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HOLY INNOCENTS' HIGH SCHOOL

Established in 1892

Candidate Name

Class | Index Number

PRELIMINARY EXAMINATION 2022
SECONDARY 4 EXPRESS
CHEMISTRY Paper 2

80

6092/02

Date: **17 Aug 2022**

Duration: **1 h 45 min**

Additional Materials: *NIL*

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 paper clips, glue or correction tape/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.

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

You are advised to spend no longer than 65 minutes on Section **A** and no longer than 40 minutes on Section **B**.
For Sections **A** and **B**, the number of marks is given in brackets [ ] at the end of each question or part question.

	For Examiner's use
Sect A	
Sect B	
.....	
.....	
.....	
Total	

Set by: Mr Daniel Lau
Vetted by: Ms Woo Wei Shan

The Periodic Table of the 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 yitrium 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 [50 marks]
Answer **all** questions in this section. Write your answer in the spaces provided.

A1 **Fig. A1.1** shows part of the Periodic Table.

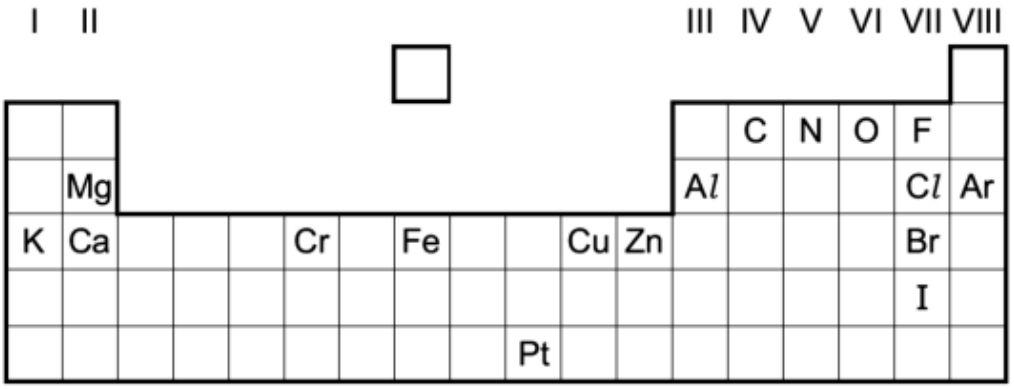


Fig. A1.1

Answer the following questions using only the symbols of the elements in **Fig. A1.1**. Each symbol may be used once, more than once or not at all.

Give the **symbol** of an element that:

(a) is used as a catalyst for the Haber process.

…….. [1]

(b) is used as a catalyst in a catalytic converter.

…….. [1]

(c) is used to galvanise iron.

…….. [1]

(d) is used to define the relative atomic mass of elements.

…….. [1]

(e) forms an oxide which contributes to acid rain.

…….. [1]

(f) reacts with cold water to form a solution that turns Universal indicator violet.

…….. [1]
[Total: 6]

A2 The following question is about bromine and compounds containing bromine.

(a) Bromine is a liquid. Describe the arrangement and motion of the molecules in bromine liquid.

……

……

…… [2]

(b) Draw the dot and cross diagram of a bromine molecule, showing only the valence electrons.

[1]

(c) Briefly explain why reddish-brown bromine liquid will turn colourless when it is added to an aqueous solution of potassium iodide. Include an ionic equation to support your explanation.

……

……

……

……

…… [3]

[Total: 6]

A3 A student carried out some experiments to investigate the displacement reactions of four metals namely, copper, cobalt, iron and a metal **E**. She added the metals separately to various salt solutions.and the observations are recorded in **Table A3.1** below.

metal	**salt solutions**			
	copper(II) sulfate	cobalt(II) sulfate	iron(II) sulfate	$\mathbf{E}_2SO_4$
copper			no change, solution remains green	no change, solution remains colourless
cobalt	brown solid forms in pink solution		no change, solution remains green	no change, solution remains colourless
iron	brown solid forms in green solution			no change, solution remains colourless
E	brown solid forms in colourless solution	grey solid forms in colourless solution	grey solid forms in colourless solution	

Table A3.1

(a) It was concluded that the order of reactivity of the four metals, in increasing order is copper, cobalt, iron, **E**.

