Name: …… Index No: …… Class: ……..…

Bukit Batok Secondary School

GCE O LEVEL PRELIMINARY EXAMINATIONS 2024

SECONDARY 4 EXPRESS

CHEMISTRY **6092/02**

Paper 2 **20 August 2024**
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.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers 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	
Section A	/ 70
Section B	/ 10
Total	/ 80

Section A

Answer **all** questions in the spaces provided.
The total mark for this section is 70.

1 The following article featured in a newspaper describes how increasing global temperatures due to global warming, grounding planes at the airport.

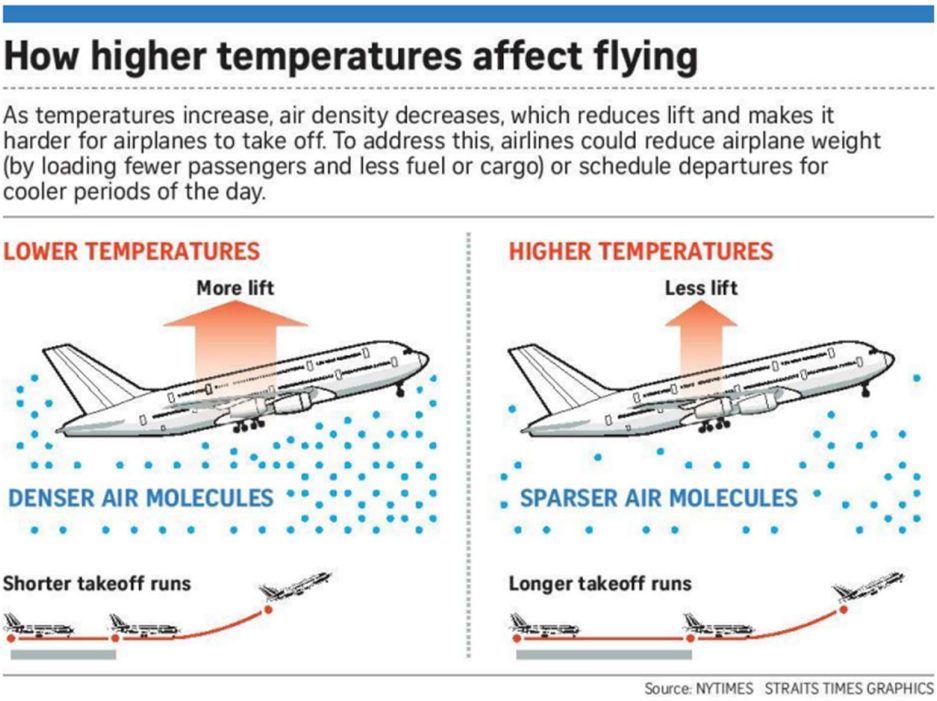


Fig. 1.1

(a) A student explained that the increase in temperature leads to fewer molecules per unit volume.

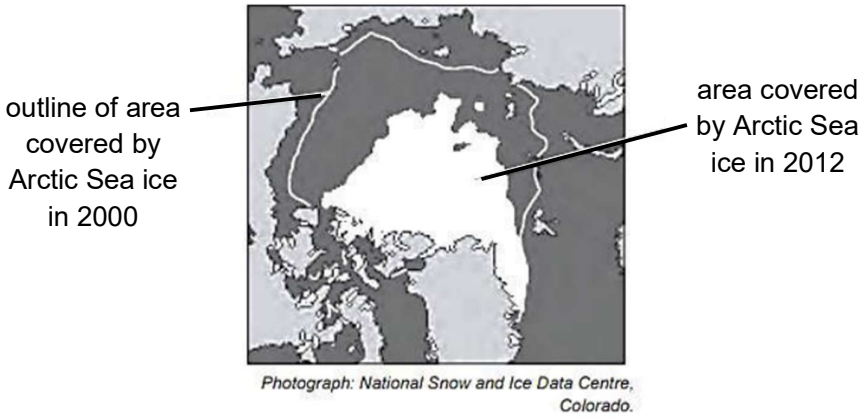
Explain, using Kinetic Particle Theory, how cooler periods of the day allow more lift for the airplane to take off.

……

……

..... [2]

(b) Environmental groups think that the shrinking of the ice caps is the result of global warming. Satellite images are used to show the area of Arctic Sea ice as shown in Fig. 1.2.



Photograph: National Snow and Ice Data Centre, Colorado.

Fig. 1.2

(i) Give **one** consequence of the reduction of Arctic Sea ice.

……

…… [1]

(ii) Describe **one** possible source of global warming that has led to the reduction of Arctic ice.

……

…… [1]

(iii) Scientists are currently developing a process called carbon capture and storage (CCS). This will reduce the problem of global warming. There are three main steps to CCS. Firstly, carbon dioxide is trapped and separated from other gases produced in coal-powered electricity plants. The captured carbon dioxide is transported to a storage location. The carbon dioxide is then stored far away from the atmosphere (underground or deep in the ocean).

Suggest one reason why some scientists do **not** support the use of CCS. Use the information above to help you answer.

