NAME	CLASS	INDEX NO.

ST. PATRICK'S SCHOOL
PRELIMINARY EXAMINATIONS 2021

SUBJECT : CHEMISTRY 6092 / 02

LEVEL : SECONDARY 4 EXPRESS

DATE : 20 Aug 2021

DURATION : 1 H 45 MIN

INSTRUCTIONS TO CANDIDATES:

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

1. Write down your name, class and index number on the **Question Paper** in the spaces provided.
2. Write in dark blue or black pen. You may use an HB pencil for any diagrams or graphs. Do not use correction fluid.
3. This paper consists of **TWO (2) Sections: Section A** and **Section B**.
4. Answer **ALL** questions in **Section A** in the spaces provided.
5. Answer **ALL** questions in **Section B** in the spaces provided.
   Question 10 is **EITHER / OR QUESTION. SELECT ONLY ONE PART OF THIS QUESTION.**
6. The use of an approved scientific calculator is expected, where appropriate.
7. **DO NOT DETACH** any sections from this paper.

INFORMATION FOR CANDIDATES:

The number of marks is given in brackets [ ] at the end of each question.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.

Parent's Signature: _____

PAPER 1	/ 40
PAPER 2	
SECTION A :	/ 50
SECTION B :	
Question 8	/ 10
Question 9	/ 10
Question 10 E/O	/ 10
TOTAL	/ 120
GRADE	

This question paper consists of 25 printed pages, including this cover page

Section A

Answer all the questions in this section in the spaces provided.

1 The formulae of some oxides are given in the following list.

SiO_2	H_2O	Na_2O_2	Br_2O	CO
ZnO	NO_2	SO_2	NiO	Ag_2O

(a) Choose oxides from the list to answer the questions. Each oxide may be used once, more than once or not at all.

(i) Which oxide is formed only when there is insufficient oxygen during the combustion of petrol?

..... [1]

(ii) Which oxide reacts with both hydrochloric acid and potassium hydroxide?

..... [1]

(iii) Which oxide is the main constituent of sand?

..... [1]

(iv) Which oxide contains oxygen with an oxidation state of −1.

..... [1]

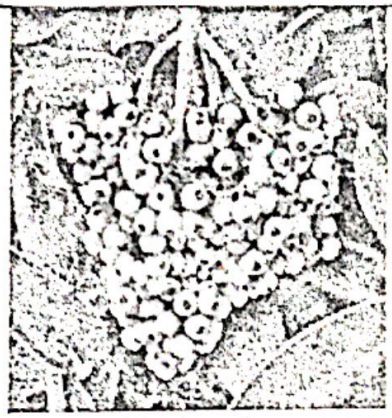
(b) Draw a dot-and-cross diagram to show the bonding in Br_2O. Show outer shell electrons only.

[2]

2 This information comes from a textbook about elderberries.

Elderberries are widely used in wine making. Extract of elderberries is a useful pH indicator and it can be separated by chromatography.

As an indicator, the colour of the extract changes to pink at a pH of 2 — 3 and to blue at a pH of 11 — 12.



elderberries

(a) Predict the colour of the elderberries extract at pH 7.

.....[1]

(b) The chromatogram shown in Fig. 2.1 was obtained when water was added to a drop of elderberries extract at the centre of a filter paper.

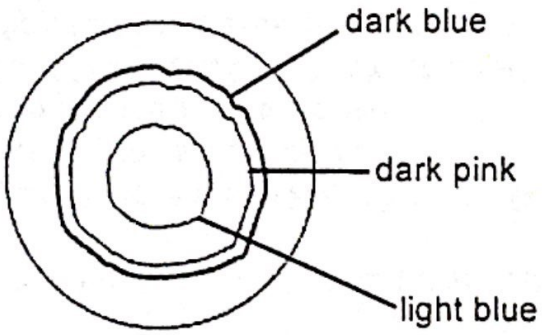


Fig. 2.1

An alternative set-up for the above experiment was shown in Fig. 2.2.