Fill in the blanks in **Table A3.1** by deducing the observations of the reactions between

(i) copper and cobalt(II) sulfate solution, and

(ii) iron and cobalt(II) sulfate solution [2]

(b) Write a balanced chemical equation for the reaction between copper(II) oxide and metal **E**.

…….. [2]

(c) Given that magnesium is found between iron and **E** in the reactivity series, suggest the method of extraction for metal **E** from ores.

…….. [1]

[Total: 5]

A4 The Andrussow process is an industrial process for the production of hydrogen cyanide in the presence of platinum as a catalyst.

The structural formulae of all chemicals are shown in the chemical equation below:

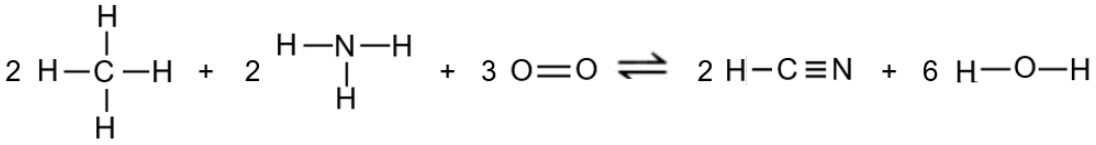


Table A4.1 shows some information about the bonds present in the chemicals.

bond	bond energy / kJmol^{-1}
H – N	390
H – O	464
C ≡ N	891

bond	bond energy / kJmol^{-1}
C – H	413
O = O	498

Table A4.1

(a) Using the information from **Table A4.1**, explain why the enthalpy change of reaction for the Andrussow process is negative.

[3]

(b) To speed up the Andrussow process, a small amount of platinum is added.
Use ideas about energy and collisions to explain how powdered platinum speeds up the process.

……

……

……

……

……

…… [3]

(c) In practice, the yield of hydrogen cyanide produced from the Andrussow process is never 100%.
Suggest a reason why.

……

…… [1]
[Total: 7]

A5 The figure **Fig. A5.1** shows some reactions involving substances **F**, **G**, **J**, **L**.

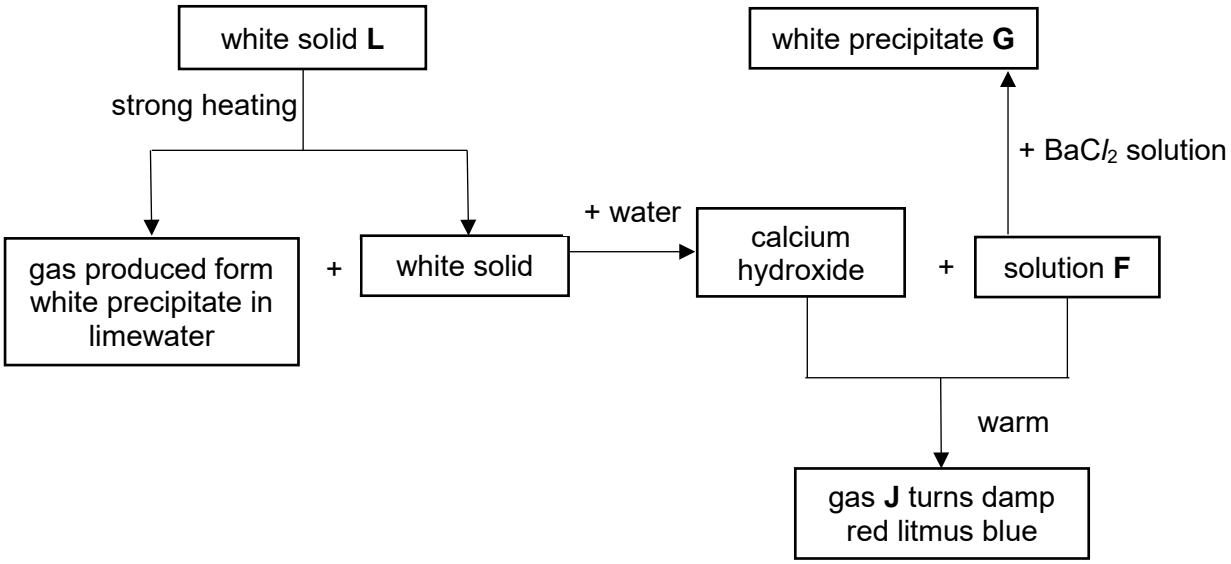


Fig. A5.1

(a) Identify **F**, **G**, and **L**.