……

…… [1]

[Total: 5]

2 Titanium (melting point of 1688 °C) can be extracted from its ore, rutile. Fig. 2.1 shows how titanium metal is extracted from rutile.

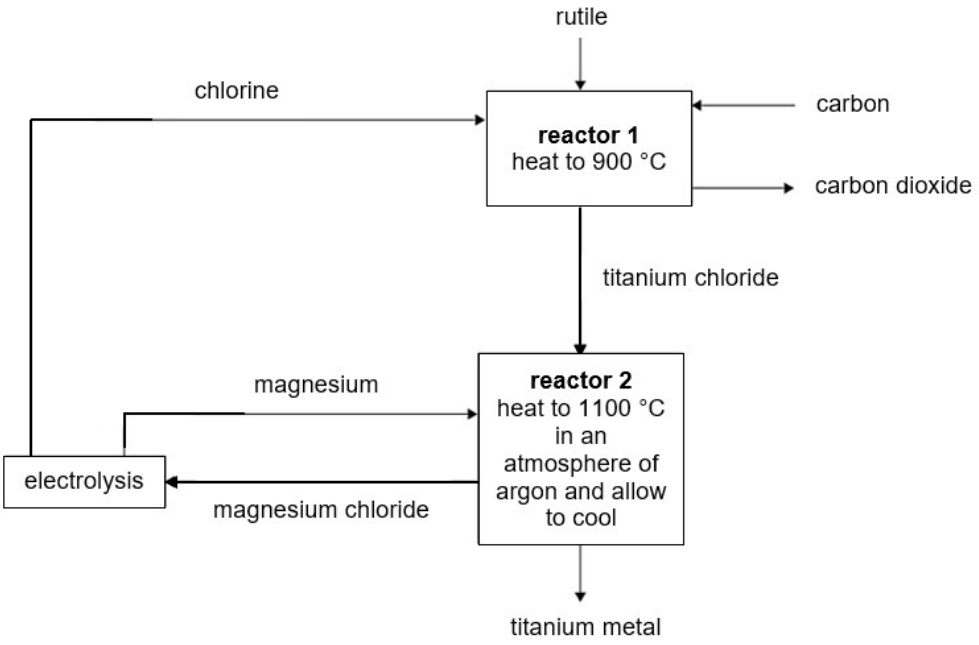


Fig. 2.1

(a) Using the information provided, arrange carbon, magnesium and titanium in increasing order of reactivity, least reactive first.

……..…….... [1]

(b) Describe an example of recycling in the extraction of titanium.

……

..... [1]

(c) Explain why an atmosphere of argon must be used in reactor 2.

…..……

……..…….... [1]

(d) Describe how the titanium produced in reactor 2 can be separated from magnesium chloride.

……

……

..... [2]

[Total: 5]

3 **(a)** The Haber Process for the production of ammonia is one of the most important industrial process.

Which of the following statements about this process are **true** and which are **false**? Put a tick (√) in one box in each row.

	true	**false**
An iron catalyst is used.		
The reaction is reversible and so the conditions must be chosen carefully to give the best yield.		
A good yield of ammonia is obtainable even without the use of high pressure.		
Nitrogen from the air is converted into a substance from which nitrogenous fertilisers can be easily produced.		

[2]

(b) Ammonia is made from nitrogen.
Nitrogen can be converted into ammonium and nitrate ions.

Various tests are conducted using solutions **A**, **B** and **C** to identify compounds of ammonium and nitrate.

Complete the following table with respect to solutions **A, B** and **C**. [5]

Solutions	tests	observations	identity of substance
A	(i)	pungent gas evolved which turns damp red litmus blue	ammonium sulfate
	(ii)	white precipitate formed is insoluble in nitric acid	
B	sodium hydroxide is added to **B**, until in excess	(iii)	copper(II) nitrate
	(iv)	pungent gas evolved which turns damp red litmus blue	
C	aqueous lead(II) nitrate is added to **C**	yellow precipitate formed	(v)

[Total :7]

4 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 present are shown in Fig. 4.1.

