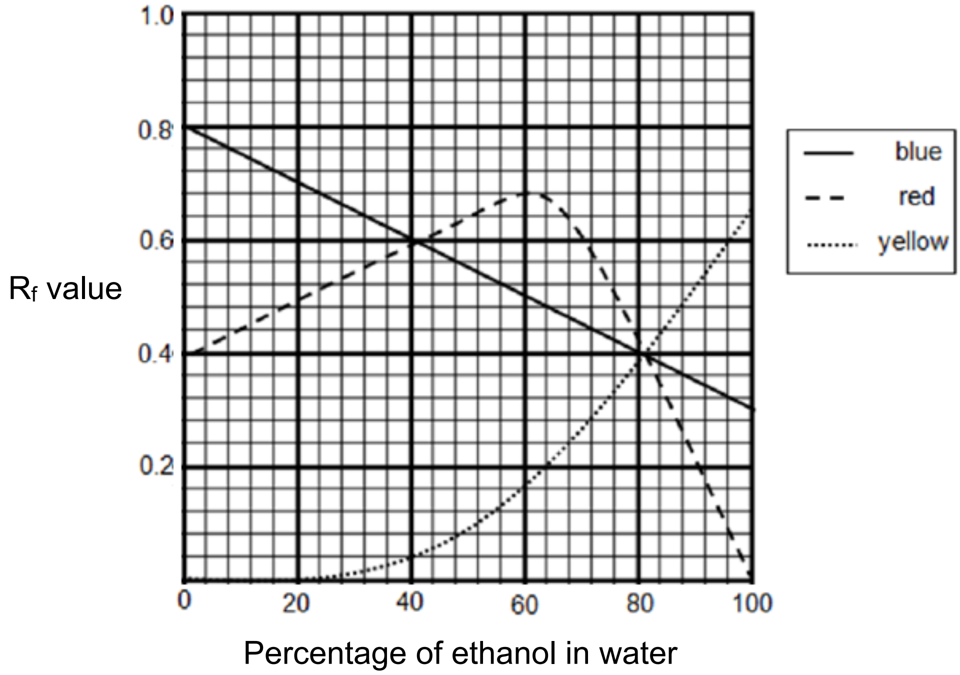
(c) Draw a 'dot-and-cross' diagram to show the electrons in a molecule of carbon dioxide. Show only the valence electrons in your diagram. [2]

(d) What type of oxide is carbon dioxide? State one property you would expect this oxide to have. [2]

___

___

A4 A sample of ink contains a mixture of red, blue and yellow dyes. To separate the dyes in the ink, the solvent used is a mixture of water and ethanol. The R_f values of the coloured dyes in solvents with different percentage of ethanol by volume in water are shown in the graph below.



Use the information above to answer the following questions.

(a) Explain why a pure solvent of either water or ethanol **cannot** be used to identify the dyes in the ink. [2]

____

____

____

____

(b) A mixture of water and ethanol was used to separate a sample of this ink. Only one spot was formed on the chromatogram. [1]
Explain why it **cannot** be concluded that the ink sample is a pure substance.

____

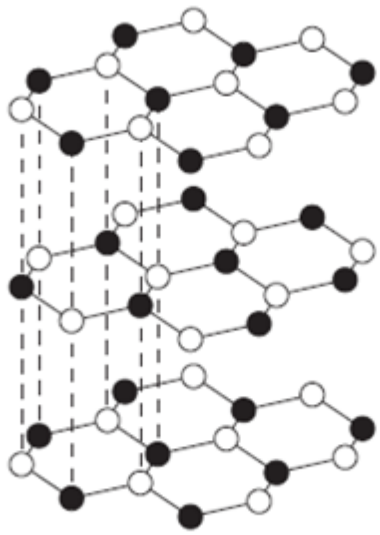
____

(c) What is the R_f value of the blue, red and yellow dye when a solvent mixture containing 90 cm^3 ethanol and 60 cm^3 water is used in the chromatography? [2]

blue: ____________ red: ____________ yellow: ____________

A5 Boron is in Group III of the Periodic Table and exhibits the properties of a non-metal. It reacts with nitrogen to form boron nitride. One form of boron nitride is the hexagonal form which has a structure similar to graphite as shown in the figure below.

Unlike graphite, hexagonal boron nitride does not conduct electricity.



Key:

● boron

○ nitrogen

(a) Explain why hexagonal boron nitride is unable to conduct electricity. [2]

____

____

____

____

(b) Hexagonal boron nitride is used in the making of lipsticks. Explain, in terms of the structure and bonding in hexagonal boron nitride, why it is suitable as the material for making lipsticks. [2]

____

____

____

____

(c) How would you expect the melting point of hexagonal boron nitride to be like? [1]

____

A6 Copper can react with either chlorine or bromine to form copper(II) halide.

$$Cu + Cl_2 \rightarrow CuCl_2$$

$$Cu + Br_2 \rightarrow CuBr_2$$

(a) Which statement(s) about the formation of copper(II) halide is/are true and which is/are false? [3]

Put a tick (✓) in one box in each row.

	true	false
The formation of copper(II) chloride is faster than that of copper(II) bromide.		
The number of electron shells of the halide increase by one after copper(II) halide is formed.		
The reactions are redox in nature.		

(b) Describe how a **pure and dry** sample of copper can be separated from a solid mixture containing copper(II) halide and copper. [2]

____

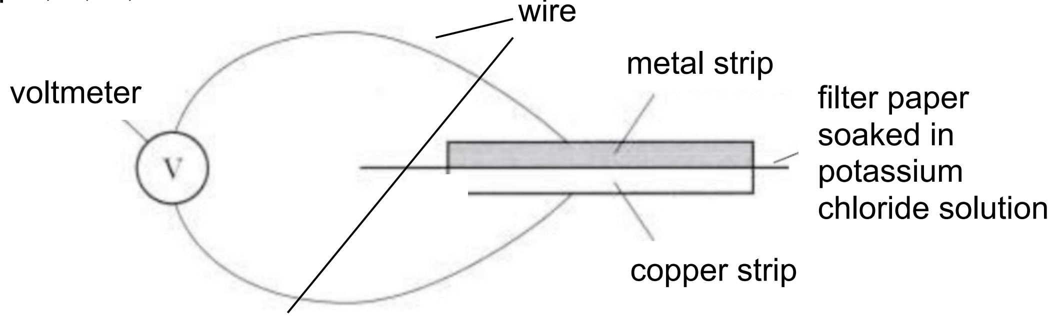
____

____

____

(c) 96 g of copper metal reacted with an excess of chlorine gas. What is the mass of copper(II) chloride formed? [2]

A7 The set-up below is used to determine the order of reactivity of five metals; copper, **P**, **Q**, **R** and **S**.