F: ……

G: ……

L: …… [3]

(b) Give your observations when **J** is passed through aqueous copper(II) sulfate until no further change.

……

……

…… [2]
[Total: 5]

A6 Acidified potassium manganate(VII) reacts with excess sodium ethanedioate. The ionic equation of the reaction is shown below.

$$2\ MnO_4^-\ (aq) + 16\ H^+\ (aq) + 5\ C_2O_4^{2-}\ (aq) \rightarrow 2\ Mn^{2+}\ (aq) + 8\ H_2O\ (l) + 10\ CO_2\ (g)$$

(a) Describe two observations for this experiment.

……

……

…… [2]

(b) State and explain, in terms of oxidation state, which chemical species is the reducing agent.

……

……

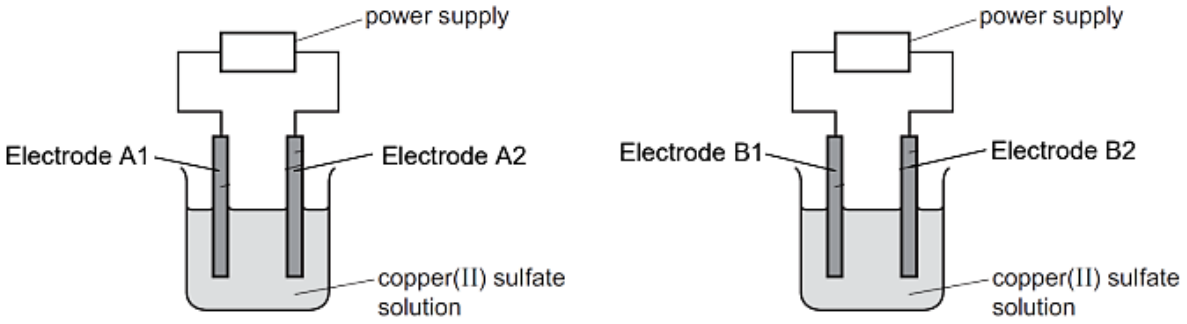
…… [2]

(c) Calculate the volume of CO_2 produced at r.t.p given that 250 cm^3 of 0.5 mol/dm^3 of potassium manganate(VII) was used.

[3]
[Total: 7]

A7 A student electrolysed aqueous copper(II) sulfate using 2 sets of apparatus shown in **Fig. A7.1** below.

The electrodes used in each apparatus are made of the same material. However, the electrodes used in apparatus **A** and **B** are made of different materials.



Apparatus A **Apparatus B**

Fig. A7.1

He recorded the observations for the 2 sets of apparatus in **Table A7.2**.

Apparatus A	Apparatus B
Mass of electrode **A1** has increased	Mass of electrode **B1** has increased
Mass of electrode **A2** remains the same	Mass of electrode **B2** has decreased
Effervescence observed at electrode **A2**	No effervescence observed at electrode **B2**

Table A7.2

(a) Name the particles which transfer the charges through the

(i) copper wires: ……

(ii) copper(II) sulfate solution: …… [2]

(b) State which electrode is the cathode in each apparatus.

Apparatus **A**: …… Apparatus **B**: …… [1]

(c) Explain, with an appropriate equation, the increase in mass at electrodes **A1** and **B1**.

……

……

……

…… [2]

(d) Write the half-equations of the reactions taking place at electrode **A2** and electrode **B2**.