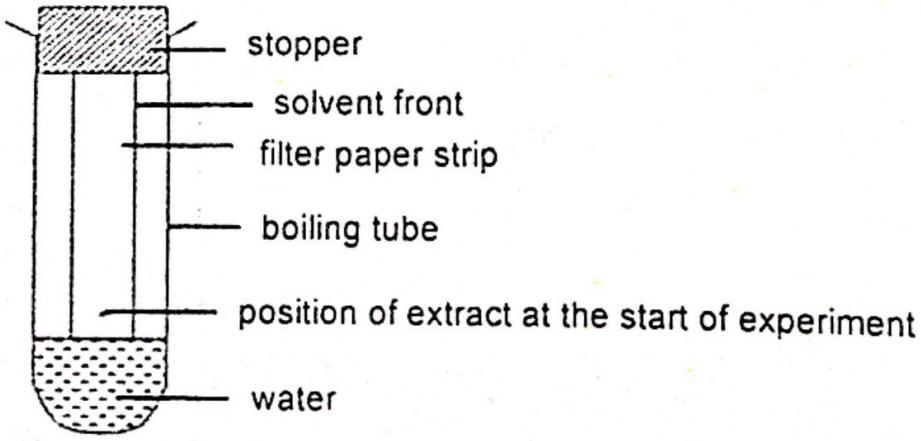


Fig. 2.2

Given that the distance travelled by the dark pink dye is 1.00 cm, complete Table 2.1 by stating the distance travelled by the light blue and dark blue dyes.

dye	R_f value	distance travelled (cm)
light blue	0.2	
dark pink	0.4	1.00
dark blue	0.5	

Table 2.1 [2]

(c) Fig. 2.3 shows how pH values changed during a titration when an acid was added from a burette into a solution of an alkali. Some drops of elderberries extract were added at the start of titration.

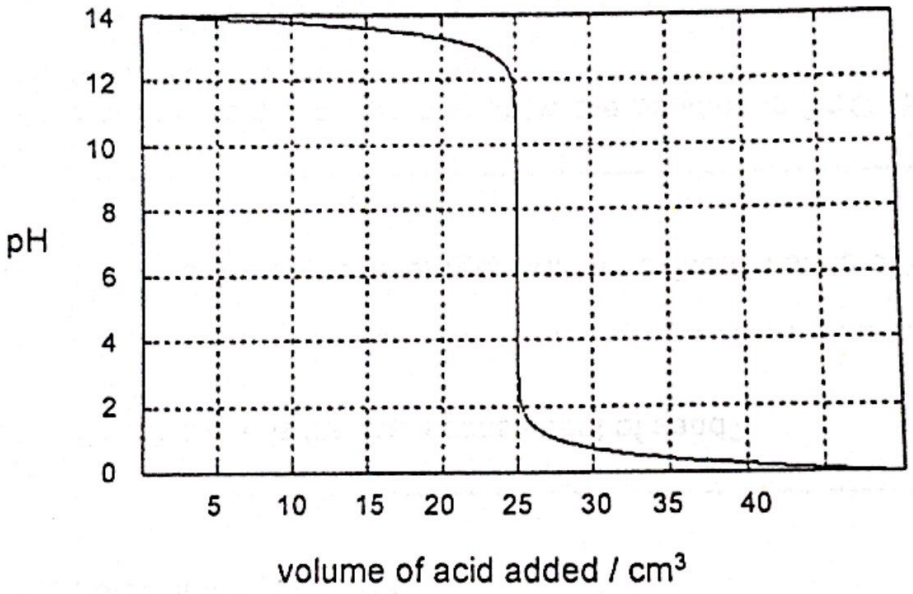


Fig. 2.3

(i) Suggest one possible chemical formula of the alkali.

.....

[1]

(ii) State the colour of the elderberries extract when the following volume of acid was added

20 cm^3 : .....

[1]

30 cm^3 : .....

[1]

3 Fluorine, Chlorine, Bromine and Iodine are elements found in Group VII of the Periodic Table.

(a) Read the statements and mark with a tick (√) the statement(s) which you think is/are true.

statement	indicate with a tick (√) if true
Iodine gains electrons more readily than fluorine.	
Iodine is an element with a simple covalent structure.	
Iodine has strong covalent bonds between molecules.	
Iodine dissolves in water to form a brown solution.	

[1]

(b) A redox reaction takes place when chlorine gas is bubbled into zinc bromide solution.