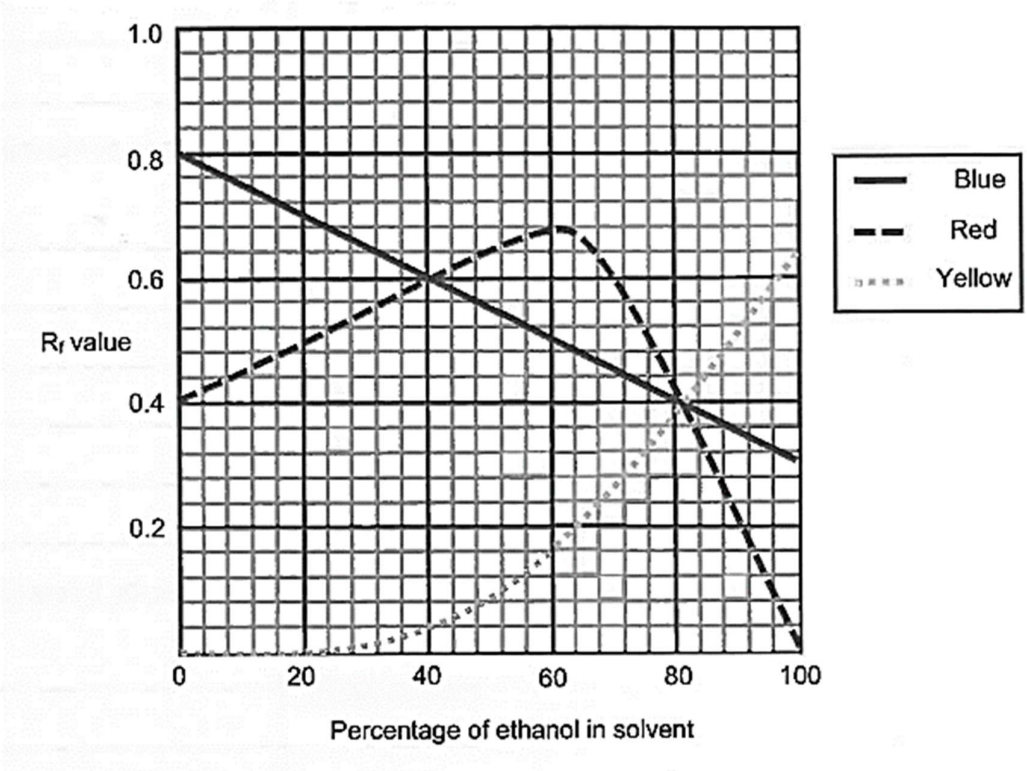


Fig. 4.1

(a) Using the graph, explain why a pure solvent of either water or ethanol **cannot** be used to separate 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. Explain why it **cannot** be concluded that the ink sample is a pure substance.

……

..... [1]

(c) What is the R_f value of the blue, red and yellow dyes when a solvent mixture containing 80 cm^3 ethanol and 120 cm^3 water is used in the chromatography?

R_f value of blue dye ……..

R_f value of red dye …….

R_f value of yellow dye ……. [2]

(d) Is the solvent mixture in **(c)** appropriate to be used if required to separate the 3 dyes? Explain why.

……

..... [1]

[Total: 6]

5 10 cm^3 of ethanoic acid of unknown concentration is titrated with 0.10 mol/dm^3 of aqueous sodium hydroxide. It was found that 20 cm^3 of the sodium hydroxide solution was required for the neutralisation to be completed.

(a) **(i)** Write a balanced chemical equation for the reaction between ethanoic acid and sodium hydroxide.

……. [1]

(ii) Calculate the concentration of the ethanoic acid used in the above titration.

[2]

(iii) The formula to calculate the pH of a solution is:
$pH = – lg [H^+]$

pH is the negative logarithm to base 10 of the concentration of hydrogen ions.

For example, if the concentration of H^+ ions is 0.1 mol/dm^3,
then $pH = – lg [0.1] = 1$

It is found that the pH value of 0.1 mol/dm^3 ethanoic acid solution is higher than 1.

Using the information above, determine the pH of ethanoic acid.
Suggest a reason why the pH is more than 1.

……...

……...

……...

……. [2]

(b) The titration curves in Fig. 5.1 show the changes in pH that occurs when a strong acid and a weak acid is titrated with sodium hydroxide respectively.

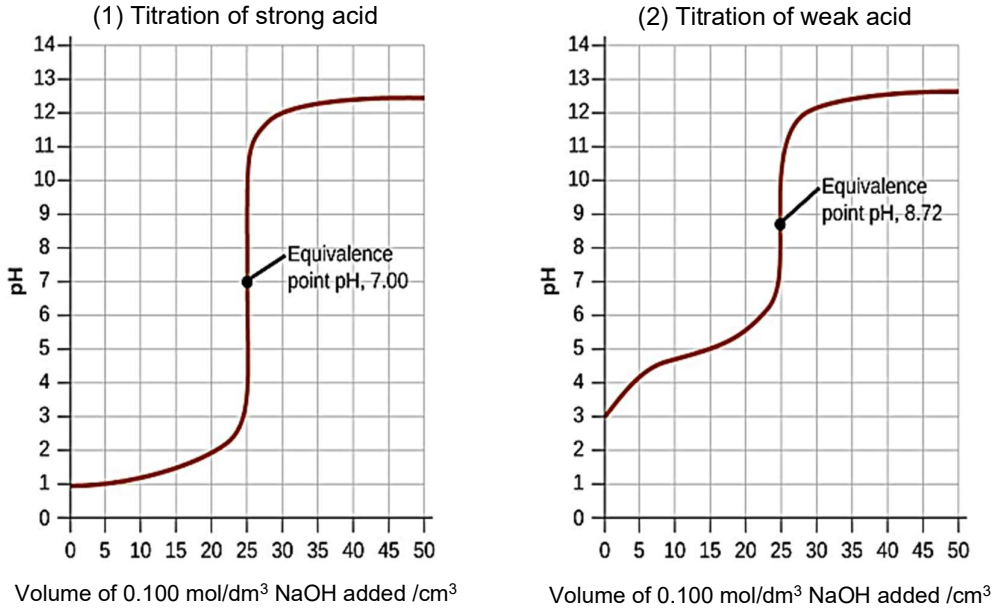


Fig. 5.1

The equivalence point is the point where the acid is neutralised by the alkali.