Half-equation of the reaction at electrode **A2**:

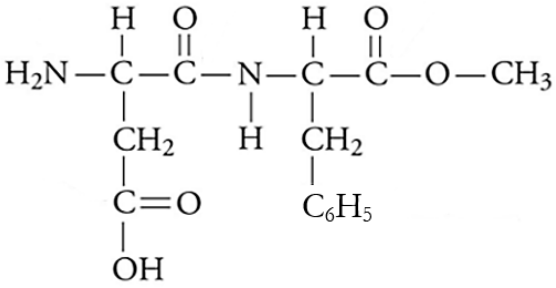
…… [1]

Half-equation of the reaction at electrode **B2**:

…… [1]

[Total: 7]

A8 The structural formula of the artificial sweetener, aspartame, is shown below.



(a) Name two functional groups present in aspartame.

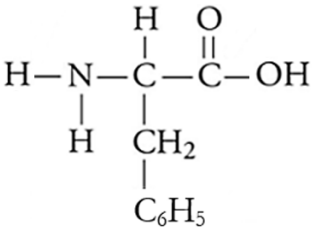
…… [1]

(b) Aspartame is hydrolysed in the stomach to produce methanol as well as the amino acids aspartic acid and phenylalanine.

Hydrolysis involves the reaction of an organic compound with water to form two or more new products through breakage of bonds in the organic compound.

Two of the products of hydrolysis of aspartame are shown below:

methanol



phenylalanine

Draw the structural formula of aspartic acid.

[1]

(c) Methanol reacts with propanoic acid to form water and an ester.

(i) Name the ester formed between methanol and propanoic acid.

…….. [1]

(ii) State the catalyst needed for this reaction.

…….. [1]

(d) A macromolecule can be formed from phenylalanine undergoing condensation polymerisation as a single monomer.

(i) Define the term ‘macromolecule’.

…….....

…….. [1]

(ii) Draw the structural formula of the polymer formed from the monomer phenylalanine, showing two repeating units. Circle the linkage.

[2]
[Total: 7]

Section B [30 marks]

Answer all **three** questions in this section. Write your answers in the spaces provided.
The last question is in the form of **Either/Or** question. Only one part should be answered.

B9 PUB's Water Treatment and Water Quality Monitoring 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, sparkling, odourless, colourless, and safe for drinking. This multi-barrier water treatment process, together with our comprehensive on-line monitoring, sampling and control system, ensures water that arrives at our taps is well within the World Health Organisation (WHO) guidelines for clean drinking water.

The Public Utilities Board's (PUB) water treatment and water quality monitoring process is shown in **Fig B9.1** and **Table B9.2**.