(i) Give the ionic equation including the state symbols for the reaction.

.....

[2]

(ii) Describe the colour change seen during the reaction.

.....

[1]

(iii) Use oxidation states to prove that this reaction is a redox reaction.

.....

.....

.....

.....

[2]

(iv) Name the reducing agent in this reaction.

.....

[1]

4 The melting point of sodium chloride and chlorine are represented in Table 4.1.

substance	melting point / °C
sodium chloride	801
chlorine	−101

Table 4.1

(a) Explain, in terms of structure and bonding, the difference in the melting points of these two substances.

.....

.....

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.....

.....

..... [3]

(b) Explain why molten sodium chloride conducts electricity but solid sodium chloride does not.

.....

.....

..... [2]

(c) Draw a 'dot-and-cross' diagram for sodium chloride, showing only the outer electrons.

[2]

5 Halogen can react with hydrogen to form hydrogen halides. Hydrogen chloride, HCl, and hydrogen fluoride, HF can be made from the reaction of hydrogen with chlorine and fluorine respectively. Table 5.1 lists some bond energies involved.

bond	bond energy (kJ/mol)
Cl–Cl	243
F–F	159
H–H	436
H–F	569
H–Cl	432

Table 5.1

(a) The equation for the formation of hydrogen chloride from its elements is

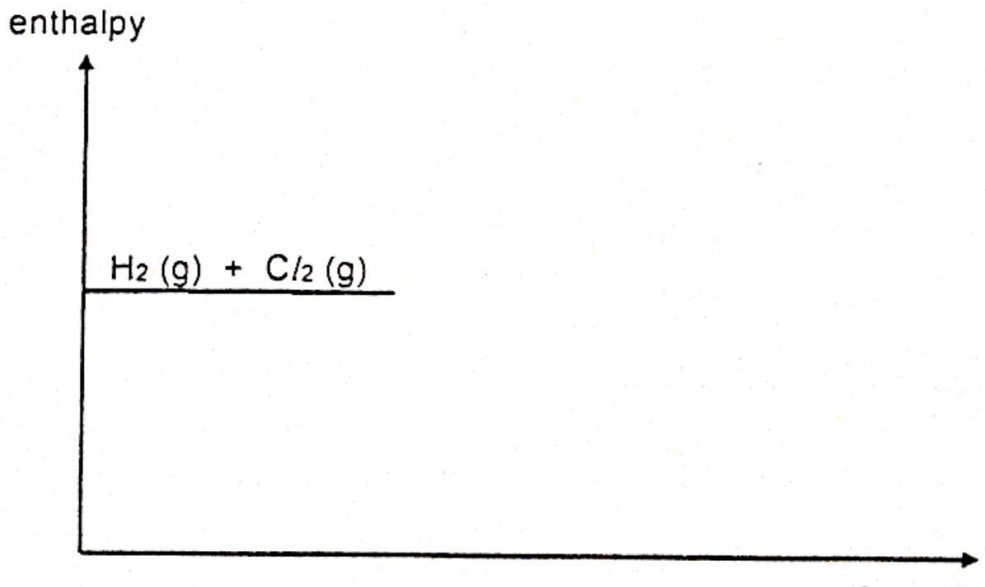
$$H_2\,(g) + Cl_2\,(g) \longrightarrow 2HCl\,(g) \qquad \Delta H = -185\ kJ/mol$$

What does the enthalpy change, ΔH, tell us about the reaction?

.....

[1]

(b) Complete and label the energy profile diagram by showing clearly the enthalpy change and activation energy for the formation of hydrogen chloride.



[2]

(c) Use the bond energies given in Table 5.1 to calculate the enthalpy change for the formation of hydrogen fluoride from its elements.

[2]

(d) When dissolved in water, hydrogen fluoride forms a weak acid while hydrogen chloride forms a strong acid.

(i) Explain the difference between a weak acid and a strong acid.

.....

..... [1]

(ii) Use the data on bond energies in Table 5.1 to explain this difference in strength of the two acids.

.....

.....

..... [2]

6 A student conducted a series of experiments at room temperature to investigate the effect of concentration on the rate of decomposition of hydrogen peroxide to form water and oxygen in the presence of manganese(IV) oxide.

experiment	concentration of H_2O_2 / mol/dm^3	volume of H_2O_2 used / cm^3
I	0.100	50
II	0.150	50
III	0.200	50

Table 6.1

The results obtained for experiment I was then plotted in Fig. 6.1.

