Pasir Ris Secondary School

Name	Class	Register No.

SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2024

CHEMISTRY **6092/02**

Paper 2 **20 Aug 2024**

1 h 45 min

Tuesday 1040 – 1225

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 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 **one** question 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	
Total	

Setter: Mr Chua Khoon Wee

[Turn over

Section A

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

1 Select oxides from the list in Table 1.1 to answer the following questions.

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

Table 1.1

calcium oxide	carbon monoxide	copper(II) oxide	nitrogen monoxide
nitrogen dioxide	silicon dioxide	sulfur dioxide	zinc oxide

(a) Which is an acidic oxide with a giant molecular structure?

……..... [1]

(b) Which oxide reacts only with acids but **not** bases?

……..... [1]

(c) Which oxide reacts with both acids and alkalis?

……..... [1]

[Total: 3]

2 An unknown solution **A** contains a mixture of two salts. A series of chemical tests was carried out and the observations were recorded as shown in Fig. 2.1.

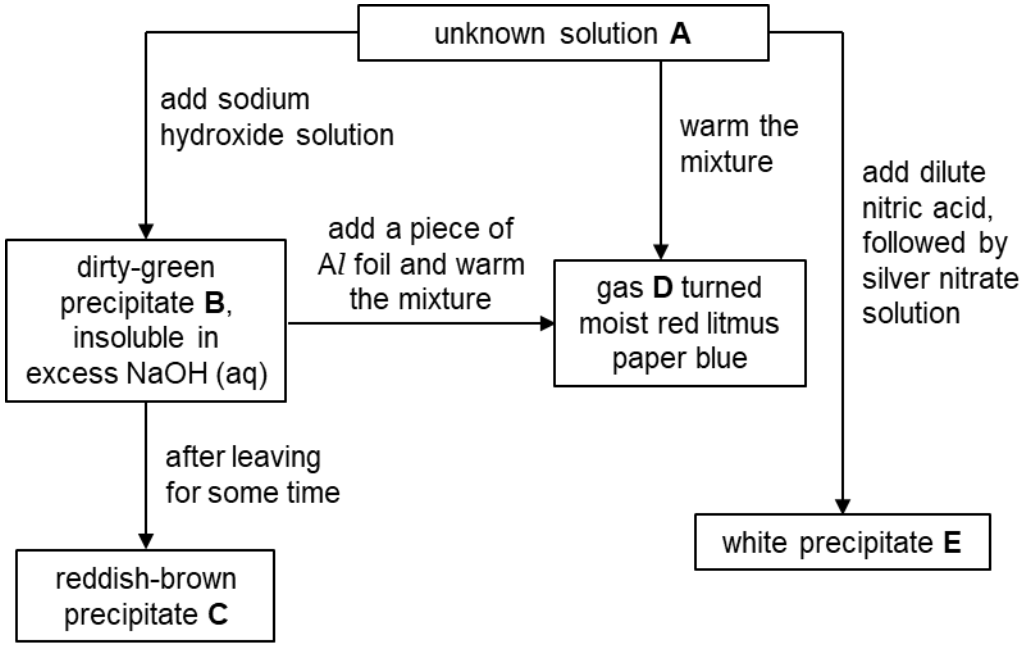


Fig. 2.1

(a) Suggest the identity of substances **B**, **C**, **D** and **E**.

(i) **B** ……

(ii) **C** ……

(ii) **D** ……

(iv) **E** ……

[4]

(b) Suggest **two** possible salts that are present in the unknown solution **A**.

…….. and …… [2]

[Total: 6]

3 Table 3.1 shows the formulae and melting points of hydrides formed from two elements in Period 3.

Table 3.1

formula of element	Group number	formula of hydride	melting point of hydride / °C
Mg	2	MgH_2	327
A*l*	13	A*l*H_3	150

(a) Fig. 3.2 shows the arrangement of electrons in aluminium hydride.