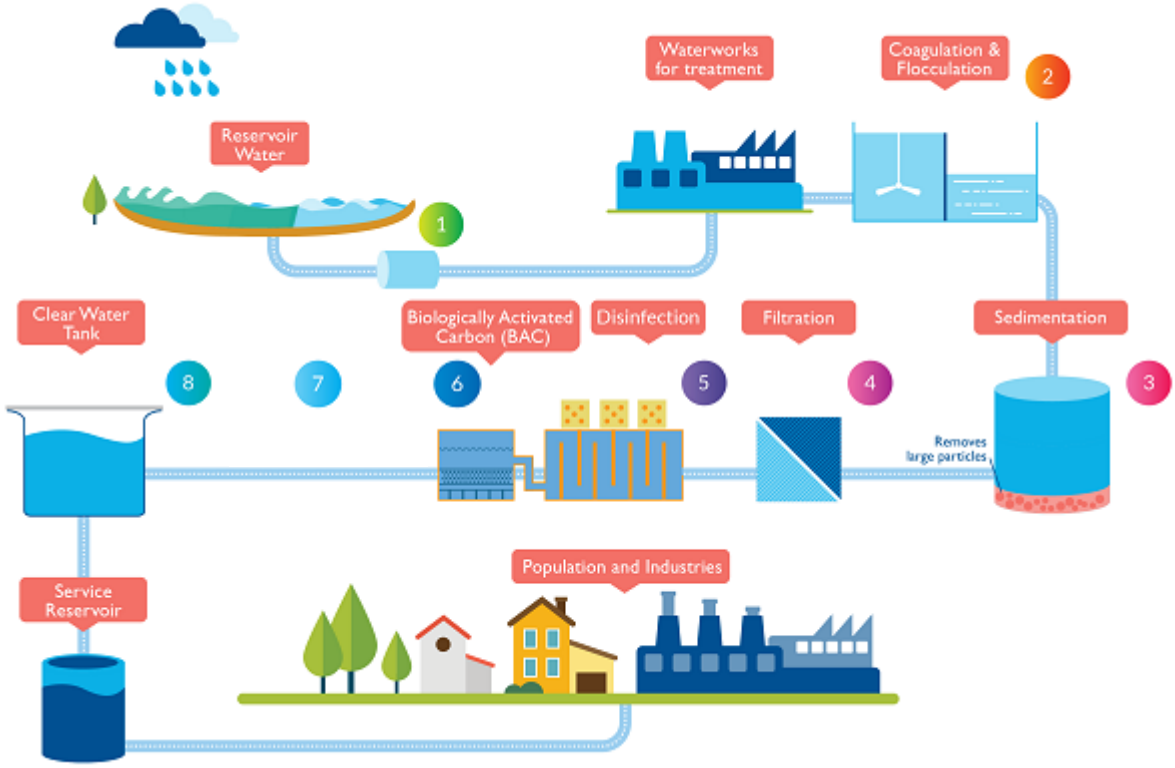


Fig B9.1

process	description of process
1. Screening	Water is pumped through self-cleaning screens to remove particles greater than 1mm.
2. Coagulation & Flocculation	Coagulants and coagulant-aids like alum (aluminium sulfate) are added to bind or "flocculate" smaller suspended matter and particles, such as silt and sand, to form larger and heavier clumps.
3. Sedimentation	Particles combine into larger clumped particles that settle to the bottom of the tank and are removed.

4. Filtration	The water then passes through either rapid sand filter or membranes to remove the finer residual particles of up to 0.02 microns.
5. Disinfection	After filtration, the water is disinfected with chlorine or ozone to kill all harmful bacteria and viruses.
6. Biologically Activated Carbon (BAC)	Granular activated carbon filters remove natural organic matter, making the water biologically-stable. It is termed biologically activated because the carbon is coated with bacteria. The carbon preferentially attracts dissolved organic compounds. The bacteria coating then helps to digest and break down the organic compounds into simpler, harmless products.
7. Residual Treatment	The water is dosed with lime (to balance the pH of water), chlorine and ammonia (to maintain the water quality in the distribution system), as well as fluoride (to prevent tooth decay).
8. Clear Water Tank	After residual treatment, water is stored in the clear water tank, before pumping to the service reservoirs for distribution to customers.

Table B9.2

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.

Paper chromatography can be used in the detection of transition metal ions. **Table B9.3** shows the standard R_f values for some cations using 5% aqueous benzalkonium chloride as the solvent.

name of ion	**R_f value**
copper(II)	0.41
cobalt(II)	0.53
iron(III)	0.24
nickel(II)	0.69

Table B9.3

(a) As seen in **Table B9.2**, aluminium sulfate is added as the main coagulant in process 2. Use the data to suggest why coagulation helps to increase the effectiveness of sedimentation (process 3) and filtration (process 4).

……

……

……

…… [2]

(b) Use the data in **Table B9.2** to explain the differences in how filtration and Biologically Activated Carbon (BAC) helps in the treatment of water.

……

……

……

…… [2]

(c) Explain how calcium oxide helps in adjusting the pH of water in process 7.

……

……

…… [1]

(d) 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 B9.4**.

name of ion	concentration in mol/dm^3
aluminium	0.32
calcium	0.78
iron(III)	0.46
lead(II)	0.40
chloride	0.91
nitrate	0.57
sulfate	0.53

Table B9.4

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.

Identify and explain the error in <u>one</u> of the company's claims.

……

……

…….. [2]

(e) A sample of water collected for routine testing is suspected to contain copper(II) and iron(III) ions.