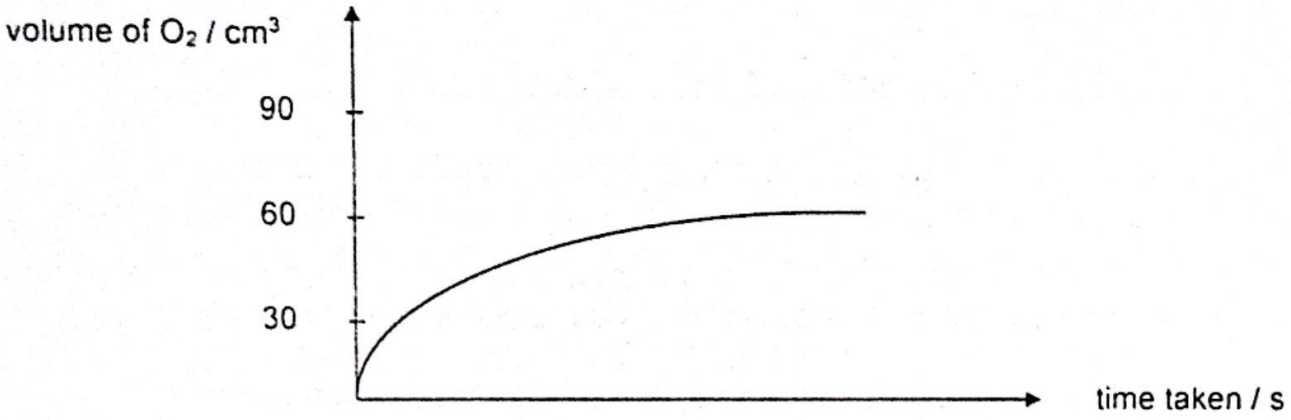


Fig. 6.1

(a) Write a balanced chemical equation for the decomposition of hydrogen peroxide.

.....

[1]

(b) (i) Explain how the rate of reaction changed during the experiment.

.....

.....

[1]

(ii) Using your knowledge on the collision theory, state and explain another factor which may affect the rate of reaction.

.....

.....

.....

[2]

(c) A 60 cm^3 gas syringe was used to measure the volume of oxygen produced in experiment III. Explain why it is impossible to measure the volume this way.

.....

..... [1]

(d) Sketch on Fig. 6.1, the result one would expect to obtain for experiment II if the percentage yield of oxygen is 75%. [1]

7 (a) Crude oil contains a mixture of hydrocarbon.

In a petrol refinery, fractional distillation is used to separate crude oil into fractions.

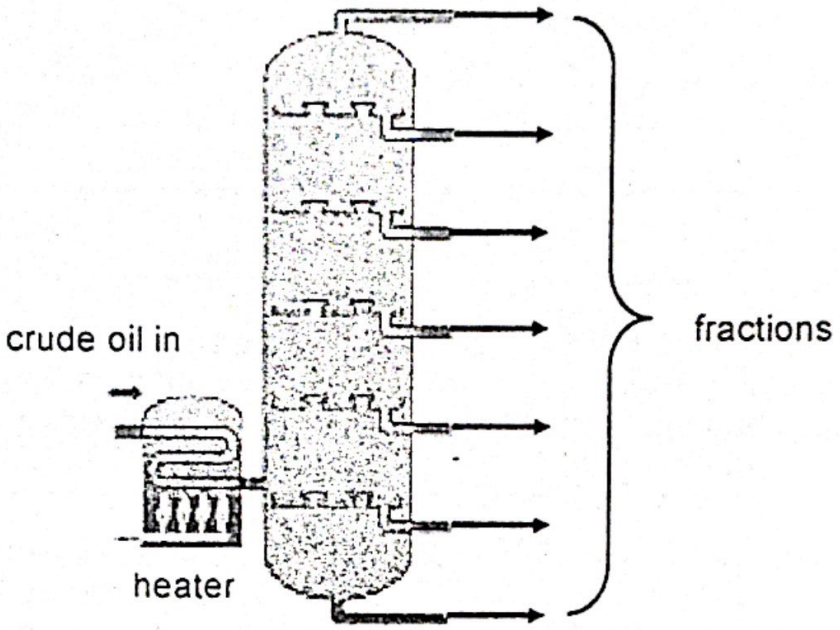


Fig. 7.1

Within each fraction the molecules are of a similar size.

