SWISS COTTAGE SECONDARY SCHOOL
SECONDARY FOUR
PRELIMINARY EXAMINATION

O

Name			Academic Class	4	A	
	Form Class Index Number		Form Class	4	S	

CHEMISTRY

6092/02

Paper 2

Wednesday 28 August 2024

1 hour 45 minutes

No Additional Materials are required.

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section B
Answer **one** question.
Write your answers in the spaces provided on the Question Paper.

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	/ 70
Section B	/ 10
Total	/ 80

This document consists of **23** printed pages and **1** blank page.

Section A

Answer **all** questions.

A1 Use the list of elements to answer the questions.

zinc	**argon**	**fluorine**	**copper**
hydrogen	**sodium**	**silicon**	**carbon**

Each element may be used once, more than once or not at all.

(a) Name the element that forms an amphoteric oxide.

....[1]

(b) Name the element that can form ions with more than one oxidation state.

....[1]

(c) Name the element that can form a neutral oxide.

....[1]

(d) Name the element that is unreactive.

....[1]

(e) Name the element that is a good oxidising agent.

....[1]

(f) Name the element that forms an oxide with a giant covalent structure.

....[1]

[Total: 6]

A2 **(a)** Fig. 2.1 and Fig. 2.2 show some properties of Group 17 elements, the halogens.

Fig. 2.1 shows the atomic radii and Fig. 2.2 shows the electronegativity of the Group 17 elements.

Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons. It is usually measured on the Pauling scale, on which the most electronegative element (fluorine) is given an electronegativity of 4.0.

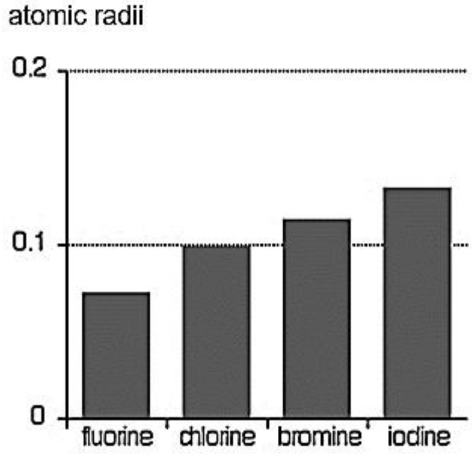

Fig. 2.1

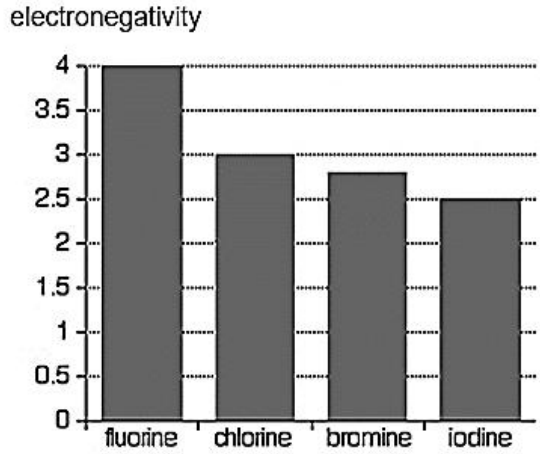

Fig. 2.2

(i) Use Fig. 2.1 to describe and explain the trend in atomic radii for halogens down the group.

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

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

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

(ii) Use Fig. 2.1 and Fig. 2.2 to state and explain the relationship between atomic radii and electronegativity of the halogens.

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

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

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

(iii) Predict and explain the electronegativity value of astatine, the next member of Group 17 element.

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

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

(b) Table 2.1 shows the melting points and boiling points of Group 1 elements, together with the atomic radii.

Table 2.1

	element	melting point / °C	boiling point / °C	atomic radii / pm
Group 1	lithium	180	1330	145
	sodium	98	890	180
	potassium	64	774	220
	rubidium	39	688	235

(i) State the trend observed in the melting and boiling points of Group 1 elements.

....

....[1]

(ii) Explain, in terms of bonding, the trend observed in **(b)(i)**.

