Paya Lebar Methodist Girls' School (Secondary)
Preliminary Examination 2022
Secondary 4 Express

CANDIDATE NAME		CLASS		CLASS INDEX NO	

CENTRE NUMBER	S					INDEX NO				

CHEMISTRY 6092/02

Paper 2 **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 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, 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.

For Examiner's Use		
Section A		
Section B		
7		
8		
9	E/O	
Total		

A copy of the Periodic Table is printed on page 2.

The use of an approved scientific calculator is expected,

where appropriate.

This document consists of 25 printed pages

[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 Ba 137	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 Ba 137	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstactium –	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** the questions in this section in the spaces provided.

The total mark for this section is 50.

A1 The formulae of some elements are given in the following list.

Al Cu Fe H_2 Na O_2 Mg

Choose elements from the list to answer the questions.

(a) Which elements in the list are transition metals?

(b) Which element is commonly used as a sacrificial protection metal to prevent rusting?

(c) Choose **one** element which shows both metallic and non-metallic character.

(d) Which element can be extracted from its ore by heating with carbon?

(e) Which element can react with steam but not cold water?

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[5]

[Total: 5]

A2 This question is about elements in Group V of the Periodic Table.

[Turn Over

(a) The table shows some properties of the Group V elements.

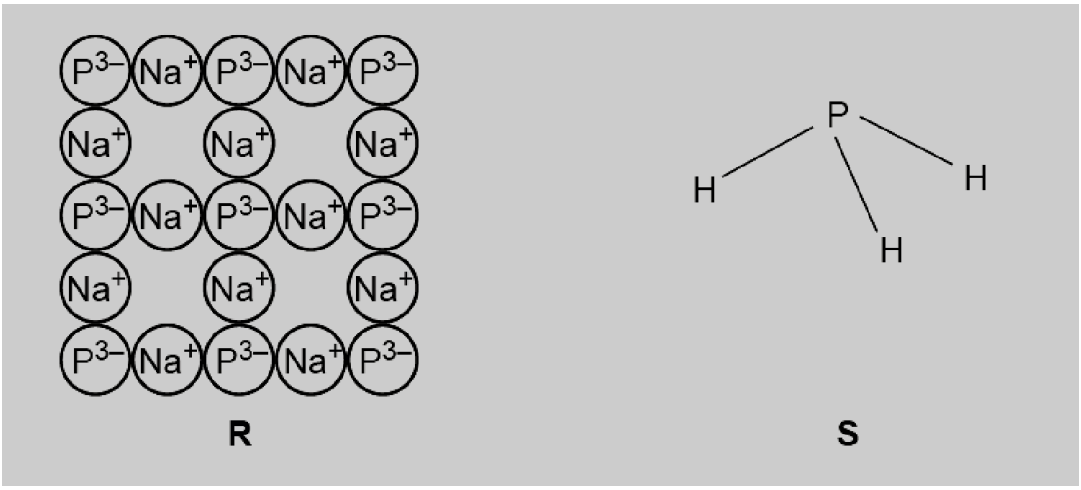
element	density at room temperature in g/cm^3	melting point in ^{0}C
nitrogen	1.17×10^{-3}	-210
phosphorus	2.34	44
arsenic	5.73	
antimony		631
bismuth	9.80	272

Use the information in the table to:

(i) Predict the density of antimony.
[1]

(ii) Suggest why it is difficult to predict the melting point of arsenic.
[1]

(b) The structure of two compounds of phosphorus, **R** and **S**, are shown.



(i) Explain in terms of structure and bonding why compound **R** has a high melting point and compound **S** has a low melting point.
[4]

compound **R** ----------

---

compound **S** ----------

(ii) Draw the 'dot and cross' diagram for compound **S**. Show only the outer most shell electrons.
[2]

(c) An oxide of phosphorus has the formula P_4O_{10}.