Describe and explain how the process of fractional distillation separates crude oil into fractions.

.....

.....

.....

.....

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.....

.....

..... [5]

(b) A molecule of $C_{17}H_{36}$ undergoes *catalytic* cracking. The reaction produces three different products, **K**, **L** and **M**.

$$C_{17}H_{36} \longrightarrow \underset{\text{hydrocarbon K}}{C_4H_{10}} + \underset{\text{hydrocarbon L}}{C_3H_6} + \underset{\text{hydrocarbon M}}{\text{.....}}$$

(i) Define the term *cracking* and explain the importance of the process of cracking.

.....

.....

.....

..... [2]

(ii) Describe a chemical test to distinguish between hydrocarbon **K** and **L** and give the results of the test.

.....

.....

.....

..... [2]

(iii) Given that hydrocarbon **M** is ethene, write the complete equation for the cracking of $C_{17}H_{36}$ as shown above.

..... [1]

Section B

Answer all the questions in this section in the spaces provided.
Answer only one of the two alternative questions in **Question 10**.

8 **Ionisation Energy of Group II metals**

The ease of a metal atom losing an electron can be determined from ionisation energy. If the electron is more strongly held by the nucleus of the atom, a higher ionisation energy is needed.

First ionisation energy is the energy required to remove 1 mole of electrons from 1 mole of gaseous atoms to produce 1 mole of gaseous ions each with a charge of 1+. The reaction can be described by the equation below:

$$X\,(g) \longrightarrow X^{+}\,(g) + e^{-}$$

The second ionisation energy is the energy required to remove 1 mole of electrons from 1 mole of gaseous cations with a charge of 1+ to produce 1 mole of gaseous ions each with a charge of 2+.

$$X^{+}(g) \longrightarrow X^{2+}\,(g) + e^{-}$$

The table shows a list of first and second ionisation energies of Group II metals: The metals are arranged according to their reactivity.

	metal	first ionisation energy / kJ/mol	second ionisation energy / kJ/mol
least reactive	beryllium	899	1757
↓	magnesium	738	1450
	calcium	589	1145
	strontium	549	1064
most reactive	barium	503	965

Table 8.1

Thermal stability of carbonates of Group II metals

Fig. 8.1 shows the temperature at which the carbonates of Group II metals decompose.