Draw on **Fig B9.5** how the chromatogram would look like if chromatography is performed on this sample of water using 5% aqueous benzalkonium chloride as solvent. [2]

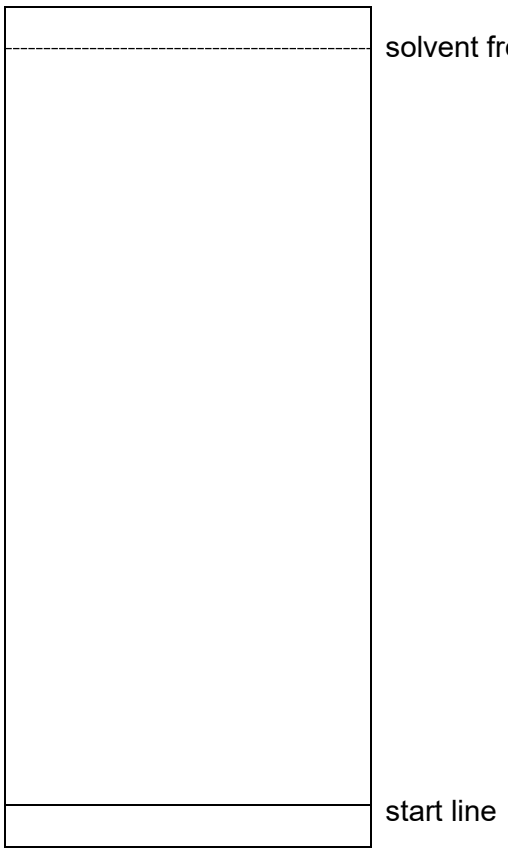


Fig B9.5

(f) If a different solvent was used for the chromatography in **part (e)**, briefly explain whether you would expect to see a similar chromatogram.

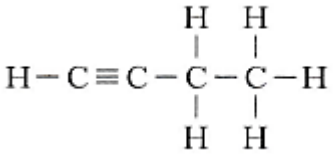
……

……

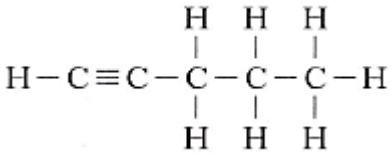
…….. [2]

[Total: 11]

B10 Alkynes are a homologous series of hydrocarbons. The structural formulae of two members of this series are shown.



1-butyne



1-pentyne

(a) Give another <u>two</u> key characteristics, in terms of a structural feature, that provides evidence that the two alkynes are members of a homologous series.

……

…… [2]

(b) The boiling points of four consecutive members of the alkynes series are shown in the table.

name	boiling point / ºC
propyne	- 23.2
1-butyne	8.1
1-pentyne	
1-hexyne	71.3
1-heptyne	100

Table B10.1

(i) Predict the boiling point of 1-pentyne and fill it in **Table B10.1**. [1]

(ii) The boiling points of alkynes increase down the table. Suggest a reason for this trend.

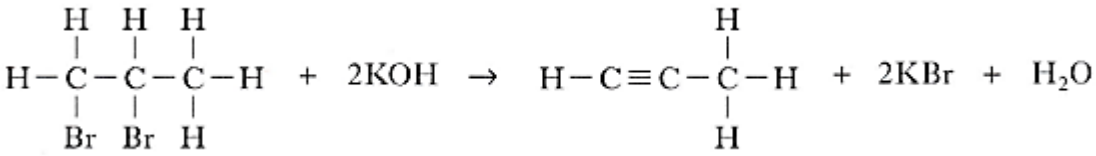
……

……

……

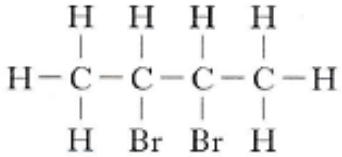
…… [2]

(c) Alkynes can be prepared by reacting a dibromoalkane with potassium hydroxide solution. An equation for the reaction is shown.



dibromopropane propyne

Another dibromoalkane shown below also reacts with potassium hydroxide solution.



(i) Draw the structural formula of the alkyne formed.

[1]

(ii) State how the alkyne formed in **part(d)(i)** is related to 1-butyne.

…….. [1]

(d) Alkynes react in a similar way to alkenes. Write an equation for the complete combustion of 1-butyne.