....

....

....

....

....[2]

[Total: 6]

A3 Table 3.1 shows some properties of oxyacids of chlorine.

Table 3.1

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.

……...

……...

………[1]

(b) Complete Table 3.1 by filling in the oxidation states of chlorine. [2]

(c) State the relationship between the oxidation state of chlorine and the strength of the acids.

Explain your reasoning using the information in Table 3.1.

……...

……...

……...

………[2]

(d) Identify the acid with the lowest electrical conductivity.

Explain your answer.

……...

………[1]

[Total: 6]

A4 **(a)** Ammonia is produced by nitrogen gas and hydrogen gas during the Haber process.

(i) Since nitrogen is the most abundant gas in air, explain why air is **not** used as a raw material during the Haber process.

....

....

....

....[1]

(ii) Concentrated aqueous ammonia is used to make fertilisers such as ammonium sulfate, $(NH_4)_2SO_4$. Aqueous ammonia reacts with dilute sulfuric acid to form ammonium sulfate, $(NH_4)_2SO_4$.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

A student titrates 20.0 cm^3 of aqueous ammonia with 0.150 mol/dm^3 sulfuric acid. 10.50 cm^3 of sulfuric acid is required to neutralise the aqueous ammonia. Calculate the concentration, in mol/dm^3 , of the aqueous ammonia.

[2]

(b) Table 4.1 shows some fertilisers that are necessary for healthy plant growth. Some of the elements needed by plants are nitrogen, potassium and phosphate.

Table 4.1

type of fertiliser	chemicals commonly used	
potassium-based fertilisers	potassium chloride	KCl
nitrogen-based fertilisers	ammonium nitrate	NH_4NO_3
	urea	$CO(NH_2)_2$
phosphate fertilisers	calcium dihydrogen phosphate	$Ca(H_2PO_4)_2$
	calcium sulfate	$CaSO_4$

Calculate the percentage by mass of nitrogen in ammonium nitrate and urea to determine which fertiliser would give more nitrogen per kg.

[2]

(c) A chemical company makes salts for use in fertilisers.

To make calcium sulfate, the company started with limestone, which is calcium carbonate. Briefly describe how pure calcium sulfate can be made from calcium carbonate.

....

....

....

....

....

....[2]

[Total: 7]

A5 A mixture of grey powder and white crystals undergoes a series of reactions as shown in Fig. 5.1.