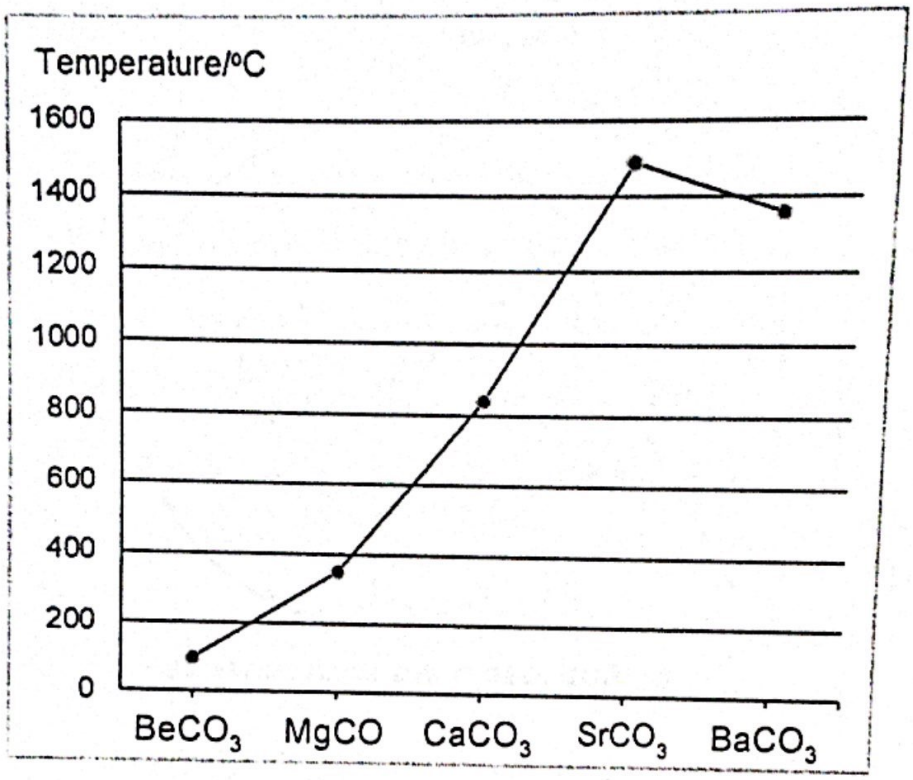


Fig. 8.1

In an experiment, 1 g of the metal carbonate is heated until no further change and the volume of carbon dioxide is measured. The results are recorded in Table 8.2.

metal carbonate	volume of carbon dioxide collected / cm^3
$BeCO_3$	348
$MgCO_3$	286
$CaCO_3$	240
$SrCO_3$	0
$BaCO_3$	0

Table 8.2

(a) What is the relationship between the second ionisation energy and the position of the metals in Group II?

.....

[1]

(b) Calculate the number of moles of calcium atoms in 1 g of calcium. Hence, find the energy required for 1 g of calcium atoms to form Ca^{2+} ions.

number of moles of calcium atom = ... mol

energy required to form Ca^{2+} ions = ... kJ [3]

(c) A student proposes that the temperature at which Group II metal carbonates decompose depends on the second ionisation energy. Is he correct? Give an explanation.

.....

.....

..... [2]

(d) Give a reason why no carbon dioxide is obtained from heating of the carbonates of strontium and barium.

.....

..... [1]

(e) 1 g of an unknown Group II metal carbonate produces 122 cm^3 of carbon dioxide when reacted with excess hydrochloric acid according to the equation:

$$XCO_3 + 2HCl \longrightarrow XCl_2 + H_2O + CO_2$$

Show by calculation that this Group II metal is barium.

[3]

9 In recent years, resolutions and laws aimed at curbing the emission of air pollutants have been passed throughout Europe and the world. The more stringent exhaust emission standards which came into effect in the USA and Europe prompted the car industry to develop new and improved technologies in car engines to reduce pollutants in exhaust gases.

Fig. 9.1 and Fig. 9.2 show the percentage of gases present in the exhaust of new improved petrol and diesel engines fitted with catalytic converters.