(i) Describe **two** key differences in the two titration curves illustrated above other than the difference in the pH values at the equivalence point.

……...

……...

……...

…… [2]

(ii) What does the pH values at the equivalence points of the two titrations suggest about the nature of the salt formed in each of the two titrations?

……...

…… [1]

[Total: 8]

6 Fig. 6.1 shows reaction schemes of organic compounds.

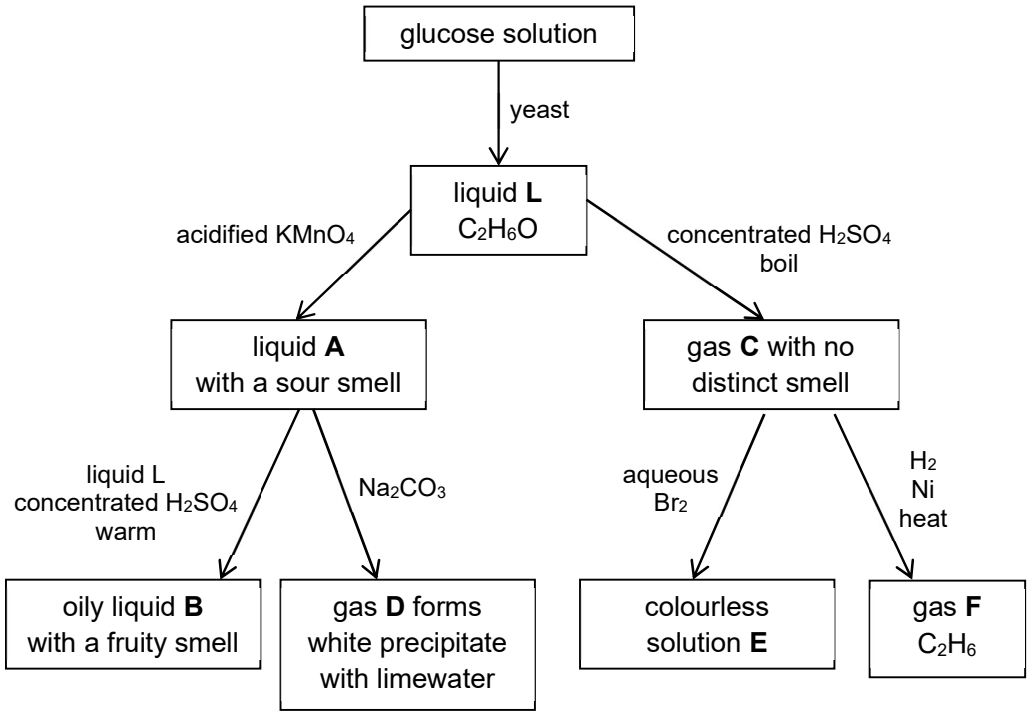


Fig. 6.1

(a) Name

liquid **A** ……

liquid **B** ……

gas **C** ……

gas **D** ……

solution **E** ……

gas **F** ……

liquid **L** …… [4]

(b) Write a balanced chemical equation for the reaction between liquids **A** and **L**.

…… [1]

[Total: 5]

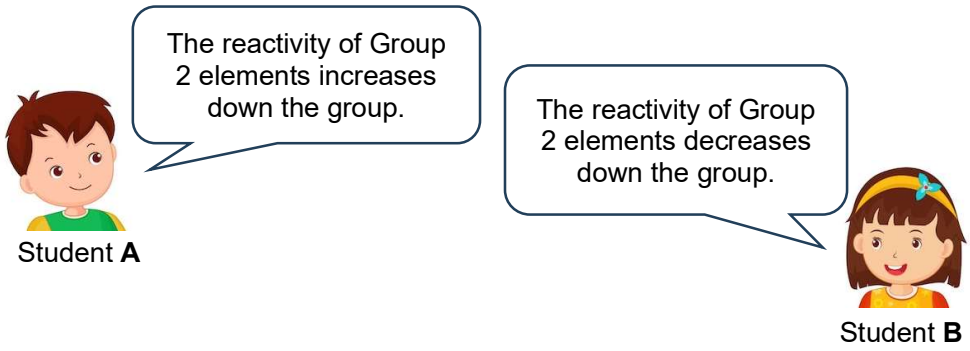
7 Table 7.1 shows some properties of the first five Group 2 metals.

Table 7.1

element	electronic configuration	melting point / °C	density / g/cm^3	atomic radius / pm
beryllium	2.2	1278	1.85	113
magnesium	2.8.2	650	1.74	160
calcium	2.8.8.2	839	1.54	197
strontium	__ . __ . __ .8.2	769	2.63	215
barium	2.8.18.18.8.2	725	3.65	217

(a) Fill in the blanks for the electronic structure of strontium in Table 7.1. [1]

(b) Two students made the following comments on the data in Table 7.1.