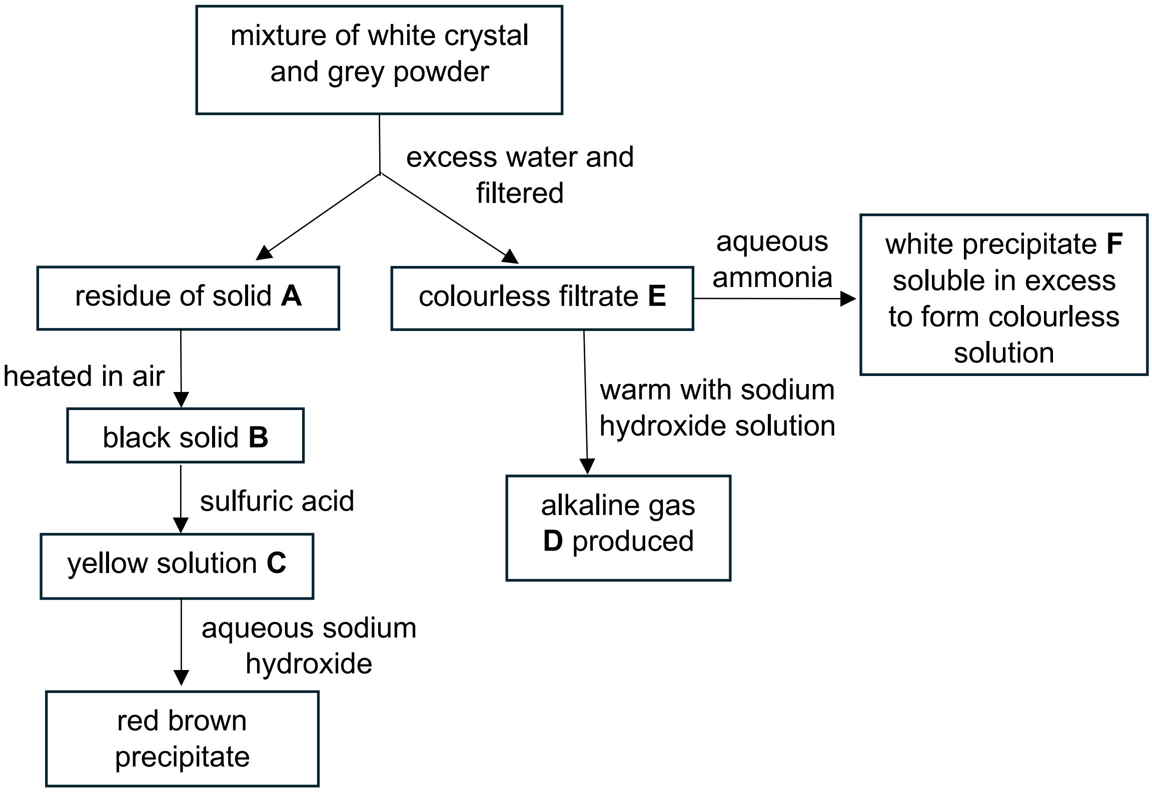

Fig. 5.1

(a) Identify substances **A**, **B**, **C** and **D**.

A ……………………………………

B ……………………………………

C ……………………………………

D …………………………………… [4]

(b) There are two cations present in filtrate **E**. Give the formulae of the two cations present in filtrate **E**.

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

(c) Write the ionic equation for the formation of precipitate **F**.

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

(d) To test for the anion present in filtrate **E**, a student added acidified silver nitrate solution to a sample of **E**. No visible change was observed. What can be concluded from this statement?

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

[Total: 7]

A6 Many metal carbonates thermally decompose to form carbon dioxide and metal oxide. Four 2.00 g samples of carbonates are heated strongly until there is no further change in their masses.
Table 6.1 shows the mass of solid remaining at the end of the heating.

Table 6.1

metal carbonate	mass before heating / g	mass after heating / g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
magnesium carbonate	2.00	0.95
zinc carbonate	2.00	1.35

(a) Calculate the percentage yield of carbon dioxide formed when 2.00 g of zinc carbonate is heated.

[3]

(b) Explain why the mass of carbon dioxide formed is different for each metal carbonate.

……

……[1]

(c) In two separate experiments, hydrogen was passed over heated aluminium oxide and heated copper(II) oxide.
Describe the observation, if any, you would expect to see in each experiment. Explain your reasoning.

……

……

……

……[2]

[Total: 6]

A7 A student electrolysed aqueous copper(II) sulfate using the set-ups shown in Fig. 7.1. The electrodes used in each apparatus are made of the same material. However, the electrodes used in experiment 1 and 2 are made of different materials