[Turn Over

(i) Calculate the percentage of phosphorus in P_4O_{10}.
[2]

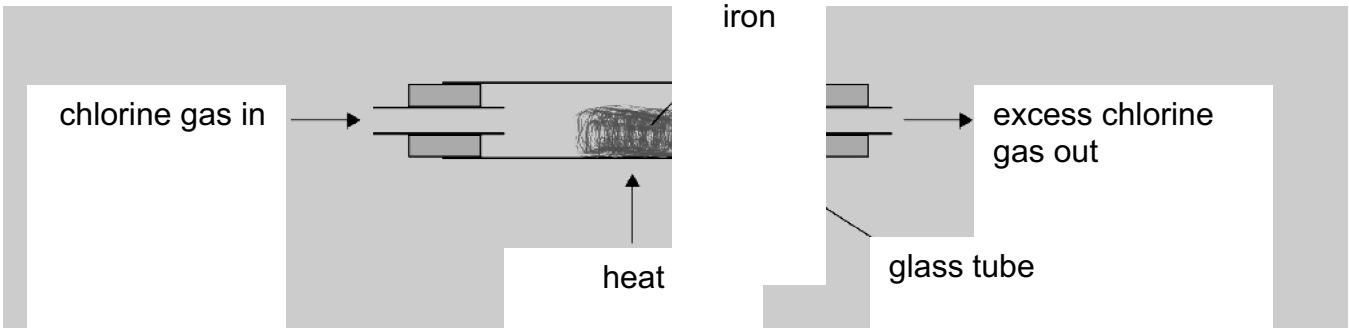
(ii) State the oxidation state of phosphorus in the compounds in the table below.

Compound	Oxidation state of phosphorus
compound **S**	
P_4O_{10}	

[2]

[Total: 12]

A3 A student investigated the reaction of iron with chlorine using the apparatus shown in Fig. 3A.



The word equation for the re

iron + chlorine → iron chloride

The student made several measurements and recorded her results in Table 3B.

	Mass in g
glass tube	51.56
glass tube and iron	56.04
glass tube and iron chloride	64.56

Table 3B

(a) Explain why the chlorine gas must be continued to pass through the apparatus until the iron has cooled down.
[1]

(b) (i) Calculate the mass of iron and chlorine in iron chloride.
[2]

[Turn Over

mass of iron = …… g

mass of chlorine = …….. g

(ii) Calculate the simplest whole number ratio of
number of moles of iron : number of moles of chlorine atoms in iron chloride
[2]

number of moles of iron : number of moles of chlorine atoms
= …….. : ……...

(iii) Hence, determine the balanced chemical equation for the reaction.
[1]

[Total: 6]

A4 In Experiment 1, magnesium ribbon reacts with dilute hydrochloric acid.

$$Mg\,(s) + 2HCl\,(aq) \rightarrow MgCl_2\,(aq) + H_2\,(g)$$

Fig. 4A shows the volume of hydrogen gas produced at 20^0C as the reaction proceeds for Experiment 1. The acid is in excess.