exhaust from the petrol engine

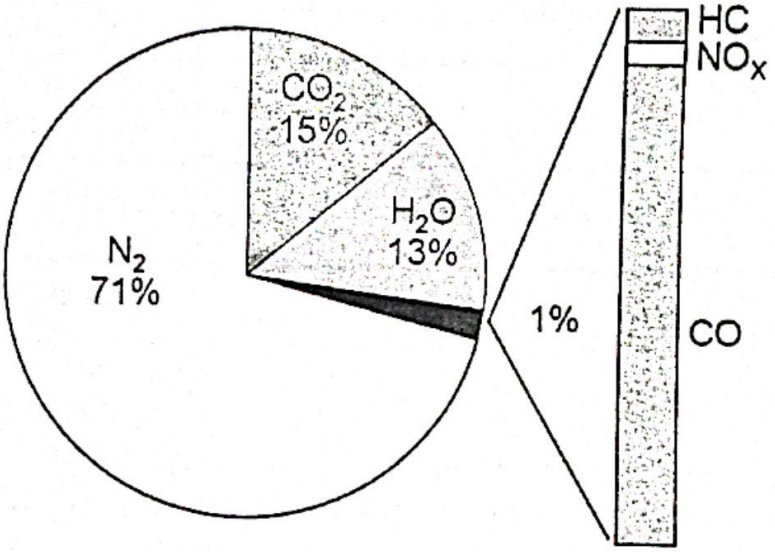


Fig. 9.1

exhaust from the diesel engine

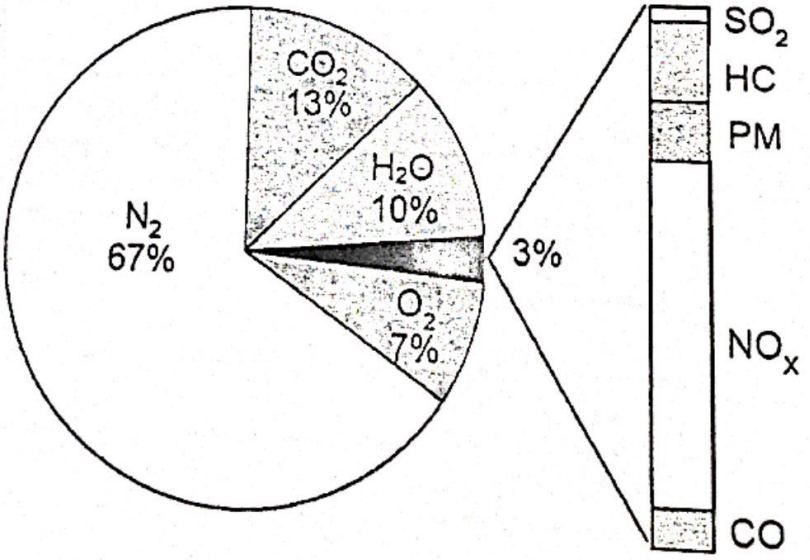


Fig. 9.2

Key :
HC – unburnt hydrocarbons, PM – particulate matter, NO_x – oxides of nitrogen

(a) Which engine is more environmentally friendly? Explain this using the information from the pie.

.....

.....

..... [2]

(b) Using the data given, suggest why the percentage of carbon monoxide produced in a petrol engine is higher than a diesel engine.

.....

.....

..... [2]

(c) Explain why there is such a high percentage of water in the exhaust of both engines.

..... [1]

(d) Suggest why the percentage of oxides of nitrogen is higher in the exhaust of the diesel engine.

..... [1]

(e) Oxides of nitrogen are removed from car exhaust emissions by catalytic converters. In a converter, nitrogen monoxide reacts with carbon monoxide.

(i) Write a balanced chemical equation for this reaction.

..... [1]

(ii) Cars fitted with catalytic converters still give out environmentally harmful gases such as carbon dioxide in large amounts. Describe a problem that carbon dioxide may cause.

.....

..... [1]

(f) The percentage composition of sulfur dioxide present in diesel exhaust is about 0.03% by volume.

(i) State why sulfur dioxide is found in diesel exhaust.

.....

..... [1]

(ii) Explain why it is important to reduce the percentage of sulfur dioxide.

.....

..... [1]

EITHER

10 Many monomer molecules react together to form one molecule of a polymer. This reaction is called polymerisation.

(a) Fig. 10.1 shows part of the structure of a protein **X** which is a natural polymer.

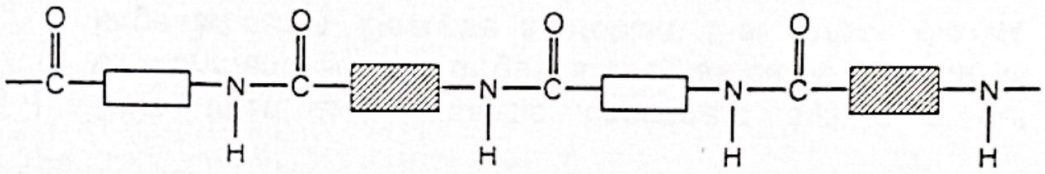


Fig. 10.1

(i) State the type of condensation polymer. Give a reason.

.....

[2]

(ii) Draw the structures of the two monomers from which the condensation polymer is made.

monomer 1:

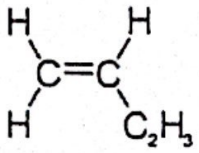
[1]

monomer 2:

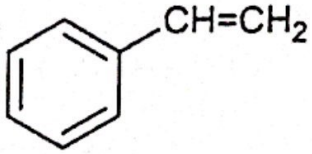
[1]

(b) Styrene-butadiene rubber (SBR) is a synthetic polymer which is made from a mixture the monomers butadiene and styrene.

The structures of butadiene and styrene are given Fig. 10.2.



butadiene



styrene

Fig. 10.2

When the mixture of butadiene and styrene polymerises, one of the possible structure for the polymer is shown in Fig. 10.3.