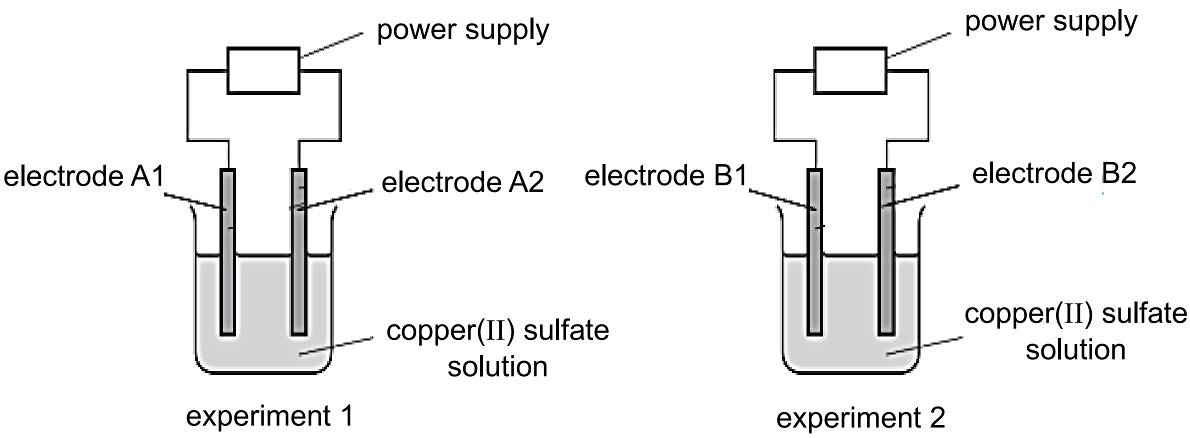

Fig. 7.1

He recorded the observations in Table 7.1.

Table 7.1

experiment 1	experiment 2
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

(a) State which electrode is the cathode in each experiment.

experiment 1 : ………….. experiment 2 : ………….. [1]

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

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

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

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

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

(c) Write the half-equations of the reactions taking place at electrode A2.

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

(d) Universal Indicator is added to the solution after the electrolysis in experiment 1.

Predict the pH and colour of the Universal Indicator in experiment 1.

colour of Universal Indicator in experiment 1 …………………………….

pH of electrolyte in experiment 1 …………………………….

Explain your reasoning.

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

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

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

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

[Total: 7]

A8 Fig. 8.1 shows the apparatus used to investigate the relative reactivity of metals, **A**, **B**, **C** and **D**. The metal strips and copper were first cleaned with sandpaper. The metal strips were connected in turn with the copper strip and the voltage was recorded.

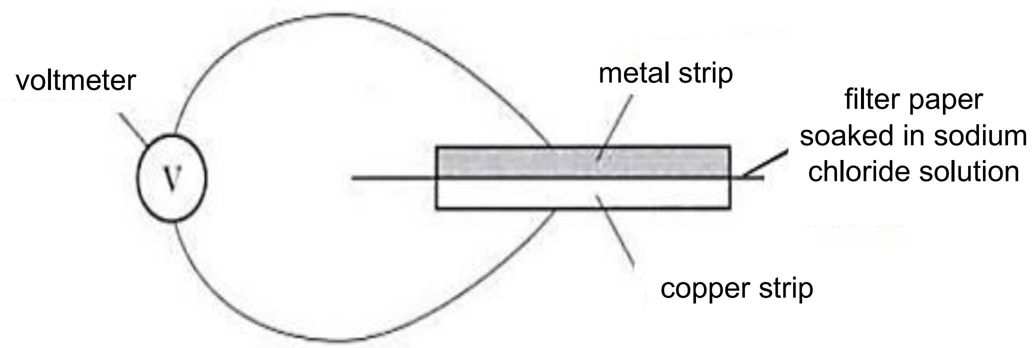

Fig. 8.1

Table 8.1 shows the results.

Table 8.1

metal strip	direction of electron flow	voltage / V
A	from copper to metal **A**	0.78
B	from metal **B** to copper	2.22
C	from metal **C** to copper	1.39
D	from metal **D** to copper	0.28

(a) Use the results in Table 8.1 to deduce the order of reactivity of these four metals and copper.

…………………………………… most reactive

……………………………………

……………………………………

……………………………………

…………………………………… least reactive [2]

(b) Given that metal **C** is an element in Group 2 of the Periodic Table and does not react readily with water, describe two observations you would expect to see if metal **C** were added to copper(II) sulfate solution.

observation 1: ……………………………………………………………………………………......

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

observation 2: ……………………………………………………………………………………..

………[2]

(c) Predict and explain the voltage reading if the experiment with metal **A** and copper were repeated using a piece of filter paper soaked in ethanol instead of sodium chloride solution.

voltage reading = ……………………………………………………………………………..........

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

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

[Total: 5]

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Name: ______________________________ (   )   Class: **4S / 4A** ________

Preliminary Examination 2024
6092 CHEMISTRY
Secondary Four

A9 In Singapore's residential homes, there are two types of supplied gas: piped gas or liquidfied petroleum gas.