The results are summarised in the table below.

metal strip	direction of electron flow	voltage / V
P	from **P** to copper	0.52
Q	from copper to **Q**	0.33
R	from **R** to copper	1.51
S	from **S** to copper	1.25

(a) Arrange the five metals in order of increasing reactivity. [1]

____

(b) Given that metal **S** is from Group **II**, give two observations that will be seen when a piece of metal **S** is dipped in a solution of copper(**II**) sulfate. [2]

1. ____

2. ____

(c) When a zinc strip is used with the copper strip, the voltage is 1.10 V. Using this information, suggest with reasons, how metal **P** is extracted from its oxide. [2]

____

____

____

(d) The metal wires in the circuit are able to conduct electricity. With reference to the structure and bonding in metal, explain why metals are good conductors of electricity. [1]

____

____

A8 You are provided with bench reagents, Bunsen burner, test tubes and teat pipettes.

Using these chemicals and apparatus only, describe how you would distinguish between each of the following pairs of substances in the table below.

Include in your answers the expected observations for each substance in the given pair.

	substances	chemical test	expected observations	
(a)	aqueous sodium chloride and aqueous sodium sulfate			[2]
(b)	solid sodium carbonate and solid zinc carbonate			[3]

A9 Hydrocarbons such as alkanes and alkenes can undergo many different types of reactions.

(a) (i) What is the meaning of hydrocarbons? [1]

____

____

(ii) Write down the general formula of alkanes. ________________ [1]

(b) Alkanes can undergo cracking. During cracking, a mixture of compounds are produced. Under different temperature and pressure, various types of products can be produced.

An alkane, $C_{20}H_{42}$ undergoes cracking in the laboratory producing a gas and two alkenes, $C_{12}H_{24}$ and **X**.

(i) Write the chemical formula of **X**. ________________ [1]

(ii) Write the balanced chemical equation to show the cracking of $C_{20}H_{42}$. [1]

____

(iii) What are the reaction conditions needed for cracking? [1]

____

(iv) Explain why cracking is an important industrial process. [1]

____

(c) Propene, C_3H_6 is part of the alkene homologous series.
it can react with aqueous bromine to form a colourless product.

(i) Give any one property of a homologous series. [1]

____

____

(ii) Name and draw the structural formula of the colourless product below. [2]

Section B

Answer **all** the questions in this section in the spaces provided.
The last question is in the form either/or and only **one** of the alternatives should be attempted.
The total mark for this section is 30.

B10 Read the information about the elements in Group II of the Periodic Table.

element	**number of electron shells in atom**	**atomic radius/ pm**	**ionic radius/ pm**	**effect of adding metal to water**
magnesium	3	150	66	reacts very slowly
calcium	4	180	99	reacts quickly with water
strontium	5	200	134	reacts vigorously with water

(1 000 000 000 000 pm = 1 meter)

Thermal stability of Group II elements and its polarising power

Polarisation is the distortion of the electron cloud of an anion by a positively charged particle. The ability of a cation to polarise an anion is called its polarising power. An approximate measure of the polarising power of a cation is its charge density.

Charge density is proportional to $\frac{charge\ of\ cation}{ionic\ radius}$.

Group II hydroxides decompose on heating to form metal oxides and steam. The temperature at which the metal hydroxides decompose are shown in the table below.

metal hydroxide	**decomposition temperature/ °C**
$Mg(OH)_2$	332
$Ca(OH)_2$	520 – 580
$Sr(OH)_2$	500 – 850

(a) (i) What is the relationship between atomic radius and the reactivity of the metals in Group II? [1]

____

____

(ii) Explain the relationship in **(a)(i)**. [2]

(b) Suggest why the radius of magnesium atom changes when it forms a magnesium ion. [1]

(c) (i) Determine which ion, Mg^{2+}, Ca^{2+} or Sr^{2+}, has the highest polarising power. [1]

(ii) A student proposes that the temperature at which Group II metal hydroxides decompose is directly proportional to the polarising power. Use the information given in the question and your answer in (c)(i) to determine if the statement proposed is true or false. [3]

(d) Strontium chloride is useful in reducing tooth sensitivity by forming a barrier over the teeth. A way to produce strontium chloride in the lab is to react strontium hydroxide with an acid.

(i) Name the acid that is added to react with strontium hydroxide. [1]

(ii) Write the balanced chemical equation for the reaction. [1]

B11 (a) The table below provides some information about four types of fuel; petrol, diesel, coal and hydrogen, that are currently used in the world today. A fuel is a substance that is used to provide heat or power, usually by combustion. Combustion is a high-temperature exothermic chemical reaction between a fuel and atmospheric oxygen.