…….. [2]

[Total: 9]

B11 Either

The minimum temperature required to decompose the Group II carbonates is shown in **Table B11.1**.

group II carbonates	minimum temperature of decomposition / ºC
$MgCO_3$	350
$CaCO_3$	832
$SrCO_3$	1340
$BaCO_3$	1450

Table B11.1

(a) When solid copper(II) carbonate is heated, it behaves in a similar way to the Group II carbonates.
Write an equation for the reaction that occurs when copper (II) carbonate is heated.

…….. [1]

(b) Describe the trend shown in **Table B11.1** for the decomposition of Group II carbonates.
Provide an explanation for this trend.

……

……

……

……

……

…….. [3]

(c) A student added 25.0 cm^3 of 0.200 mol/dm^3 of dilute sulfuric acid to 1 g of solid $MgCO_3$ and $CaCO_3$ separately. She recorded her observations in **Table B11.2** below.

observation with $MgCO_3$	observation with $CaCO_3$
Rapid effervescence. Solid $MgCO_3$ disappears completely.	Some effervescence initially and then stops. Solid $CaCO_3$ remains.

Table B11.2

(i) Provide an explanation for the observation with $CaCO_3$ in **Table B11.2**.

……

……

……

…… [2]

(ii) The student's teacher said that her observation for $MgCO_3$ is **incorrect**. Show, using calculations, that the student's observation for $MgCO_3$ is indeed **incorrect**.
Hence, describe the correct observation.

Calculations:

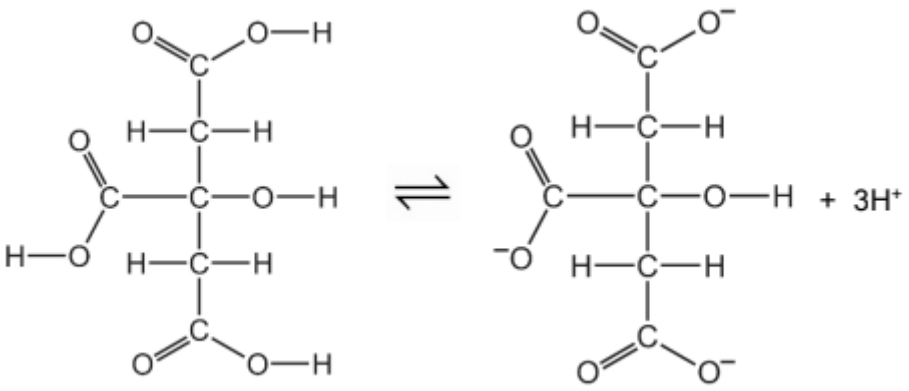
[3]

Observation: ……

…… [1]
[Total: 10]

B11 Or

Citric acid ionises when it is dissolved in water.



(a) A student prepared two conical flasks **A** and **B** which contain 100 cm^3 of 1.00 mol/dm^3 of different acids. Flask **A** contains aqueous citric acid while flask **B** contains dilute sulfuric acid. Excess magnesium was added into both flasks. The gas produced was collected and measured

The observations were recorded in **Table B11O.1**.

observation 1:	Effervescence of colourless gas was more rapid in flask **B**.
observation 2:	The volume of gas collected from flask **A** is larger.

Table B11O.1

(i) Name an apparatus to collect the gas produced.

…….. [1]

(ii) Describe a test to identify the gas produced in both experiments.

…….....

…….. [2]

(iii) Explain **observation 1** and **2**.

…….....

…….....

…….....

…….. [2]

(b) A sample of aqueous citric acid was titrated with aqueous potassium hydroxide to obtain potassium citrate as the salt.

Potassium citrate decomposes at 230 ºC and is used to treat people with kidney stones and gout.

(i) State the type(s) of bonding present in potassium citrate.

…….. [1]

(ii) Explain why potassium citrate is described as the salt of the reaction.

……

…….. [1]

(iii) Describe how you would obtain pure dry crystals of potassium citrate from its solution.

……

……

……

……

……

…….. [3]

[Total: 10]

- End of paper -