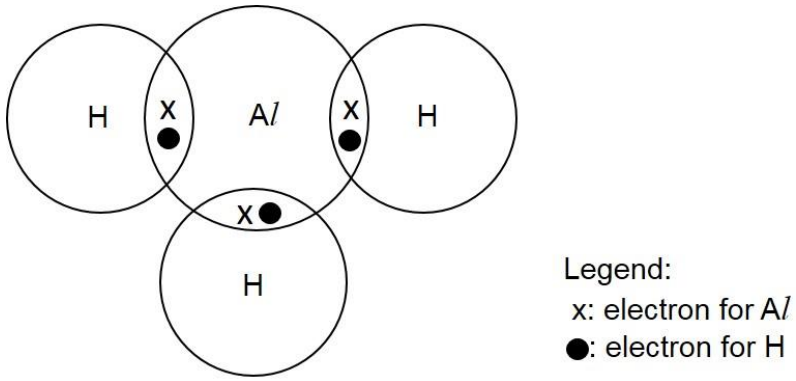


Fig. 3.2

(i) Identify the type of bonding present in aluminium hydride. Explain your answer.

.....

..... [2]

(ii) Explain why the arrangement of electrons in aluminium hydride is unusual.

.....

..... [1]

(b) Magnesium has a different type of bonding present compared to aluminium hydride.

(i) Draw a 'dot-and-cross' diagram to show the bonding in magnesium hydride. Show outer electrons only.

[2]

(ii) Explain, in terms of structure and bonding, why the melting point of magnesium hydride is much higher than that of aluminium hydride.

.....

.....

.....

..... [3]

[Total: 8]

4 Chalcopyrite, $CuFeS_2$, is a copper ore containing both the copper(II) and iron(II) ions. Copper is extracted from chalcopyrite by first heating it with silicon dioxide in air to form copper(I) sulfide.

$$2CuFeS_2 + 2SiO_2 + 4O_2 \rightarrow Cu_2S + 2FeSiO_3 + 3SO_2$$

The copper(I) sulfide is converted to copper by blasting it with hot air.

$$Cu_2S + O_2 \rightarrow 2Cu + SO_2$$

The copper formed is called blister copper. It is brittle and 96.0% pure.

(a) The extraction of copper from chalcopyrite can pose large environmental problem if it is not properly controlled. Identify which substance may be a pollutant and describe the problems it can cause.

……...

……...

……... [2]

(b) Fig. 4.1 shows the cross-section of a tank used for the purification of copper metal.

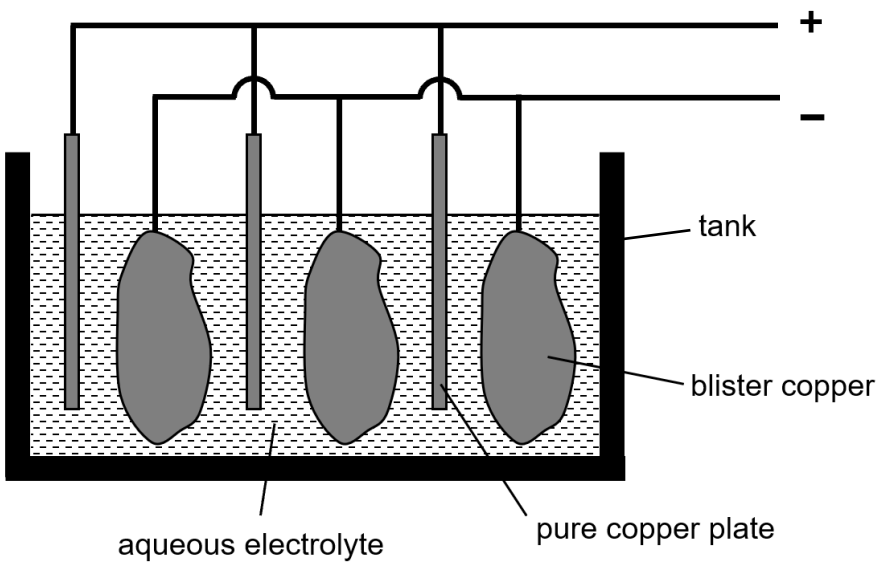


Fig. 4.1

(i) Suggest a suitable electrolyte for the purification process.