Unlike petrol, diesel and coal, hydrogen is used in fuel cells to generate power using a chemical reaction rather than combustion. The hydrogen-fuel cell is a device that converts the chemical energy from the chemical reaction of oxygen and hydrogen into electricity.

name of fuel	**cost in cents / 100 g**	**energy in kJ / 100 g**	**energy in kJ per cent**	**product(s) formed during energy production**		
				carbon dioxide	**sulfur dioxide**	**water vapour**
petrol	6.0	4800	800	√		√
diesel	4.0	2000	500	√		√
coal	3.5	1050	300	√	√	√
hydrogen	18.0	14400	800			√

A student was tasked to use the information above to compare these four types of fuel and rank them from the best to worst. He ranked them as follows:

best fuel → worst fuel

hydrogen → petrol → diesel → coal

With reference to the information in the table above,

(i) Suggest a reason why the student placed coal as the worst fuel. [1]

____

____

(ii) Suggest a reason why the student placed hydrogen-fuel cell as the best fuel. [1]

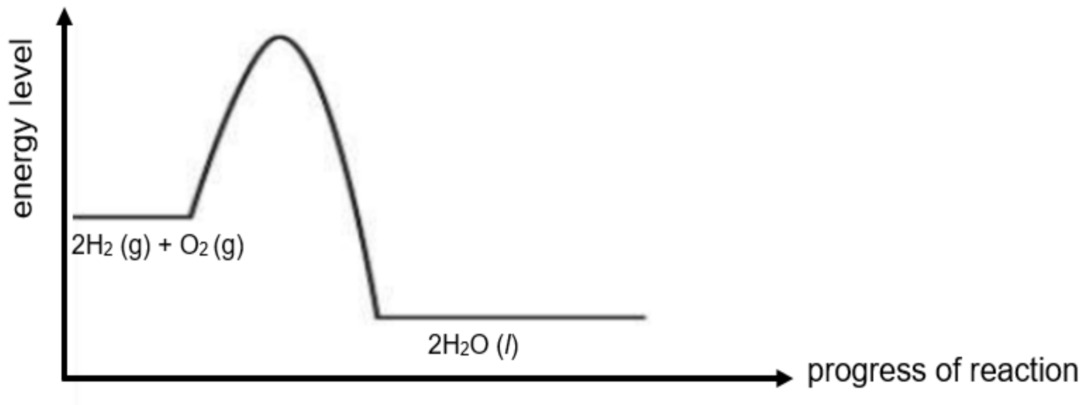
____

____

(b) In the future, hydrogen-fuel cell may be used to power cars. In a hydrogen-fuel cell, the overall reaction is represented by the chemical equation as shown.

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l)$$

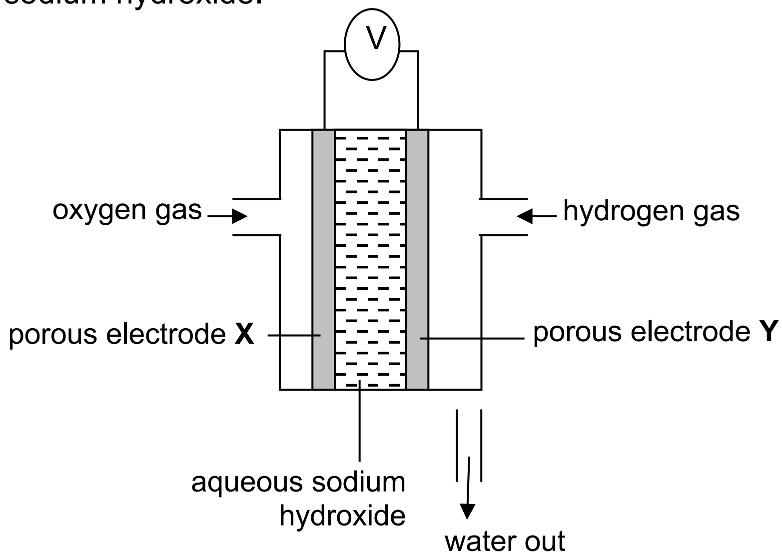
The figure below shows the energy profile diagram for the overall reaction in a hydrogen-fuel cell.



(i) With reference to the figure above, is the reaction exothermic or endothermic? Explain your answer in terms of the energies involved in bond breaking and bond making. [2]

(ii) A catalyst is added to the hydrogen-fuel cell. Draw and label clearly a second curve, on the figure above, to show the energy profile for the catalysed reaction. [1]

(c) An example of a fuel cell is shown below. It is used to produce electricity from the controlled reaction between hydrogen and oxygen, in the presence of aqueous sodium hydroxide.



The reaction taking place at electrode **X** can be represented by the equation below.

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

(i) Draw arrows on the diagram to indicate the direction of electron flow in the external circuit. [1]

(ii) Write the equation for the reaction occurring at electrode **Y**. [1]

____

(iii) Describe the function of aqueous sodium hydroxide in the fuel cell. [1]

____

____

(iv) State with a reason, whether oxidation or reduction has occurred at electrode **X**. [2]

____

____

____

____

EITHER

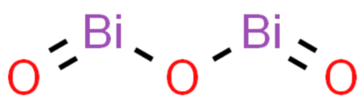
B12 Bismuth is a silvery-white metal added into other metals to lower their melting points.

Bismuth oxide is prepared by first reacting bismuth with hot dilute nitric acid to form bismuth nitrate, followed by the addition of excess aqueous sodium hydroxide to form bismuth hydroxide.

Roasting bismuth hydroxide in air will produce bismuth oxide. Bismuth oxide is a yellow solid which has been used in fireworks. Some properties of bismuth oxide at room conditions are given below.

properties	
electrical conductivity	poor
solubility in water	insoluble
solubility in dilute citric acid	soluble
solubility in aqueous potassium hydroxide	soluble

A book gave the structural formula of bismuth oxide shown below.



(a) (i) What is the empirical formula of bismuth oxide? [1]

(ii) Describe how you would prepare pure and dry crystals of bismuth nitrate from bismuth. [3]

(iii) Write down the balanced chemical equation for the reaction of bismuth nitrate and aqueous sodium hydroxide. [2]

____

(iv) Explain why excess aqueous sodium hydroxide is used in the preparation of bismuth hydroxide. [1]

____

____

(v) Why does roasting bismuth hydroxide in air produce bismuth oxide? [1]

____

____

(b) (i) How does the structure of bismuth oxide explain that it has poor electrical conductivity? [1]

____

____

(ii) What type of oxide is bismuth oxide? [1]
Explain your answer using information from the table.

____

____

OR

B13 Poly(propene) and nylon are both used to make waterproof ropes.
Poly(propene) is an addition polymer and nylon is a condensation polymer.