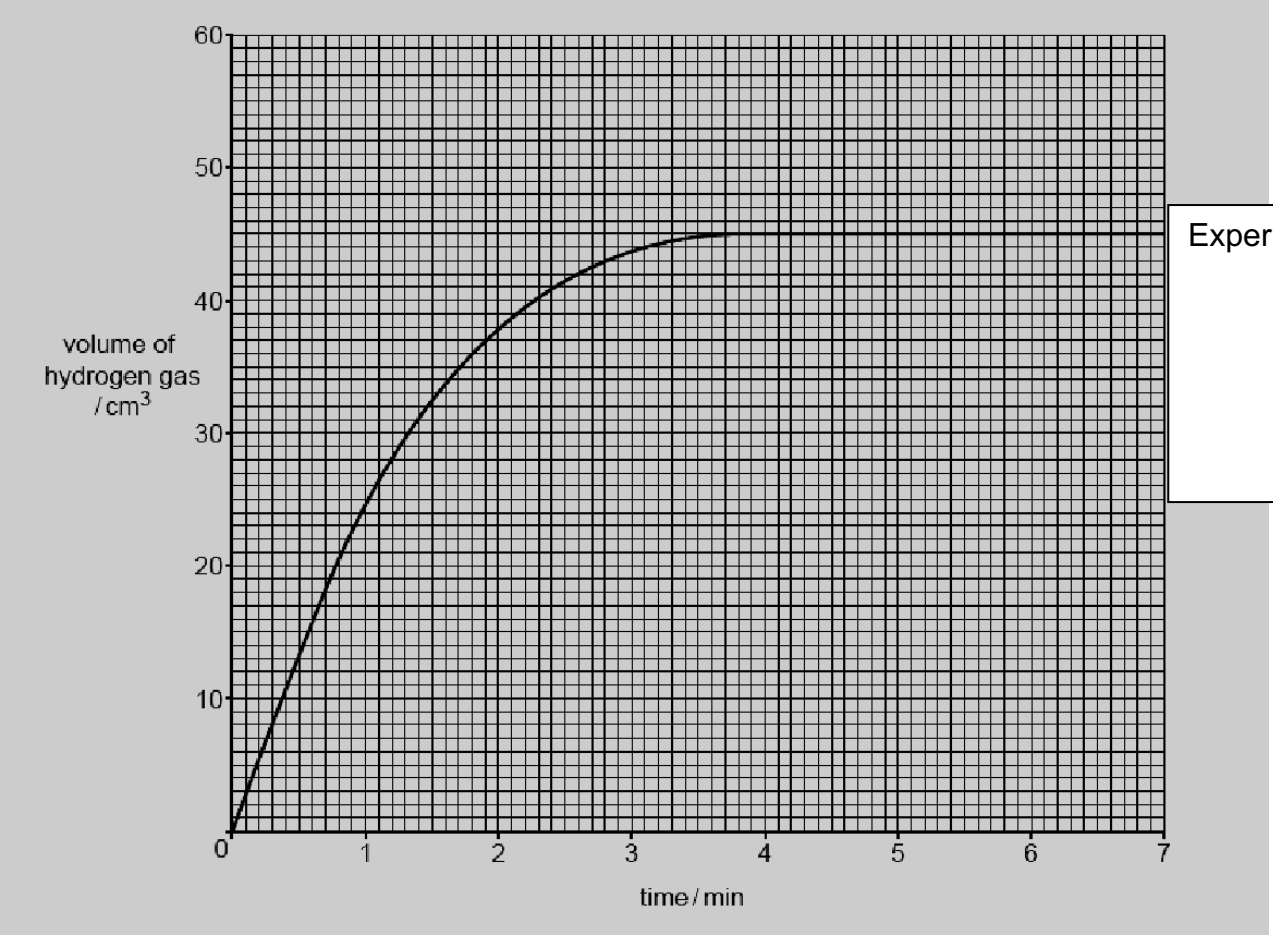


Fig. 4A

(a) Based on the information from Fig. 4A, calculate the mass of magnesium that was used in the reaction.

[2]

[Turn Over

mass of magnesium = …… g

(b) In Fig. 4B, draw the energy profile diagram for the reaction between magnesium and hydrochloric acid represented by Fig. 4A.
Label clearly the

- activation energy, E_a
- enthalpy change, ΔH
- reactants and products

[3]

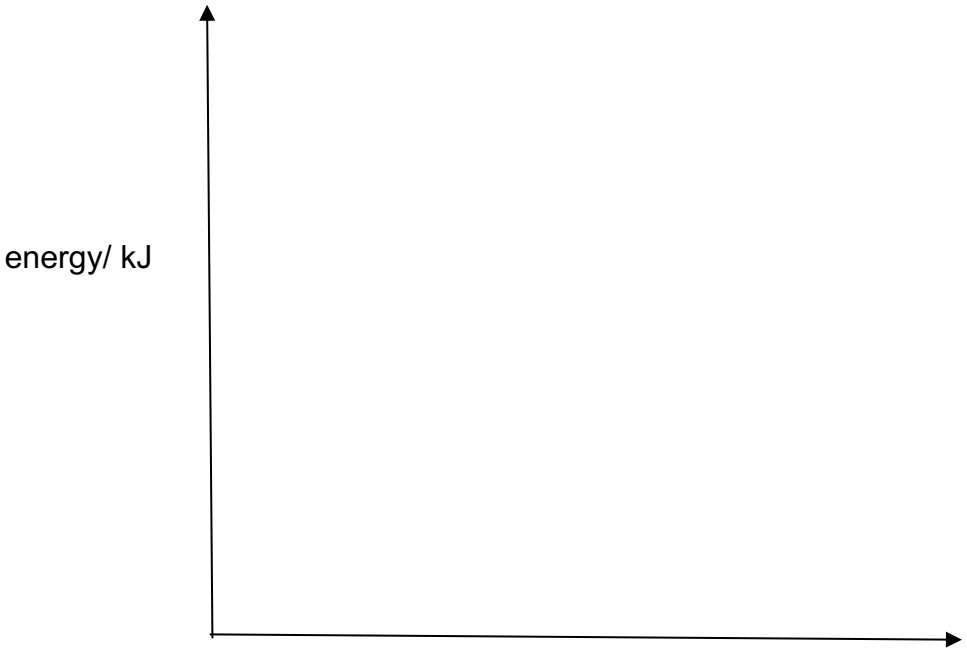


Fig. 4B

(c) In Experiment 2, the volume and concentration of hydrochloric acid and temperature of the acid used is the same as Experiment 1. The mass of magnesium used is halved of that used in Experiment 1.