..... [1]

(ii) Write the ionic half equations, with state symbols, for the reaction that takes place at the copper plate and blister copper respectively during the purification.

copper plate: .....

blister copper: ..... [2]

(iii) Explain why the electrolyte for this reaction may be used continuously without changing or replacing.

.....

.....

..... [2]

(c) 2.00 tonnes of blister copper is obtained during an extraction of copper from chalcopyrite. Calculate the mass of chalcopyrite used in the reaction. [1 tonne = 1000 kg]

[2]

(d) Zinc can be added to blister copper in a 1:9 ratio to make bronze, an alloy of copper. Bronze is a very hard and strong material. It also has relatively good electrical conductivity.

(i) Explain why bronze is harder and stronger than blister copper.

.....

.....

.....

..... [2]

(ii) Give a reason why bronze is a good electrical conductor.

..... [1]

[Total: 12]

5 Three experiments were carried out to investigate the speed of reaction between acids and excess zinc. Table 5.1 shows the quantity of the reagents used and the time needed to collect 30 cm^3 of hydrogen evolved in each of the experiments.

Table 5.1

experiment	amount of reactants used		time taken / s
	acid	zinc	
1	25 cm^3 of 0.5 mol/dm^3 H_2SO_4	2.0 g, powdered	20
2	25 cm^3 of 0.5 mol/dm^3 HC*l*	2.0 g, powdered	32
3	25 cm^3 of 0.5 mol/dm^3 HC*l*	2.0 g, granulated	46

(a) Use ideas about collisions between particles to explain why the time taken for

(i) experiment **2** was longer than that in experiment **1**,

.....

.....

..... [2]

(ii) experiment **3** was longer than that in experiment **2**.

.....

.....

..... [2]

(b) **(i)** Calculate the maximum volume of hydrogen gas produced in experiment **1** under room temperature and pressure. Include a chemical equation to support your answer.

[3]

(ii) Fig. 5.2 shows the graph of volume of hydrogen produced against time for experiment **2**.

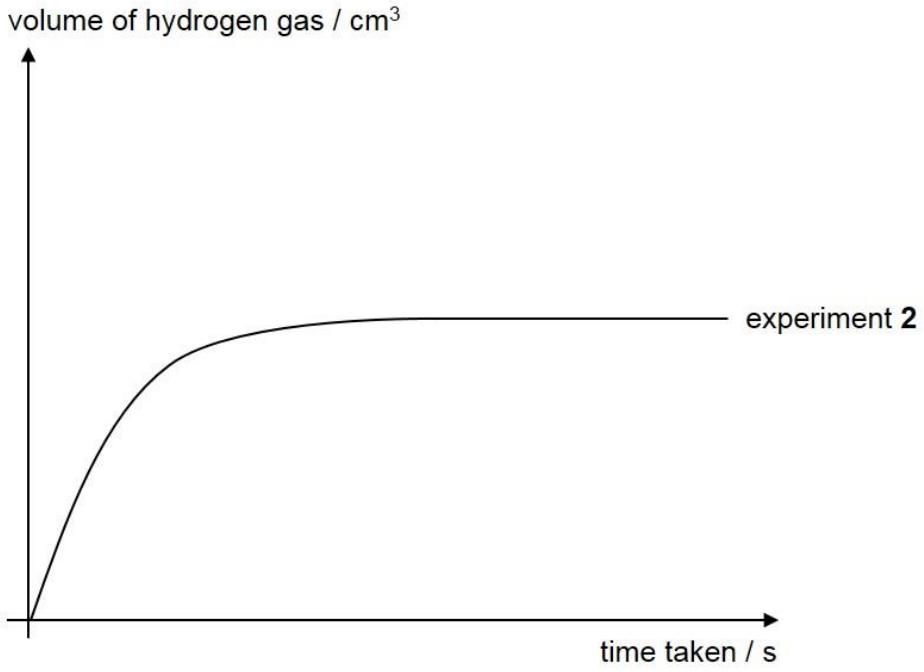


Fig. 5.2

Sketch and label on Fig. 5.2 the graphs of volume of hydrogen produced against time for experiments **1** and **3**. [2]

(c) A little copper(II) oxide catalyst is added to the contents in experiment **1** at the beginning of the experiment.