(a) (i) Give another example of addition polymer and condensation polymer. [2]

____

____

(ii) State two differences between addition polymers and condensation polymers. [2]

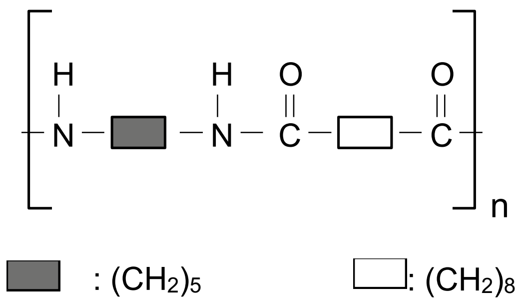
1. ____

____

2. ____

____

(b) There are many commercial types of nylon. The figure below shows a repeating unit of nylon-5,8.

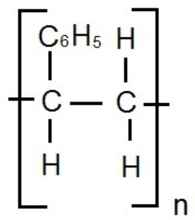


(i) Draw the structural formulae of the two monomers that react to form nylon-5,8. [2]

(ii) During the production process, the length of the chain of nylon polymer can be controlled with the processing temperature and time. Depending on the type of nylon produced, a nylon polymer can have 12 000 to 20 000 repeating units. [2]

What is the relative molecular mass of nylon-5,8 with 20 000 repeating units?

(c) Similarly, there are also many types of addition polymers such as polystyrene, shown below.



(i) Draw the structural formula of the monomer that is used to produce polystyrene. [1]

(ii) Suggest a use of polystyrene in our daily life. [1]

____

____

END OF PAPER

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

ZHONGHUA SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
SECONDARY 4E

Candidate's Name	Class	Register Number

CHEMISTRY **6092 /02**

15 September 2022
1 hour 45 minutes

Additional Materials: NIL

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class in the spaces at the top of this page and on all separate answer paper used.

Write in dark blue or black pen.

You may use a pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions.

Write your answers in the spaces provided on the question paper

Section B

Answer all **three** questions, the last question is in the form either/or.

Write your answers in the spaces provided.

You are advised to spend no longer than one hour on **Section A** and no longer than 45 minutes on **Section B**.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

All essential working must be shown clearly.

A copy of the Periodic Table is printed on page 17.

For Examiner's Use	
Section A	**50**
B7	**12**
B8	**8**
B9	**10**
Total	**80**

Setter: Mrs Maybrie Ang
Vetter: Ms Julia Yeo

This document consists of **17** printed pages, including this cover page.

Section A

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The equations **A** – **E** illustrate some chemical reactions.

A $Mg + 2HCl \rightarrow H_2 + MgCl_2$

B $2H_2 + O_2 \rightarrow 2H_2O$

C $CuCO_3 \rightarrow CuO + CO_2$

D $Fe_2O_3 + 3CO \rightarrow 3CO_2 + 2Fe$

E $FeCl_2 + 2NaOH \rightarrow Fe(OH)_2 + 2NaCl$

F $C_{12}H_{28} \rightarrow C_4H_{10} + C_8H_{18}$

Use the letters **A** – **F** which represent the above chemical reactions to answer the following questions, where necessary.
Each letter may be used once, more than once or not at all.

(a) Which reaction can be used to test for a metal cation? ……………………………….. [1]

(b) State the role of carbon monoxide for the reaction in **D.** ……………………………….. [1]

(c) Name the type of reaction for **F.** ……………………………….. [1]

(d) Describe what would be observed when reaction **C** is carried out in the laboratory.

………………………………………………………………………………………………….. [1]

(e) Identify all the redox reactions. ……………………………….. [1]

(f) Identify the chemical reaction which illustrates combustion. …………………………… [1]

[Total: 6]

A2 Excess hydrochloric acid was reacted separately with 3 powdered metals **A, B** and **C**.
The volume of hydrogen collected over time were recorded and plotted on graph as shown in Fig 2.1.

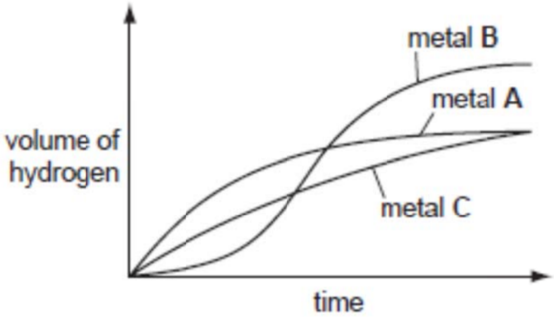


Fig 2.1

The metals used are zinc, magnesium and aluminium and the same number of moles of metals were used for each of the reactions.

(a) Write the chemical reactions between hydrochloric acid and the three metals.

zinc equation:………………………………………………………………………………...

magnesium equation:……………………………………………………………………….

aluminium equation: ……………………………………………………………………... [3]

(b) Identify metals **A** and **C.** Use the graphs and the equations in part **(a)** to explain your answer.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(c) Identify metal **B** and explain why the shape of the graph obtained is different from that of metals **A** and **C.**

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(d) In the reactions for metals **A** and **C**, 500 cm^3 of hydrogen gas were produced.
Use the equations in part **(a)** to show how you can calculate the volume of hydrogen gas produced when metal **B** was used.

volume of hydrogen gas ……………cm^3 [2]

[Total: 9]

A3 Different indicators change colour over different pH ranges and it is important to choose the correct indicator to obtain an accurate result in a titration.
Table 3.1 shows information about some indicators.

Table 3.1

indicator	pH range for the colour change	colour	
		lower pH	higher pH
A	0.3-3.0	yellow	violet
B	4.2-6.3	red	yellow
C	8.2-10.2	colourless	pink
D	11.6 – 14.0	blue	yellow

Fig 3.1 shows the change of pH when a 2 mol/dm^3 aqueous ammonia is added to a 25 cm^3 volume of dilute hydrochloric acid in a titration.