Draw on Fig. **4B**, the ***energy profile diagram*** for this new reaction. Label the graph as Experiment 2.
[1]

(d) Experiment 3 is conducted with same conditions and variables as Experiment 2, except that the initial temperature of the acid was at 15^0C. Sketch the graph obtained for this new reaction on Fig. **4A**. Label the graph as Experiment 3.

[1]

(e) Use ideas about collisions between particles to explain how an increase in temperature affects the rate of the reaction.

[3]

[Total: 10]

A5 When SO_2 dissolves in water, a small proportion of it reacts with water to form a *weak* **[Turn Over**

acid, sulfurous acid, H_2SO_3**.**

(a) Explain the term *weak acid.*

[1]

(b) Write the chemical equation for the reaction of SO_2 with water.
[1]

(c) Describe one source of SO_2.
[1]

(d) Describe one harmful effect of excess SO_2 in the atmosphere.
[1]

(e) Emissions of SO_2 from coal fired power stations can be removed by mixing the coal with powdered limestone.

Limestone is heated to form CaO in **reaction 1**.
This then reacts with SO_2 and O_2 to form $CaSO_4$ in **reaction 2**.

reaction 1 $CaCO_3\,(s) \rightarrow CaO\,(s) + CO_2\,(g)$

reaction 2 $CaO\ (s) + SO_2\ (g) + \frac{1}{2} O_2\ (g) \rightarrow CaSO_4\ (s)$

(i) State the type of reaction occurring in **reaction 1**.
[1]

(ii) Explain, in terms of oxidation state, why SO_2 is oxidised in **reaction 2**.
[2]

(iii) Use the information in Table 5 to calculate the enthalpy change for **reaction 2**.

substance	bond energy in **each mole** of substance/ kJ mol^{-1}
CaO (s)	635
SO_2 (g)	297
O_2 (g)	498
$CaSO_4$ (s)	1434

Table 5

ΔH = …… kJ/mol [2]

[Total: 9]

A6 A student investigated the electrolysis of copper (II) chromate solution using the set-up

[Turn Over

in Fig. 6A. Copper (II) chromate solution is green. Copper (II) chromate solution contains:

• blue coloured Cu^{2+} ions

• yellow coloured CrO_4^{2-} ions

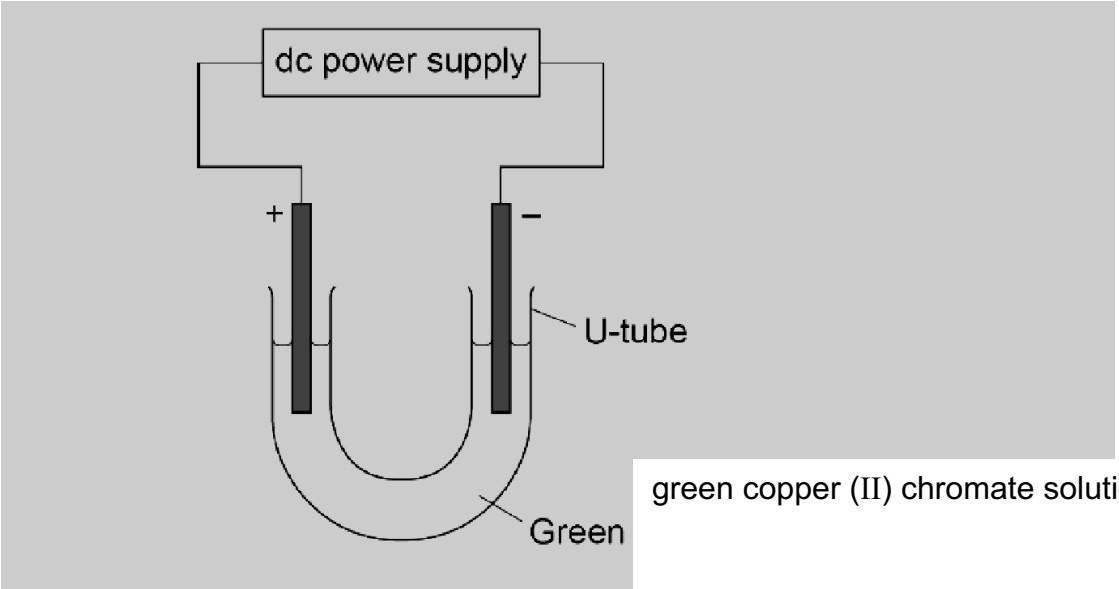


Fig. 6A

Table 6B shows the student's observations a

	positive electrode	negative electrode
observation 1	solution turned yellow	solution turned blue
observation 2		

Table 6B

(a) Explain why the solution at the positive electrode turns yellow.
[1]

(b) The gas produced at the anode is oxygen gas. The oxygen gas was produced from the hydroxide ions.
Write the half- equation to show the production of oxygen.
[1]

(c) Describe how the product at the negative electode is formed, with the help of a half-equation.