Explain how time required to collect 30 cm^3 of hydrogen will be affected.

……...

……... [1]

[Total: 10]

6 In the Haber process, hydrogen and nitrogen react reversibly in the presence of finely divided iron at suitable pressure and temperature to form ammonia. The equation for the reaction is shown.

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

Table 6.1 shows the percentage of ammonia in the equilibrium mixture at 250 atm pressure and various temperatures.

Table 6.1

temperature / ^{o}C	percentage yield of ammonia
1000	negligible
550	20
200	88

(a) State the source of nitrogen used in the Haber process.

……... [1]

(b) In practice, a temperature of 450 ^{o}C is chosen as the operating temperature.

Suggest a reason why the following temperatures are **not** used.

(i) temperature greater than 450 ^{o}C

.....

..... [1]

(ii) temperature lower than 450 ^{o}C

.....

..... [1]

(c) The ammonia produced from the Haber Process is used in the manufacture of ammonium fertilisers. A farmer added some ammonium fertilisers to his crops to improve the growth. This was done after the addition of excess calcium oxide to neutralise the acidic soil.

Explain why the crops were still unlikely to grow well after both chemicals had been added.

……...

……...

……...

……... [2]

(d) Nitrogen reacts with hydrogen to form another product, hydrazine (N_2H_4). Hydrazine is often used as a rocket fuel. Fig. 6.2 shows the structural formula of hydrazine.

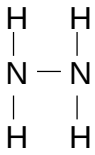


Fig. 6.2

The reaction between hydrazine and iodine can be represented by the equation below.

$$N_2H_4\,(g) + 2I_2\,(g) \rightarrow N_2\,(g) + 4HI\,(g)$$

Table 6.3 shows the average bond energies, measured in kJ/mol.

Table 6.3

bond	bond energy in kJ/mol	bond	bond energy in kJ/mol
N – N	170	H – I	161
N – H	391	N ≡ N	945
I – I	151	H – H	436

(i) Calculate the enthalpy change for the complete reaction of one mole of hydrazine with iodine.

[2]

(ii) In Fig. 6.4, draw an energy profile diagram for the reaction between hydrazine and iodine.

Your diagram should include

- the formulae of the reactants and products of the reaction,
- labels for the enthalpy change and activation energy of the reaction.

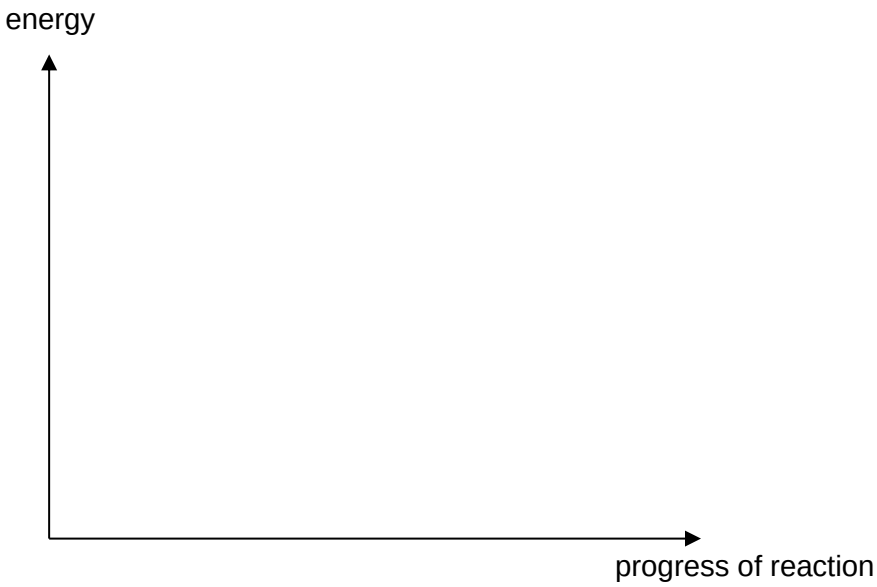


Fig. 6.4

[3]

[Total: 10]

7 Table 7.1 summarises the formulae and chemical properties of the chlorides of the elements across Period 2. The chlorides behave differently when they are added to water. Some of the chlorides dissolve to form a solution. Some hydrolyse when they are added to water. This means that they react chemically with water to produce new products.