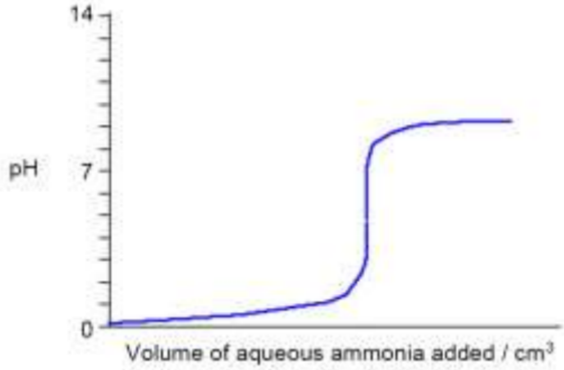


Fig 3.1

(a) Using Fig 3.1, state the pH of aqueous ammonia and dilute hydrochloric acid.

aqueous ammonia …………………. dilute hydrochloric acid …………………… [1]

(b) Using the information from Table 3.1 and Fig 3.1 to explain which indicator would be the best choice to be used in this titration between aqueous ammonia and dilute hydrochloric acid.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(c) A student repeated the titration by using 25 cm^3 of dilute hydrochloric acid and titrated it with a 2 mol/dm^3 solution of dilute sodium hydroxide solution.

(i) Sketch the pH curve that would be obtain in Fig, 3.1. [1]

(ii) State and explain which indicator(s) is/are suitable for this titration.

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[Total: 6]

A4 Some takeaway food has a self-heating feature that allows the food to be heated in the bowl provided due to a chemical reaction.
A student heat up a bowl of noodles using the heating pack provided by mixing the calcium oxide powder and cold water.
She measured the temperature change when 10.0 g of calcium oxide was added to cold water and recorded them in Table 4.1

Table 4.1

temperature / °C	25
highest temperature recorded after mixing/ °C	100
calculated energy change, ΔH / KJ	720

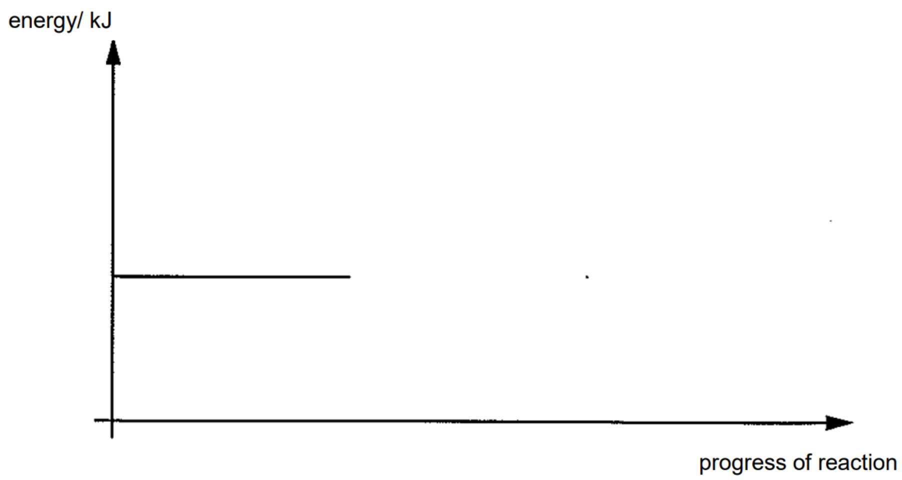
(a) Use the information in Table 4.1 to explain if the reaction has a positive or negative value of ΔH.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

………………………………………………………………………………………………….. [2]

(b) When the heating pack and cold water are mixed, calcium hydroxide solution forms.
Complete the energy profile diagram below.
Your diagram should include
- the formulae of the reactants and the products,
- enthalpy change of reaction and,
- the activation energy.



[2]

(c) Use the student's results to calculate the enthalpy change when one mole of calcium oxide reacts with cold water.

enthalpy change …………………….. kJ/ mol [2]

(d) Another student commented that a similar temperature change will be observed when ammonium chloride was added to room temperature water. Explain whether you agree with this student.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

[Total: 8]

A5 Compound **T** belongs to the homologous series called aldehyde.
Fig. 5.1 shows a reaction scheme for compound **T**.