Half-equation: ----------
[1]

Explanation: ----------
[1]

(d) Using your answers in **(b)** and **(c)**, fill in the blanks in **Table 6B** for the missing observation 2 for each electrode.
[2]

(e) Describe what will be **observed** when aqueous ammonia is added in **excess** to a test tube of copper (II) chromate solution.
[2]

[Total: 8]

Section B

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

[Turn Over

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

B7 Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons.

If the atoms are equally electronegative, both have the same tendency to attract the bonding pair of electrons, and so it will be found on average half-way between the two atoms. This is illustrated below for atoms A and B.

To get a bond like this, A and B would usually be from the same element. This type of bond is a “pure” covalent bond, where the electrons are shared evenly between the two atoms.

If atom B is more electronegative than A, B will attract the bonding pair of electrons more than A does.

That means that the B end of the bond has more than its fair share of electron and so becomes slightly negative. At the same time, the A end becomes slightly positive. This is illustrated below.

In the diagram above, "δ" (read as "delta") means "slightly", so δ+ means "slightly positive". This type of covalent bond is known as a polar bond.

A polar bond is a covalent bond in which one end is slightly positive and the other slightly negative.

The electronegativity of some common elements is shown below.

F > O > C*l* > N > Br > I > S > C > H > metals

(most electronegative) (least electronegative)

The most electronegative element is fluorine. The trend in electronegativity must always increase towards fluorine in the Periodic Table, which is illustrated in Fig. 7A.

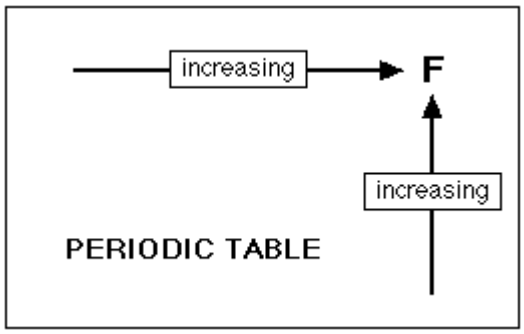


Fig. 7A

The greater the difference in the electronegativity of two elements in a compound, the more polar the bond is, the easier it is for the compound to dissociate to form ions.

Adapted from https://chem.libretexts.org/

(a) Give the chemical formula of a substance that has a "pure" covalent bond.
[1]

(b) Explain why metals have the lowest electronegativity.
[2]

(c) In Fig. 7A, Group 0 elements have been excluded. Explain why Group 0 elements have been excluded from the electronegativity trend.
[2]

(d) Table 7B shows some compounds with polar bond(s). Draw on **each element** of the compounds in the table the symbols δ+ and δ- to show the polarity of the compound.

The first compound, hydrogen fluoride has been done for you.
[3]

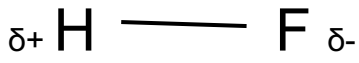
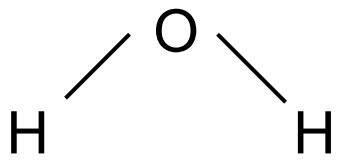
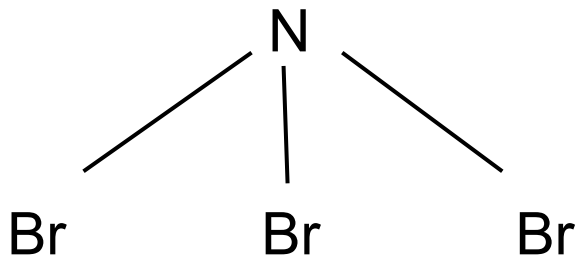
Compound	Diagram to show polarity of the compound.
Hydrogen fluoride	
Water	
Carbon disulfide	
Nitrogen bromide	

Table 7B

(e) Hydrogen halides, HF, HC*l*, HBr, HI act as acids when dissolved in water. The acid strength of the hydrogen halides differ.