Table 7.1

element	metal / non-metal	formula of main chloride	bonding in chloride	effect of adding chloride to water	products of adding chloride to water
Li	metal	LiC*l*	ionic	dissolves	LiC*l*(aq)
Be	metal	BeCl_2	covalent	hydrolyses	complex mixture of products including $Be(OH)_2$(s), HC*l*(aq)
B	non-metal	BCl_3	covalent	hydrolyses	H_3BO_3(aq), HC*l*(aq)
C	non-metal	CCl_4	covalent	immiscible	-
N	non-metal	NCl_3	covalent	hydrolyses	NH_3(aq), HC*l*O(aq)
O	non-metal	OCl_2	covalent	hydrolyses	HC*l*O(aq)
F	non-metal	FC*l*	covalent	hydrolyses	HF(aq), HC*l*(aq)

(a) Describe the pattern for the ratio of each element to chlorine across Period 2. Include ratios in your answer.

……...

……...

……...

……... [2]

(b) **(i)** Identify the chloride which forms a precipitate when it is added to water.

..... [1]

(ii) Write a balanced chemical equation, with state symbols, for the reaction between gaseous nitrogen trichloride, NCl_3, and water.

..... [2]

(c) Using ideas about oxidation states, deduce and explain whether the reaction between boron trichloride, BCl_3, and water is a redox reaction.

……...

……...

……...

……... [2]

(d) Two students talk about the data in Table 7.1.

Student 1: “I think that whether the chloride hydrolyses in water is linked to the metal or non-metal character of the element.”

Student 2: “I think that all covalent compounds hydrolyse in water.”

Does the information in the table support the ideas of the students? Explain your reasoning.

……...

……...

……...

……... [3]

(e) Carbon tetrachloride, CCl_4, was added into water. It was found to be immiscible with water.

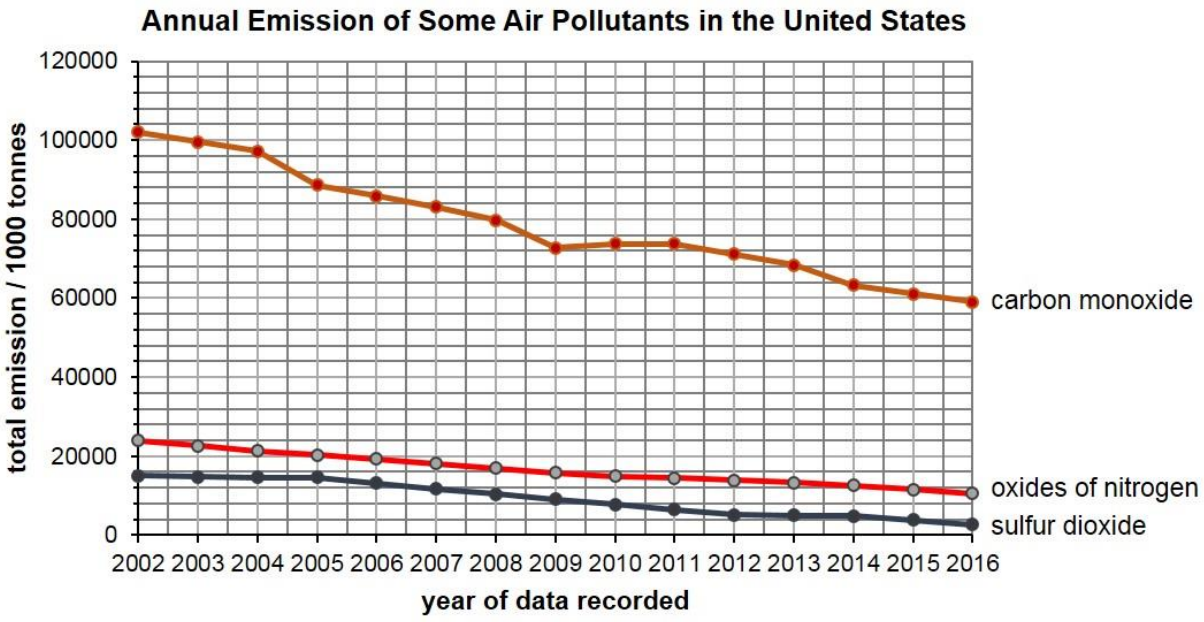
Suggest a method of separation that can be used to obtain CCl_4 from water.