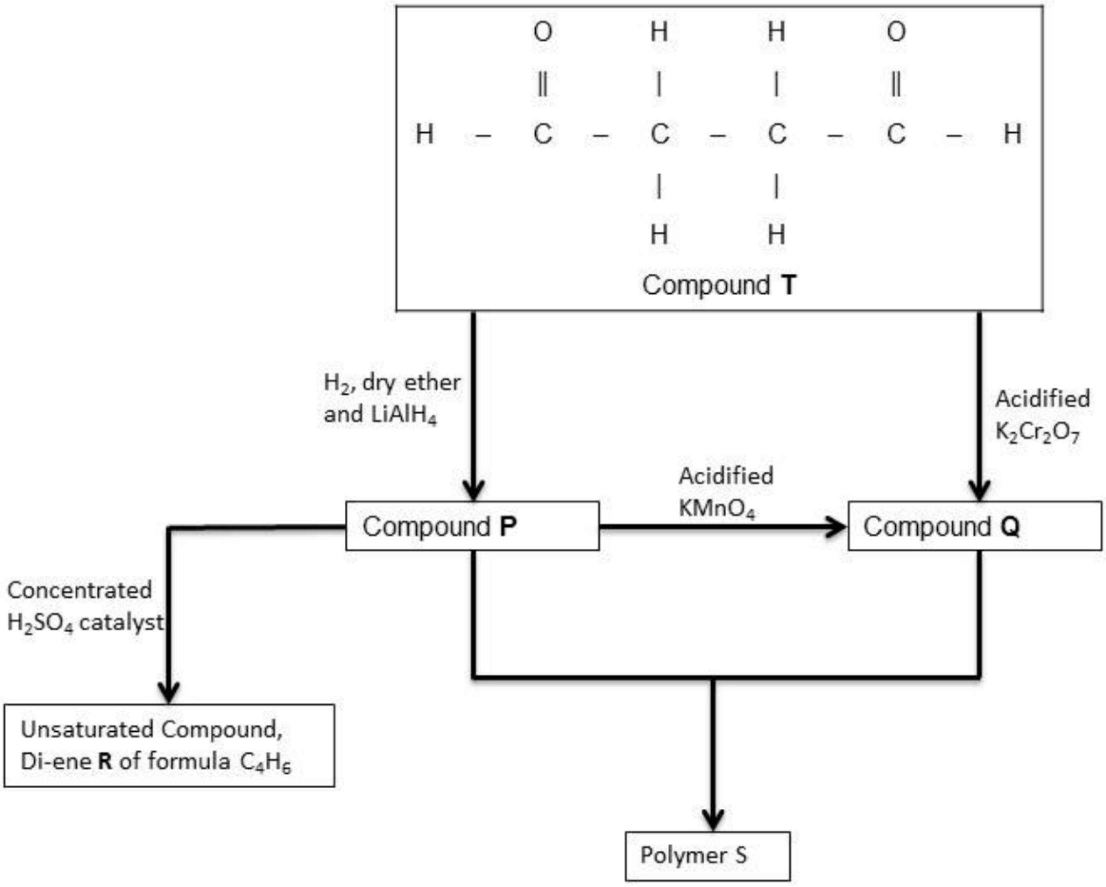


Fig. 5.1

(a) Explain the term 'homologous series' and 'unsaturated' described in Fig. 5.1.

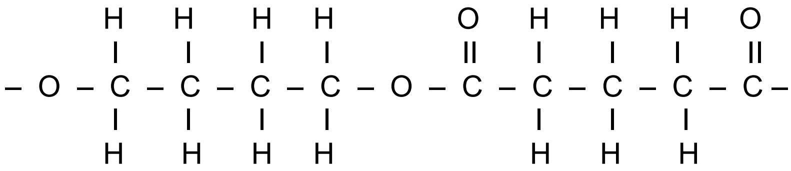
homologous series ……………………………………………………………………………

……………………………………………………………………………………………………

unsaturated …………………………………………………………………………………….

…………………………………………………………………………………………………… [2]

(b) A section of polymer **S** is given below.



Draw the full structural formulae of the monomers **P** and **Q** that is used to make polymer **S**.

P	**Q**

[2]

(c) **(i)** State the type of polymerisation that produces polymer **S**.

…………………………………………………………………………………………….. [1]

(ii) Name the type of polymer that **S** belongs to.

……………………………………………………………………………………………... [1]

(d) **(i)** Draw the structure of the diene, **R**.

[1]

(ii) Draw two repeating units of a polymer that could be formed using the diene, **R,** drawn in **(d) (i)** as the monomer.

[1]

(e) Briefly describe a test to show that **R** is unsaturated.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

[Total: 10]

A6 The electrolysis of concentrated aqueous hydrochloric acid was carried out using the apparatus as shown in Fig.6.1.

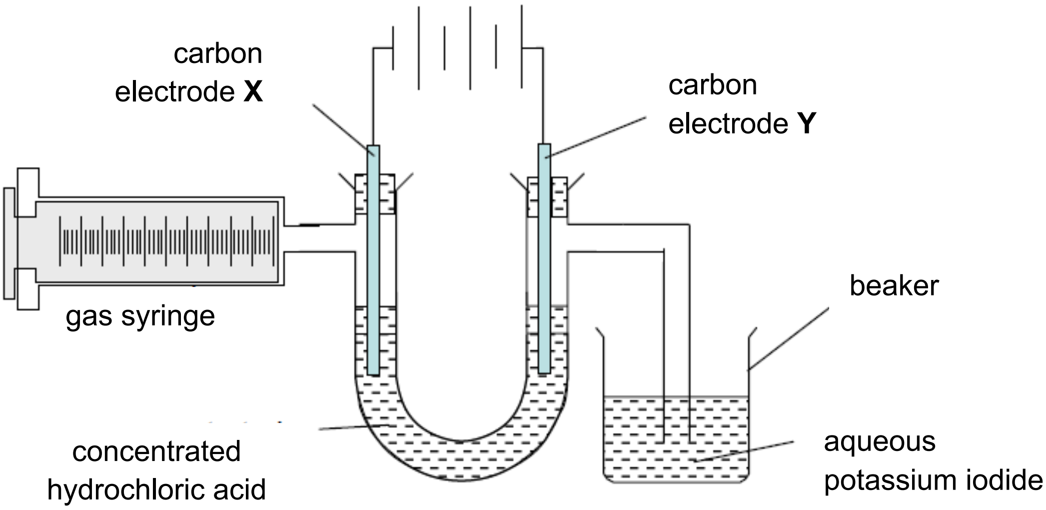


Fig. 6.1

(a) Construct the half equations with state symbols for the reactions at the electrodes.

electrode **X** ……………………………………………………………………………….

electrode **Y** ……………………………………………………………………………… [2]

(b) As shown in Fig 6.1, the gas discharged at electrode **Y** is bubbled into a beaker containing aqueous potassium iodide.

(i) Name the reaction that takes place in the beaker.

……………………………………………………………………………………………… [1]

(ii) With the aid of a balanced chemical equation, describe what you would observe in the beaker.

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(c) After the electrolysis was allowed to proceed for some time, it was observed that a new product was formed at carbon electrode **Y**.

(i) State the identity of this new product and explain why it is formed.

……………………………………………………………………………………………….

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(ii) After allowing the electrolysis to carry on for a while with the new gas coming out, it was found that 30 cm^3 of gas was collected in the gas syringe. State and explain what is the volume of this new gas produced at electrode **Y.**

……………………………………………………………………………………….....

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………….. [2]

(iii) Determine the number of moles of electrons that have passed through when the 30 cm^3 of the gas was collected at the gas syringe.

number of moles of electrons……….………… [2]

[Total: 11]

Section B

Answer **all** three questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Below are some information about ozone.
Read through them and answer the questions that follows.

Ozone
Ozone is an inorganic molecule with the chemical formula O_3. It is a pale blue gas with a distinctively pungent smell. It is an allotrope of oxygen that is much less stable than the diatomic allotrope O_2 when it is broken down in the lower atmosphere.
Ozone is formed from oxygen gas by the action of ultraviolet (UV) light and electrical discharges within the Earth's atmosphere. It is present in very low concentrations in the earth's atmosphere with its highest concentration high in the ozone layer of the stratosphere, which absorbs most of the Sun's ultraviolet (UV) radiation.