Piped gas comprises hydrogen gas and is delivered straight to your kitchen through built-in pipes whenever you turn on the gas stove, whereas liquidfied petroleum gas comprises mainly propane and butane gas, and comes in gas cylinders.

(a) One mole of hydrogen gas gives out 247.5 kJ of energy when combusted. Write a chemical equation for the combustion of hydrogen gas and its enthalpy change of reaction in kJ/mol.

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

(b) The enthalpy change for the combustion of one mole of propane is – 2025 kJ/mol.

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\Delta H = -2025$ kJ/mol

(i) Explain, in terms of bond forming and bond breaking, why the combustion of propane is exothermic.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) Draw the energy profile diagram for the combustion of propane.

[2]

(c) Suggest one advantage for using each type of gas.

piped gas: ……………………..………………………………………………………………..………

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

liquidfied petroleum gas: ……………………………………………………………..…………

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

[Total: 8]

A10 Co-ordinate Bonds

In 1913, the Bohr model was introduced to explain the structure of an atom. Based on the Bohr model, an atom consists of a small, dense nucleus surrounded by electrons in fixed orbits.

The Bohr model also shows the formation of a simple covalent bond as the sharing of a pair of valence electrons from two atoms. A co-ordinate bond is a covalent bond in which both electrons come from the same atom.

An example of a co-ordinate bond can be found in the ammonium cation. Ammonium ion is formed when ammonia gas reacts with hydrogen chloride. During the reaction the H^+ ion will attach to ammonia forming ammonium ion while the electron from hydrogen remains on the chlorine atom to form a chloride ion.

$$NH_3 + HCl \rightarrow NH_4Cl$$

The co-ordinate bond is represented by an arrow in the structural formula, pointing from the atom that contributes the pair of electrons to the other atom. The structural formula of ammonium cation is as shown in Fig. 10.1.

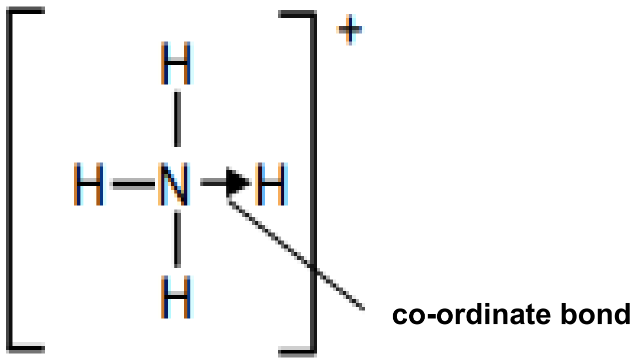


Fig. 10.1

Ligand Exchange Reactions

Ligands are ions or molecules that bind to a central metal atom to form a complex metal ion. The ligand shares one of its electron pair with the central metal atom, forming a co-ordinate bond.

In general, the cations involved in qualitative analysis are considered as complex metal ions. For example, in a beaker containing $CuSO_4$ solution, water acts as a ligand, sharing one electron pair with Cu^{2+} ion, forming a complex ion of copper(II) with molecular formula $[Cu(H_2O)_6]^{2+}$. The structural formula of $[Cu(H_2O)_6]^{2+}$ is as shown in Fig. 10.2 .

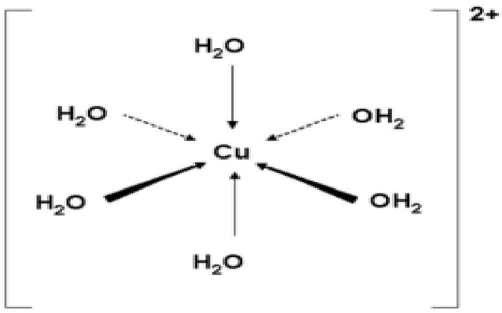


Fig. 10.2

When a small volume of aqueous sodium hydroxide is added to a solution of copper(II) ions, a complex, light blue precipitate of $Cu(H_2O)_4(OH)_2$ is formed. The molecular formula of the precipitate remains the same when excess aqueous sodium hydroxide is added.