……... [1]

[Total: 11]

8 With large scale industrialisation and increasing demand for transportation of people and goods, the quality of air changes over the decades. The quality of air affects how people live and breathe, and can change from day to day or even hour to hour. In some countries, the quality of air may reach unhealthy or hazardous level, which poses health risks and causes deaths.

In the United States, documentation of the various air pollutants has been made over the decades by the Environmental Protection Agency (EPA) to monitor the quality of air. Fig. 8.1 shows the annual emission of some air pollutants in the United States over a period of 15 years.



Source: Data obtained from United States Environmental Protection Agency

Fig. 8.1

To control the harmful emission of such air pollutants, EPA traces the sources of each pollutant. Fig. 8.2, Fig. 8.3 and Fig. 8.4 show the main sources of carbon monoxide, oxides of nitrogen and sulfur dioxide respectively.

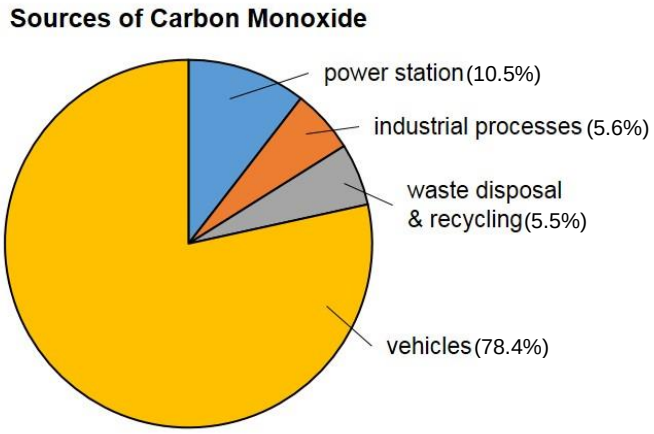


Fig. 8.2

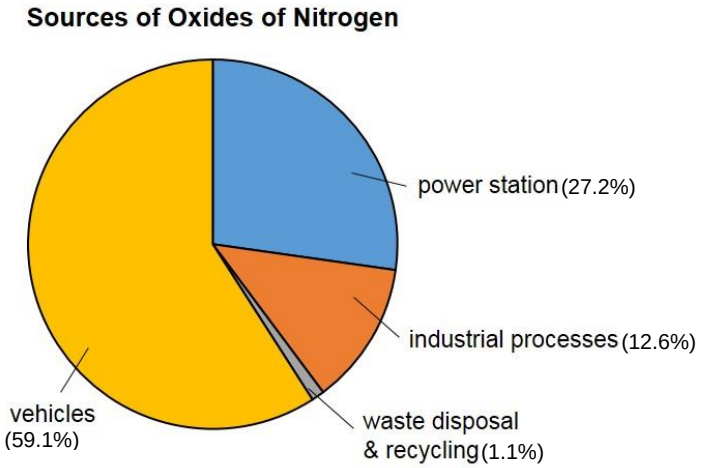


Fig. 8.3

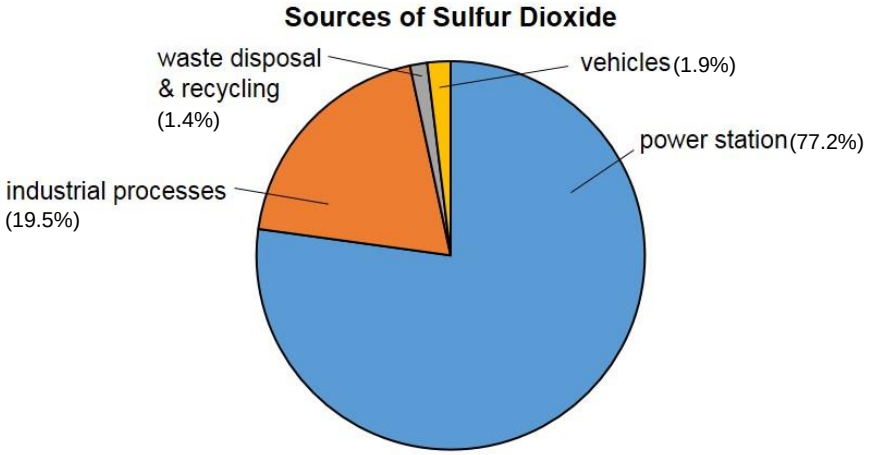


Fig. 8.4

(a) **(i)** With reference to Fig. 8.1, describe the trend in the annual emission of air pollutants in the United States over the last 15 years.

.....

..... [1]

(ii) Identify the air pollutant which poses the greatest threat to the United States. Explain the effect of this pollutant on the environment.

.....

.....

..... [2]

(b) Scientists believe that emission from vehicles is the main source for all air pollutants.

Do you agree? Explain your answer using evidence from Fig. 8.2 to Fig. 8.4.