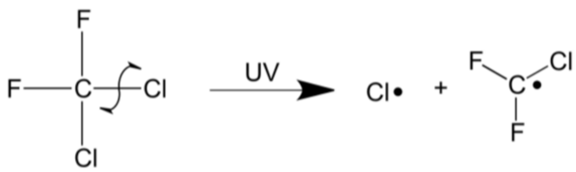
Ozone Layer Depletion in the Stratosphere
Chlorofluorocarbons (CFCs) are organic compounds of carbon, fluorine and chlorine, which have been used in large quantities as solvents and aerosol propellants. Table 7.1 shows the bond energies for some of the bonds in CFCs.

Table 7.1

bond	bond energy in kJ / mol
C – F	485
C – Cl	327

Fig. 7.1 shows how ozone is slowly destroyed by CFCs in stages. In the presence of UV radiation, CFC decomposes. Chlorine atom, Cl•, is formed when the pair of electrons between C-Cl is broken. The Cl• then decomposes the ozone.

Formation of chlorine atom



CFC free radicals

Decomposition of ozone by chlorine atom

$$Cl\bullet + O_3 \longrightarrow O_2 + Cl\dot{O}$$

$$Cl\dot{O} + O_3 \longrightarrow 2O_2 + Cl\bullet$$

Overall Ozone equation

$$2\,O_3 \rightarrow 3\,O_2$$

Fig. 7.1

Ozone in Photochemical Smog

Photochemical smog forms from a complex process. Nitrogen oxides and volatile organic compounds (VOC) react in the presence of ultraviolet light to form secondary pollutants, such as ozone and peroxyacetyl nitrate (PAN) creating a brown haze above cities.
Photochemical smog forms from the pollutants produced by the combustion of fossil fuels, burning trees and the processing of organic waste. In the presence of ultraviolet light, these pollutants and volatile organic compounds (VOCs) become harmful to human health.
The primary pollutants in photochemical smog are nitrogen oxides from car exhaust, coal power plants, factory emissions and VOCs compounds released from burning fuels or consumer products like cigarettes, paints and cleaning solvents that easily become vapours or gases. When these compounds react they form airborne particles and ground-level ozone, commonly known as smog.

The two dominant toxins produced in photochemical smog are ozone and peroxyacetyl nitrate. When nitrogen dioxide interacts with VOCs, it is prevented from consuming ozone, leading to harmful levels of ozone at ground level. Thus, a secondary pollutant is formed. As a layer of the atmosphere, ozone protects Earth but when it is found nearer the ground, ozone becomes harmful.

Photochemical smog relies on ultraviolet rays from the sun to be produced. As such, hotter and sunnier days in high-density cities result in more photochemical smog being formed.

Fig. 7.2 shows the results of a study done on how the concentration of nitrogen oxides (NO_x) and ozone (O_3) which are air pollutants in a busy city varies with time. NO_x comprises of a mixture mainly of nitrogen monoxide (NO) and nitrogen dioxide (NO_2). The concentration of the gases are measured in parts per billion (ppb)

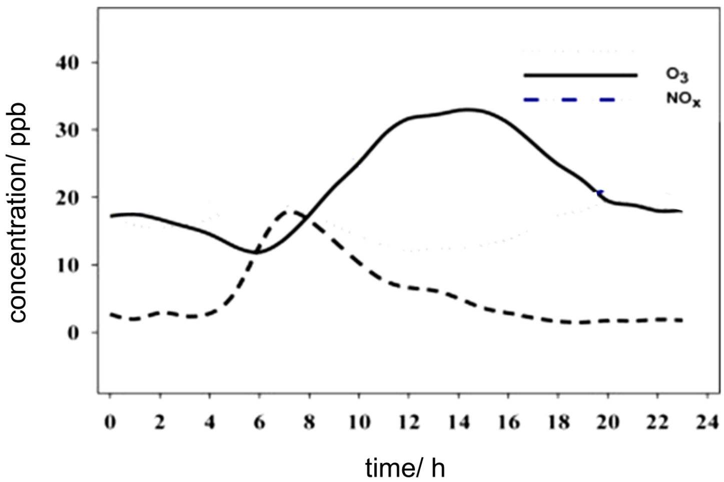


Fig.7.2

The largest source of contributor of NO_x is vehicle and other automobiles while power plants that rely on coals produce the necessary pollutants to facilitate the production of photochemical smog.

(a) Use ozone and oxygen gas to explain the term '*allotrope*'.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(b) Use Table 7.1 to explain why the ozone layer contains more chlorine atoms than fluorine atoms.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(c) Use Fig. 7.1 to identify and explain the catalyst in the decomposition of ozone.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(d) Explain this statement found in the information provided.

'As a layer of the atmosphere, ozone protects Earth but when it is found nearer the ground, ozone becomes harmful'.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(e) Both carbon monoxide and NO_x are produced by vehicles.

(i) Describe how NO_x are produced by vehicles.

……………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(ii) Use Fig. 7.2 to describe and explain how the time of the day affects an increase in concentration of nitrogen oxides and how during these times, more photochemical smog is formed.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

(f) What cross-border environmental problems do nitrogen oxides and ozone cause?

………………………………………………………………………………………….. [1]

(g) The catalytic converter removes pollutant gases such as nitrogen monoxide and carbon monoxide.
Write an equation to show how carbon monoxide and nitrogen monoxide react together in the converter.

………………………………………………………………………………………………….. [1]

[Total: 12]

B8 Hydrogen peroxide is a colourless liquid. An aqueous solution of hydrogen peroxide reacts with the iodide ions in acidified potassium iodide to form water and iodine.

$$H_2O_2\ (aq) + 2\,H^+\ (aq) + 2\,I^-\ (aq) \rightarrow 2\,H_2O\ (l) + I_2\ (aq)$$

(a) Identify and explain using the oxidation states the reducing agent in this reaction.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) Table 8.1 shows how the speed of this reaction changes when different concentrations of potassium iodide and sulfuric acid are used. The hydrogen peroxide is always in excess and the temperature remains constant.