When a small volume of aqueous ammonia is added to a solution of copper(II) ions, $Cu(H_2O)_4(OH)_2$ is formed, containing four H_2O ligands and two OH^- ligands. When aqueous ammonia is added in excess, four ammonia ligands replaces two OH^- ligands and two H_2O ligands.

(a) **(i)** Draw the dot-and-cross diagram of ammonium chloride, showing only the outer shell electrons.

[2]

(ii) Given that there is only one co-ordinate bond formed from the reaction between ammonia and boron trifluoride, draw the structural formula of the product, NH_3BF_3.

[1]

(b) **(i)** Describe the observations when aqueous ammonia is added to a solution of copper(II) ions until there are no further changes.

....

....

....

....[2]

(ii) Suggest the molecular formula of the complex ion of copper(II) after adding excess aqueous ammonia.

....[1]

(iii) Draw the structural formula of the complex ion of copper(II) after adding excess aqueous ammonia.

[2]

(c) **(i)** Suggest the molecular formula of the complex ion of iron(II) after adding excess aqueous ammonia.

....[1]

(ii) With reference to the complex ions of both metals, explain the difference in observations when excess aqueous ammonia is added to copper(II) and iron(II) solutions in separate test tubes.

....

....

....[1]

(iii) Green precipitate formed after adding aqueous sodium hydroxide to iron(II) solution. After a while, It was observed that the surface of the green precipitate in the test tube turns red-brown. Explain the observation.

....

....

....[2]

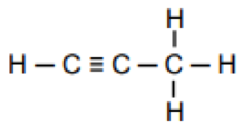
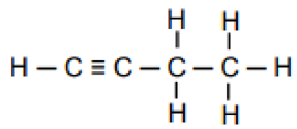
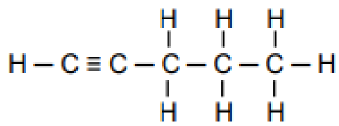
[Total: 12]

Section B

Answer **one** question from this section.

B11 Alkenes and alkynes are two homologous series of hydrocarbons. These hydrocarbons are sometimes obtained from the fractional distillation of crude oil. Table 11.1 shows the structural formulae of the first four members of alkynes.

Table 11.1

alkyne	**structural formula**
ethyne	H – C ≡ C – H
propyne	
but-1-yne	
pent-1-yne	

(a) Ethyne and propyne are unsaturated hydrocarbons. Both have the same general formula.

(i) Explain what is meant by '*ethyne and propyne are unsaturated hydrocarbon*'.

....

....[2]

(ii) Deduce the general formula of alkynes.

....[1]

(iii) Draw the full structural formula of the fifth member of the alkyne homologous series.

[1]

(b) The chemical reactivity of alkynes is similar to alkenes.

(i) When propyne reacts with chlorine gas, the reaction is similar to reaction with aqueous bromine, a mixture of organic compounds are formed. One compound is able to decolourise aqueous bromine while the other does not.
Draw two possible full structural formulae of these organic compounds.

[2]

(ii) X is an isomer of pent-1-yne that can form a polymer. Part of this polymer structure is shown in Fig. 11.1.

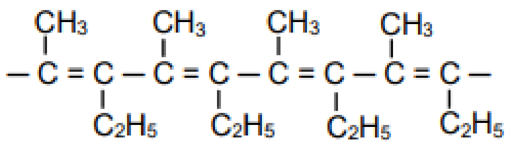


Fig. 11.1

State the type of polymerisation that X can undergo and draw the full structural formula of this isomer.

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

(iii) One of the organic compounds formed in **(b)(i)** continues to react with chlorine gas and formed a mixture of organic molecules when exposed to ultra-violet light. Draw the full structural formulae of a product formed.
Name the product you have drawn.

name of organic compound: ………………………………………………………...….[2]

[Total: 10]

B12 **(a)** Fig. 12.1 shows various reactions involving organic compounds, with ethene as the starting material.