……...

……...

……... [2]

(c) To comply with the stricter regulation of exhaust emissions set by the EPA, all vehicles must be fitted with catalytic converters to reduce the emission of harmful gases. In fact, it is illegal to drive a vehicle without a catalytic converter fitted on the exhaust pipe.

The catalytic converter removes pollutant gases like carbon monoxide and nitrogen monoxide by oxidation and reduction. The amount of air in the pollutant gases thats enter the catalytic converter affects the reactions in the converter. Fig. 8.5 shows the percentage of carbon monoxide and nitrogen monoxide that the catalytic converter successfully removes.

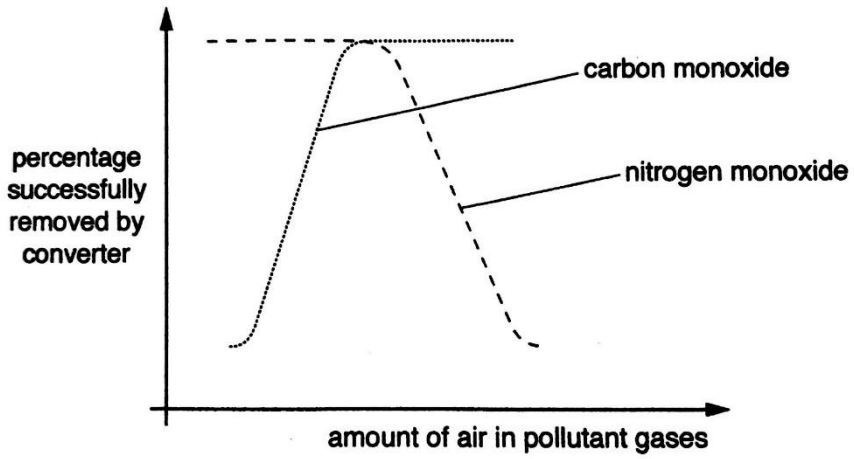


Fig. 8.5

(i) Write a balanced chemical equation to show how carbon monoxide and nitrogen monoxide react together in the catalytic converter.

..... [1]

(ii) Describe and explain how increased amounts of air affect the removal of carbon monoxide and nitrogen monoxide.

.....

.....

.....

.....

..... [3]

(iii) “Apart from reacting with each other in the catalytic converter, carbon monoxide and nitrogen monoxide can also react with other substances.”

Suggest how the graph in Fig. 8.5 shows that the above statement is true.

.....

..... [1]

[Total: 10]

Section B

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

9 Butene is an unsaturated hydrocarbon formed from the catalytic cracking of the diesel and lubricating oil fractions. It is an important petrochemical feedstock for other synthetic materials such as plastics and rubber. The structure of butene is shown in Fig. 9.1.