Do you agree with student **A** or **B**?
Explain your answer with reference to the data in Table 7.1.

……

……

……

…… [2]

(c) Table 7.2 shows some properties of mercury.

Table 7.2

element	electronic configuration	melting point / °C	density / g/cm^3	common oxidation states
mercury	2.8.18.32.18.2	–39	13.5	+1, +2

(i) Deduce the chemical formulae of the oxides formed by mercury.

……..……. [1]

(ii) Predict the nature of the oxides formed by mercury.

…… [1]

(d) Mercury(II) sulfate, commonly called mercuric sulfate, has the chemical formula $HgSO_4$. It is an odourless salt that forms white granules or crystalline powder.

Draw the dot-and-cross diagram of the sulfate ion in mercury(II) sulfate.

[2]

[Total: 7]

8 The reaction between sodium persulfate, $Na_2S_2O_8$, and potassium iodide, KI, is very slow. This reaction can be sped up by the addition of iron(III) chloride solution.

The ionic equation for the uncatalyzed reaction is :
$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$

In the presence of a small amount of iron(III) chloride solution, the catalysed pathway involved two steps :

Step 1 : $2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$
Step 2 : $2Fe^{2+}(aq) + S_2O_8^{2-}(aq) \rightarrow 2Fe^{3+}(aq) + 2SO_4^{2-}(aq)$

(a) Identify the oxidising and reducing agents in step 2 of the catalysed reaction.

oxidising agent : ……

reducing agent : …….. [1]

(b) Give the overall equation of the catalysed reaction.

……. [1]

(c) Explain how a catalyst works.

……

……

……

…… [2]

(d) Based on the charges of the reactants, suggest why the uncatalyzed reaction between sodium persulfate and potassium iodide is very slow.

……

…… [1]

(e) Explain why only a small amount of iron(III) chloride is required to catalyse the reaction.

……

…… [1]

(f) With reference to oxidation states, suggest why magnesium chloride solution **cannot** be used to catalyse this reaction.

……

…… [1]

[Total : 7]

9 Bond energies and distance between nuclei

The formation of a covalent bond involves the sharing of electrons between atoms, forming a stable balance between attractive and repulsive forces between the two atoms being bonded. In a hydrogen molecule, H_2, the hydrogen atoms share two electrons via covalent bonding. The bond energy is the amount of energy needed to break one mole of a covalent bond. The bond energy of a H – H bond is 432 kJ/mol.

Fig. 9.1 shows how the bond energy between the two hydrogen atoms varies with the distance between their nuclei.

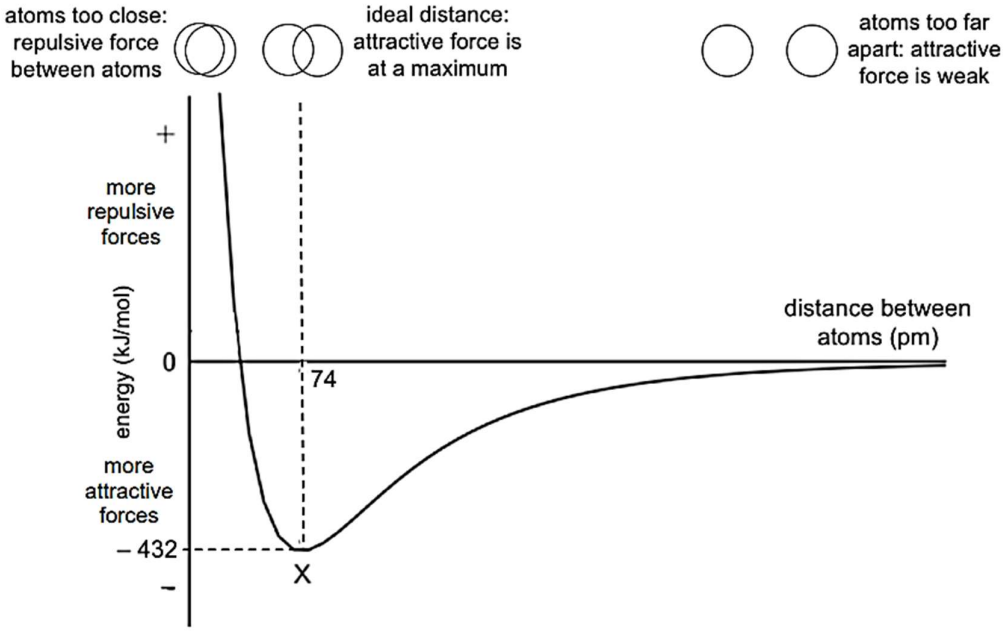


Fig. 9.1

A positive energy value means that repulsive forces between the atoms' nuclei are dominant.

A negative energy value means that attractive forces between the atoms' nuclei 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 (pm).