Table 8.1

experiment	concentration of potassium iodide in mol/dm^3	concentration of sulfuric acid in mol/dm^3	speed of reaction in mol/dm^3/s
1	0.1	0.1	0.00017
2	0.2	0.2	0.00034
3	0.1	0.2	0.00017
4	0.3	0.1	0.00051
5	0.1	0.3	0.00017

Using the information in Table 8.1 to describe how increasing the concentration of the following reagents affects the speed of reaction of

(i) potassium iodide

…………………………………………………………………………………………………..

………………………………………………………………………………………………….. [2]

(ii) sulfuric acid

…………………………………………………………………………………………………..

………………………………………………………………………………………………….. [2]

(c) Explain, in terms of collisions between reacting particles, why increasing the temperature increases the speed of reaction between hydrogen peroxide and acidified potassium iodide.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Total: 8]

Either

B9 Fig. 9.1 shows two possible forms of boron nitride which are named hexagonal boron nitride and cubic boron nitride.

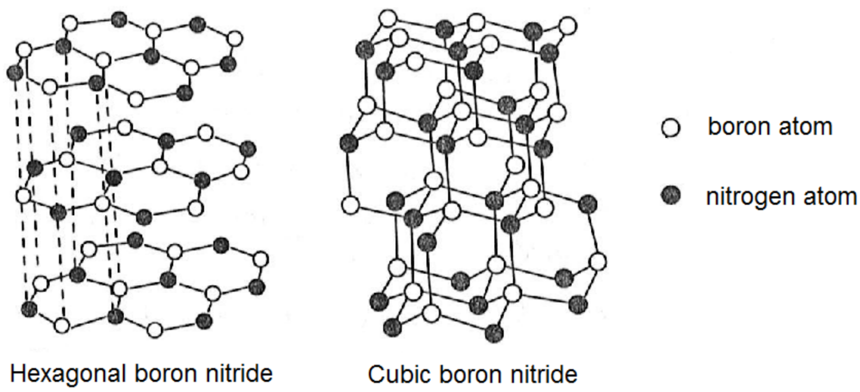


Fig 9.1

Table 9.1 shows the melting points of hexagonal boron nitride and two other compounds of nitrogen.

Table 9.1

compound	melting point / °C
hexagonal boron nitride	2973
aluminium nitride	2200
Hydrazine (N_2H_4)	2

(a) Based on the structures shown in Fig 9.1, explain why both hexagonal boron nitride and cubic boron nitride have very high melting point.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) Use the structure to explain a possible use of hexagonal boron nitride.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) Draw the 'dot and cross' diagram to represent the bonding in

(i) hydrazine (showing all electrons)

[1]

(iii) aluminium nitride (showing only valence electrons)

[2]

(d) Use the structure and bonding in Table 9.1 to explain the difference in the melting points between aluminium nitride and hydrazine.

aluminium nitride

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

hydrazine

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

[Total: 10]

Or

B9 Fig 9.2 describes some of the reactions of salt **C**.

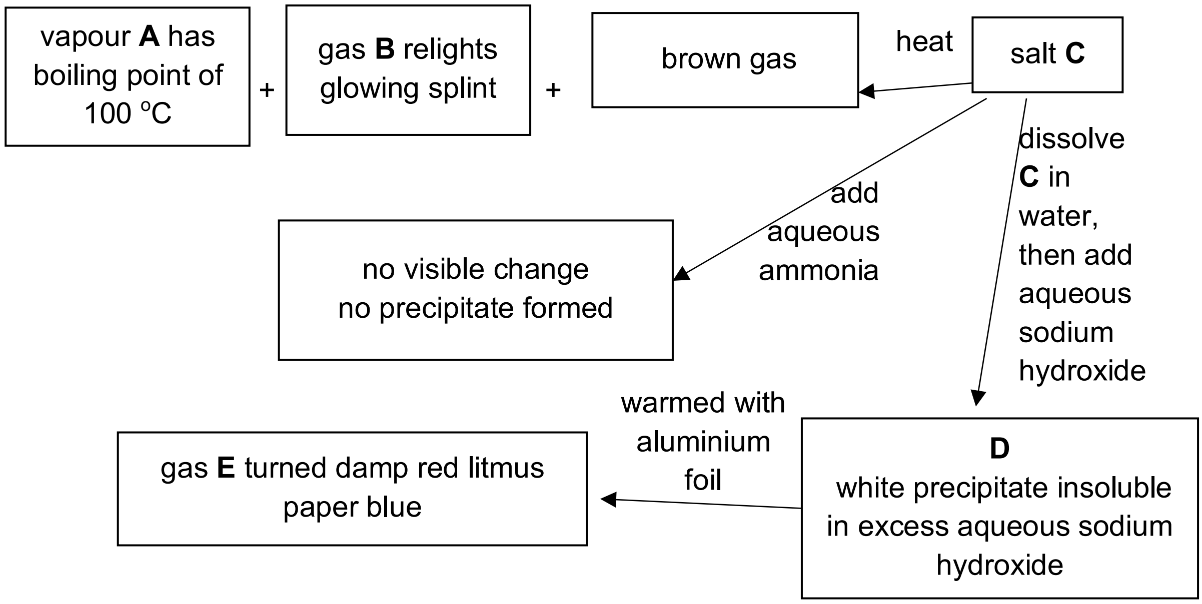


Fig 9.2

(a) Identify the substances **A** to **E**.

A .... **B** ....

C .... **D** ....

E .... [5]

(b) Write a an ionic equation with state symbols for the reaction of aqueous **C** with aqueous sodium hydroxide to form **D**.

.... [2]

(c) Name the brown gas formed.

.... [1]

(d) Describe what you would observe when you test the brown gas with moist litmus paper.

.... [1]

(e) Briefly describe a test to identify the liquid formed after vapour **A** condensed to form a liquid.

....

.... [1]

[Total: 10]

End of paper

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).