Determine the order of the acid strength of the hydrogen halides. Explain why hydrogen halides behave as acids and the order of their acid strength.

Order of acid strength:

(strongest) (weakest)

[1]

Explanation:

[3]

[Total: 12]

B8 Table 8A shows the ease of reduction of some metal oxides by heating with carbon.

Metal oxide	Colour of oxide	Ease of reduction with carbon
lead (II) oxide	red	easily reduced at 300^0C
magnesium oxide	white	not reduced at 900^0C
nickel (II) oxide	green	easily reduced at 500^0C

zinc oxide	white	fairly easily reduced at 900^0C

Table 8A

(a) Use the information in Table 8 to put the **metals** in order of their reactivity.

[1]

least reactive → most reactive

(b) Nickel (II) oxide is heated with magnesium metal.
Describe what you would observe.
Provide an explanation for your observations.
[3]

(c) Which metal oxide(s) will react with aqueous sodium hydroxide?

[1]

(d) A student wants to obtain magnesium by electrolysis. She is considering one of the substances in Table 8B as an electrolyte.

substance	melting point /^{0}C
magnesium oxide	2852
magnesium chloride	714

aqueous magnesium chloride	116-118

Table 8B

Of the three substances in Table 8B, which should the student choose to obtain magnesium from the electrolysis of the electrolyte? Support your choice with explanation.

Choice of electrolyte: ----------

Explanation for choice of electrolyte:

---

[2]

(e) Describe how you would determine the purity of solid magnesium chloride.
[1]

[Total: 8]

EITHER

B9 One of the compounds in paraffin is the straight- chain alkane, dodecane, $C_{12}H_{26}$.

[Turn Over

(a) Give the name of the substance from which paraffin is obtained.
State the name of the process used to obtain paraffin from this substance.
[2]

Substance ----------

Process ----------

(b) Dodecane can be cracked to form other compounds.
When one molecule of dodecane is cracked, an alkene **A** and hydrogen gas is produced.

Alkene **A** has 85.7% carbon and 14.3% hydrogen and a relative molecular mass of 84.

Determine the empirical formula of alkene **A**.

empirical formula ----------

[2]

Hence, determine the molecular formula of alkene **A**.

molecular formula

[1] ----------

(c) Which substance, dodecane or alkene **A** has a higher melting point? Explain your answer.
[2]

(d) Alkene **A** undergoes complete combustion to form carbon dioxide and water (steam).

(i) Write the balanced chemical equation for the complete combustion of alkene **A**.

[1]

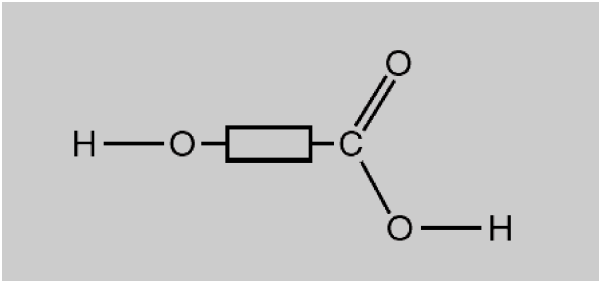
(ii) Enthalpy change for the combustion of **one** mole of alkene **A** is - 4657 kJ/mol. Calculate the energy released when 12 g of alkene **A** is burnt.

[2]

[Total: 10]

OR **[Turn Over**

B9 The structure of glycolic acid can be represented as shown.



(a) Glycolic acid is a solid at room temperature.
Describe the arrangement and motion of the molecules in glycolic acid at room temperature.
[2]

(b) Glycolic acid can polymerise with itself to form a polyester called poly(glycolic acid)

(i) What type of polymer is a polyester?
[1]

(ii) Draw a section of the polymer chain of poly(glycolic acid), showing at least two repeating units.
[2]

(c) Glycolic acid is produced by heating methanal, carbon monoxide and water in the presence of a sulfuric acid catalyst.

$CH_2O + CO + H_2O \rightarrow CH_2(OH)COOH$

methanal glycolic acid

(i) A sample of 1.8 kg of methanal reacts with excess carbon monoxide and water. The percentage yield of glycolic acid is 45%.
Calcuate the mass, in grams, of glycolic acid produced.

[3]

mass of glycolic acid = ---------- g

(ii) Is methanal oxidised or reduced in the reaction? Provide an explanation for your answer in terms of oxygen gain or loss.

[2]

[Total: 10]

END OF PAPER