Bond energies of elements in Period 2

Table 9.1 shows how the H – H bond compares with the number of bonds, bond lengths and bond energies of some elements in Period 2.

Table 9.1

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	125
N ≡ N	3	942	110
F – F	1	155	142

Chemical bonding in covalent compounds

Fig. 9.2 shows the trends of boiling points of some covalent compounds across Period 3 of the Periodic Table.

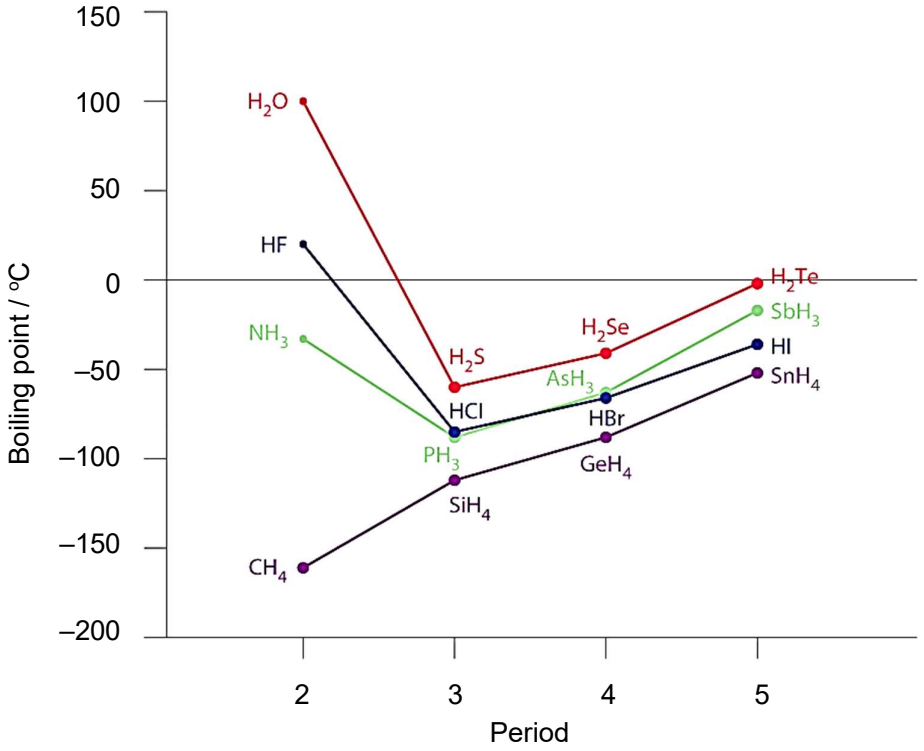


Fig. 9.2

Hydrogen bonds are electrostatic attraction forces formed between a hydrogen atom of a molecule and a highly electronegative atom (e.g. fluorine, oxygen and nitrogen) of another molecule.

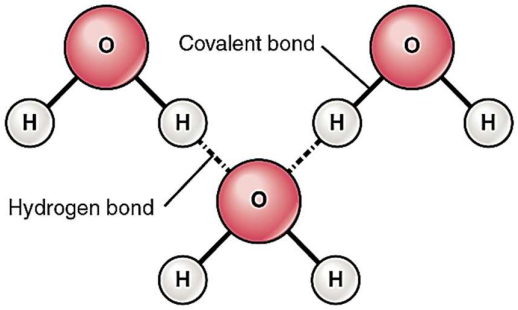


Fig. 9.3

Hydrogen bonds provide many of the critical, life-sustaining properties of water and stabilize the structures of proteins and DNA, the building block of cells.

(a) **(i)** Use Fig. 9.1 to describe how the H – H bond energy changes with the distance between the two hydrogen atoms.

……..

……..

……..

……..

……..

……..…… [3]

(ii) With consideration of how the sub-atomic particles are arranged in an atom, suggest why the bond energy is lowest at 74 picometres.

……..

……..

……..…… [2]

(b) "The greater the number of bonds, the shorter the bond length."

Do you agree with this statement?
Use the information in Table 9.1 to explain your reasoning.

……..……..

……..……..

……..……..

……..…..…… [2]

(c) When nitrogen reacts with oxygen to produce nitrogen monoxide, the reaction is endothermic.

The bond energy of the N = O bond is 607 kJ/mol, and the enthalpy change of reaction is +222 kJ/mol.

Explain, in terms of bonds broken and formed, why this reaction is endothermic.

……..……..

……..……..

……..…..…… [2]

(d) **(i)** In terms of structure and bonding, explain the boiling point of silicon tetrahydride (silane).

……..……..

……..……..

……..……..

……..……. [2]

(ii) Water does **not** follow the trend between boiling point and relative molecular mass of covalent compounds. Using the information given, explain why.

……..……..

……..……..

……..……. [1]

[Total: 12]

10 A student carried out the electrolysis of dilute hydrochloric acid using platinum electrodes. Fig. 10.1 shows the electrolytic cell.