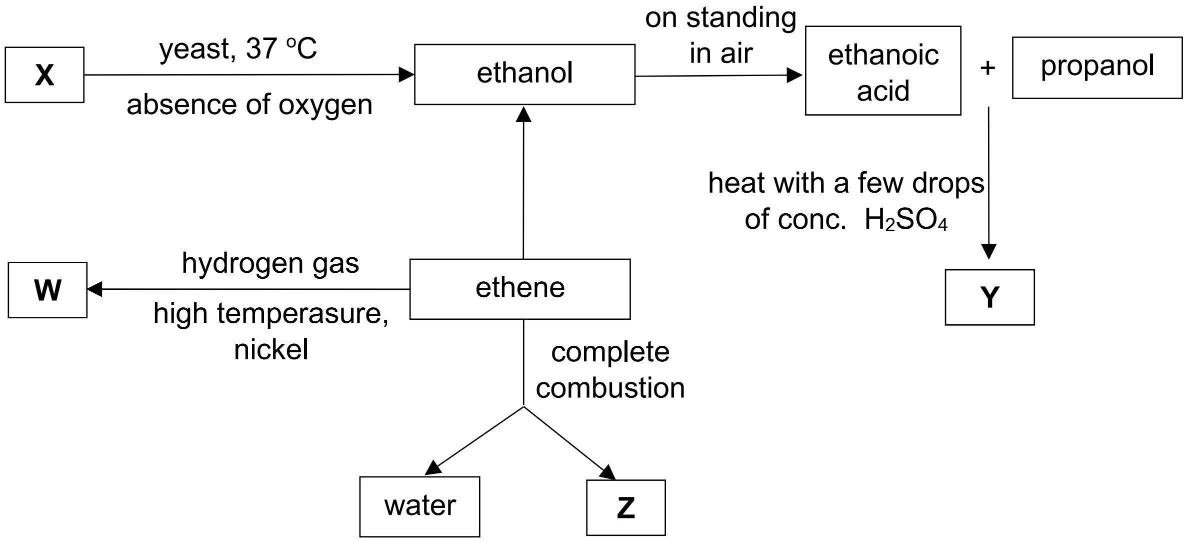


Fig. 12.1

Identify **W**, **X**, **Y** and **Z**.

W .... **X** ....

Y .... **Z** .... [4]

(b) Fumaric acid is a white crystalline chemical compound which can be extracted from plants. When solid fumaric acid is dissolved in water, a colourless solution is formed. Fig. 12.2 shows the structural formula of fumaric acid.

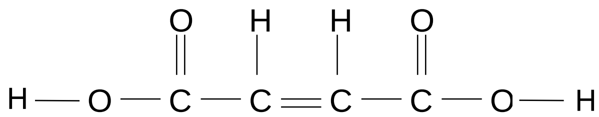


Fig. 12.2

(i) Describe what you would observe when aqueous fumaric acid is added to bromine solution and draw the **full structural formula** of the product formed.

....

....[2]

(ii) Fumaric acid can undergo condensation polymerisation with ethane-1,2-diol to form polymer **M**. Fig. 12.3 shows the structural formula of ethane-1,2-diol.

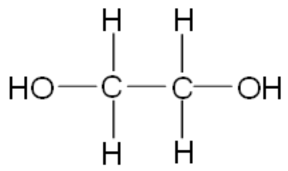


Fig. 12.3

Name the linkage present in **M**.

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

(c) Fumaric acid can also undergo addition polymerisation to form polymer **N**. Polymer **N** is non-biodegradable and can possibly pose problem to our environment during disposal.

(i) Draw the structure of polymer **N**, showing two repeating units.

[1]

(ii) Define *non-biodegradable*.

……………………………………………………………………………………………….

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

(iii) Suggest a possible problem that polymer **N** can pose to our environment during disposal.

……………………………………………………………………………………………….

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

[Total: 10]

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							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	3	4	5	6	7	8	9	10	11	12	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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).
The Avogadro constant, $L = 6.02 \times 10^{23}\,mol^{-1}$.