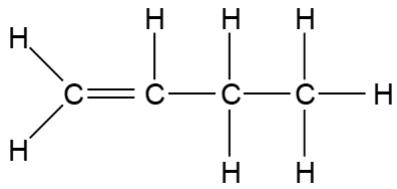


Fig. 9.1

(a) Explain why butene is described as *unsaturated*.

……..... [1]

(b) Describe what happens during cracking of petroleum fractions.

……

……..... [1]

(c) The hydration of butene produces two alcohols which are isomers.

(i) State the conditions required for the reaction.

……..

……... [2]

(ii) Draw the full structural formula of the two isomers.

[2]

(d) The structure of 1,3,5-hexatriene is shown in Fig. 9.2.

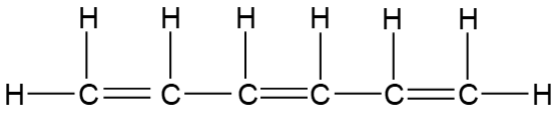


Fig. 9.2

When 20.0 kg of 1,3,5-hexatriene is hydrogenated, 21.0 kg of the product was formed.

(i) Show, by calculation, that the product formed is still unsaturated.

[2]

(ii) The labels on two beakers have dropped off. One beaker contains 50 cm^3 of 1,3,5-hexatriene while the other beaker contains 50 cm^3 of the product in **(d)(i)**.

Describe a simple experiment to identify the chemicals in each beaker.

……...

……...

……...

……... [2]

[Total: 10]

10 Polymers are macromolecules which are made up of many small molecules bonded together. The two main types of polymers that can form are addition polymers and condensation polymers.

(a) Poly(ethene) is formed from addition polymerisation of many monomers of ethene. It is a type of non-biodegradable plastic.

(i) Draw the structural formula of poly(ethene).

[1]

(ii) Calculate the number of $H_2C=CH_2$ monomer units, n, in one molecule of poly(ethene) with molar mass of 40,000 g.

Hence, determine the number of carbon atoms present in the molecule of poly(ethene).

[3]

(iii) Describe **two** methods of recycling plastics to reduce the pollution problems caused by the disposal of non-biodegradable plastics.

……

……

……

…… [2]

(b) The structure of a liquid crystal polymer is shown in Fig. 10.1.

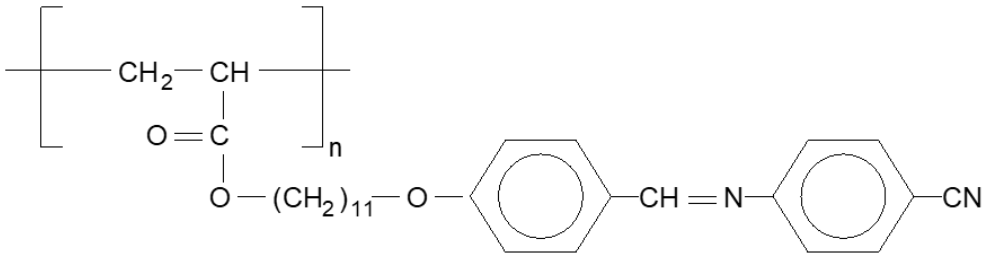


Fig. 10.1

(i) Explain why the above polymer is produced through addition polymerisation and **not** condensation polymerisation.

…… [1]

(ii) Describe a chemical test to distinguish the monomer of the liquid crystal from an organic compound with chemical formula C_4H_{10}.

……

……

…… [2]

(c) Dacron is an example of a polymer that is formed by condensation polymerisation. Fig. 10.2 show the structural formula of the two monomers used to prepare Dacron.

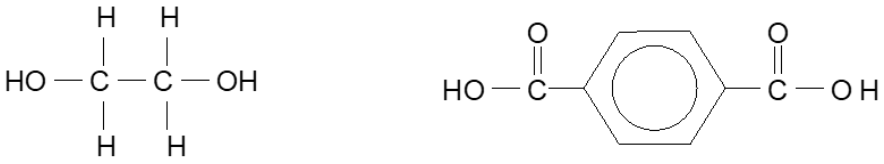


Fig. 10.2

Draw the full structural formula of the repeating unit in Dacron.

[1]

[Total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							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	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, $L = 6.02 \times 10^{23}\ mol^{-1}$