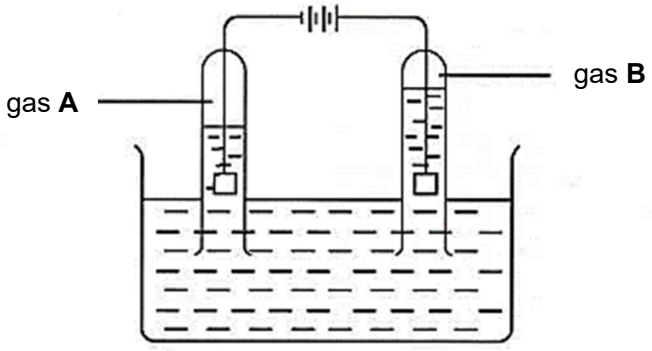


Fig. 10.1

(a) Name gases **A** and **B**.

A : …….

B : …….. [1]

(b) Describe a test to confirm the identify of gas **B**.

……..……..……

……..…… [1]

(c) With the aid of equations, explain why the volume of gas **A** is twice that of gas **B**.

……..……..……

……..……..……

……..……..……

……..……..…… [2]

(d) The student replaces the platinum anode with an aluminium anode.
Fig. 10.2 shows the change in mass of the aluminium anode with time.

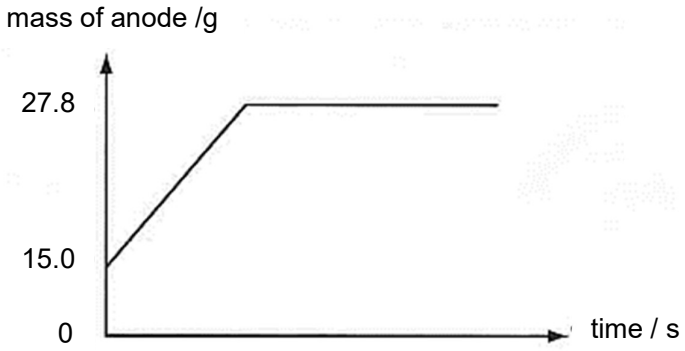


Fig. 10.2

(i) Explain the initial increase in mass of the aluminium anode.

……..……..

……..… [1]

(ii) Suggest why the mass of the anode stopped increasing and became constant.

……..……..

……..… [1]

(iii) With reference to the graph, calculate the volume of hydrogen gas evolved at the cathode.

volume of hydrogen gas = …….. [2]

[Total : 8]

Section B

Answer **one** question from this section.
The total mark for this section is 10.

11 Alkenes can be made from alcohols via a dehydration process. The reaction is shown below.

$$\text{alcohol} \xrightarrow[\text{heat to } 170\,^{o}C]{\text{concentrated } H_2SO_4} \text{alkene + water}$$

When an alcohol is dehydrated, the -OH group and a hydrogen atom from the next carbon atom in the chain are removed.

(a) Mead is a unique class of alcoholic beverage characterized by three ingredients: fermented honey, water, and yeast. It contains 8 – 18% of ethanol. Mead is the first known alcoholic beverage consumed by mankind and is believed to predate wine by nearly three thousand years.

(i) Briefly describe the conditions needed to produce mead.

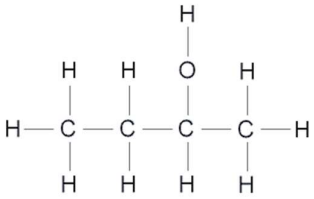
……..…… [1]

(ii) Suggest how the mead produced can be purified.

…….…….. [1]

(b) Another member in the same homologous series as ethanol is butanol.

A butan-2-ol molecule can be dehydrated to produce two butene molecules which are isomers.



(i) Draw the displayed formulae of **two** isomers of butene that are produced by dehydrating butan-2-ol.

[2]

(ii) Give formula of **one** compound, apart from butanol, that can be made from butene.

…….…….. [1]

(c) The polymer show in Fig. 11.1 can be made from 2-propen-1-ol.

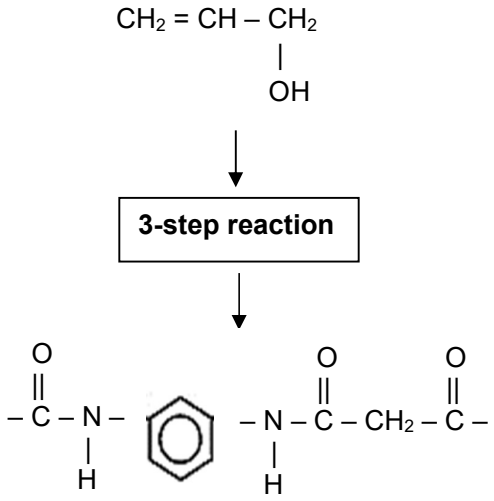


Fig. 11.1

Describe the steps you would carry out to manufacture this polymer through a 3-step reaction scheme.

Include the reagents and conditions for each step as well as diagrams of the structures of the intermediates.

The structure or formula of the other monomer is **not** required.

……

……

……

……

……

……

……

……

……

……

…… [5]

[Total : 10]

12 Fig. 12. 1 illustrates the RSI values of three different polymers under different temperatures. The RSI values measures the thermal resistance of a material that is, the ability of a material to prevent heat transfer from one side of the material to the other.

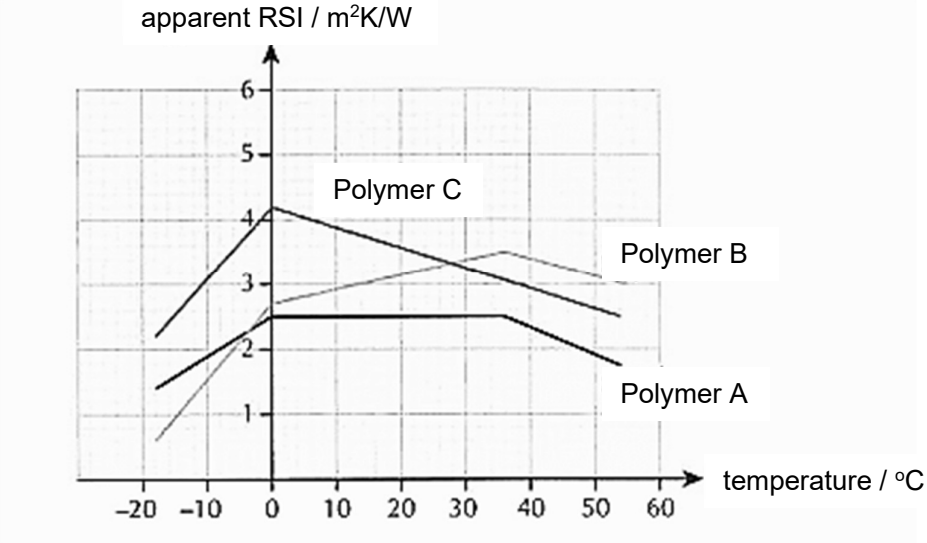


Fig. 12.1

The formula for calculating RSI value is given as :

$$\frac{\text{surface area of material x temperature difference on any one side}}{\text{heat loss}}$$

(a) (i) State, which is the best polymer to use for insulation material during winter. Explain your answer using the information given.

……

……

……

…… [2]

(ii) Astronauts in space are often exposed to a wide range of temperatures. Depending on whether they are receiving sunlight or not, the temperature ranges from –100 °C to 260 °C.

State if any of the polymers in Fig. 12.1 would be suitable for lining the insides of spacesuits. Explain your answer.

……

……

…… [2]

(b) Polymer **X** has been found suitable for making spacesuits. It provides good heat insulation and is resistant to damage cause by chemicals and ultraviolet rays.

Polymer **X** is a condensation polymer known as polyimide. It is formed between a diamine molecule and a dianhydride molecule, while releasing a small molecule as a by-product. The polymer contains imide linkages.

Fig. 12.2 shows part of the structure of polymer **X**.

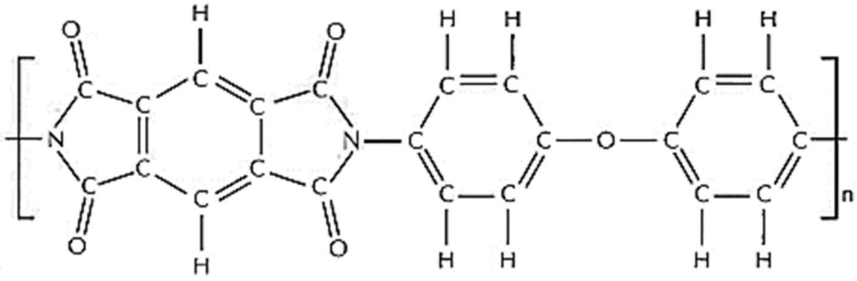


Fig. 12.2

(i) Polymer **X** can be recycled by acid hydrolysis to obtain its monomers.

Fig. 12.3 shows the dianhydride monomer of Polymer **X** obtained after hydrolysis.

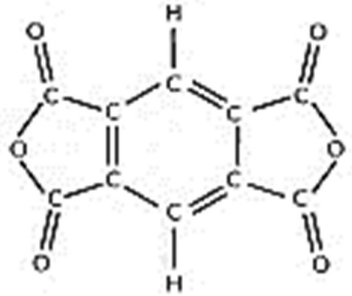


Fig. 12.3

Draw the diamine monomer that is used to make Polymer **X**.

[1]

(ii) Suggest the name of the small molecule that is removed in the formation of Polymer **X**.

…….. [1]

(iii) Draw the structural formula of the imide linkage in Polymer **X**.

[1]

(iii) Describe another chemical method and a physical method to recycle Polymer **X**.

chemical : ……..……..

……..……..

……..……..

physical : …….

……..……..

……..…… [3]

[Total: 10]

End of paper

DATA SHEET

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											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 –		

Key

proton (atomic) number

atomic symbol

lanthanoids	57 **La** Lanthanum 139	58 **Ce** Cerium 140	59 **Pr** Praseodymium 141	60 **Nd** Neodymium 144	61 **Pm** Promethium 147	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** 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.).