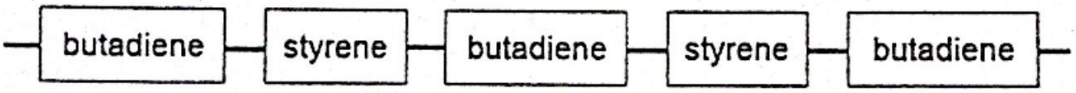


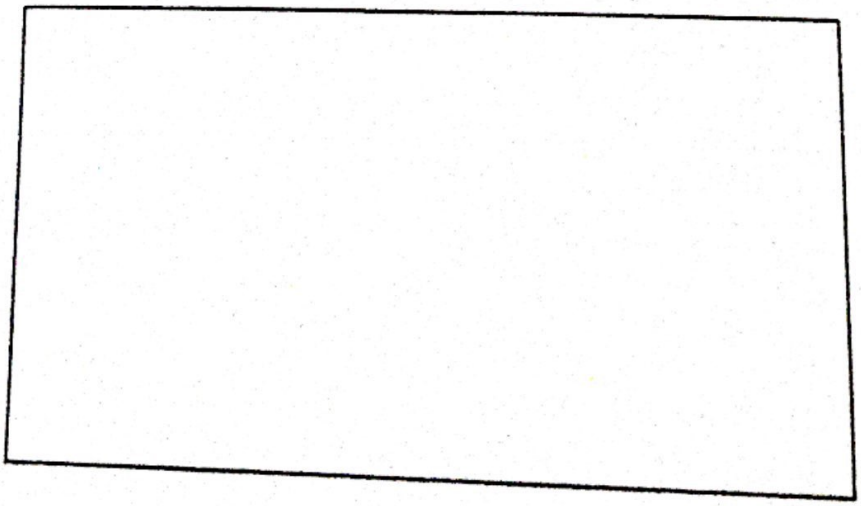
Fig. 10.3

(i) What type of polymerisation does the monomers undergo to form SBR? Explain your answer.

.....

..... [2]

(ii) Draw the full structural formula for one repeat unit in the polymer structure in (b).



[2]

(iii) Explain why the mixture of monomers is likely to produce a polymer of irregular repeat pattern that is different from the above.

.....

..... [1]

(iv) Like most synthetic polymers, SBR is *non-biodegradable*. Describe one problem which this property causes.

.....

.....

..... [1]

OR

10 Aqueous copper(II) sulfate is electrolysed as shown in Fig. 10.1.

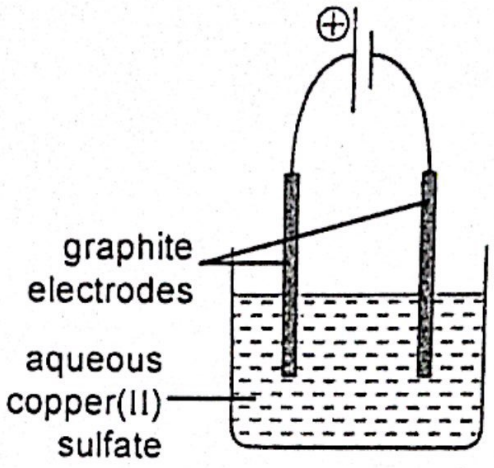


Fig. 10.1

(a) Write a half-equation for the reaction that occurs at the cathode.

.....

[1]

(b) Describe and explain any changes that occur in the electrolyte as the reaction continues for a period of time.

.....

.....

.....

.....

[3]

(c) Suggest another type of electrodes that can be used to replace these graphite electrodes without changing the results of the experiment.

.....

[1]

(d) Two students, A and B made statements about the electrolytic set-up.

Student A: "If we change the electrolyte to a highly concentrated solution of copper(II) sulfate, the results of this experiment will be entirely different."

Student B: "The concentration of the copper(II) sulfate electrolyte here does not affect the results of the experiment."

Which student made the correct statement? Give a reason for your answer.

.....

.....

..... [2]

(e) A student investigated the relationship between the mass of copper formed and the total charge passed through the solution. The graph of the results are seen in Fig. 10.2.

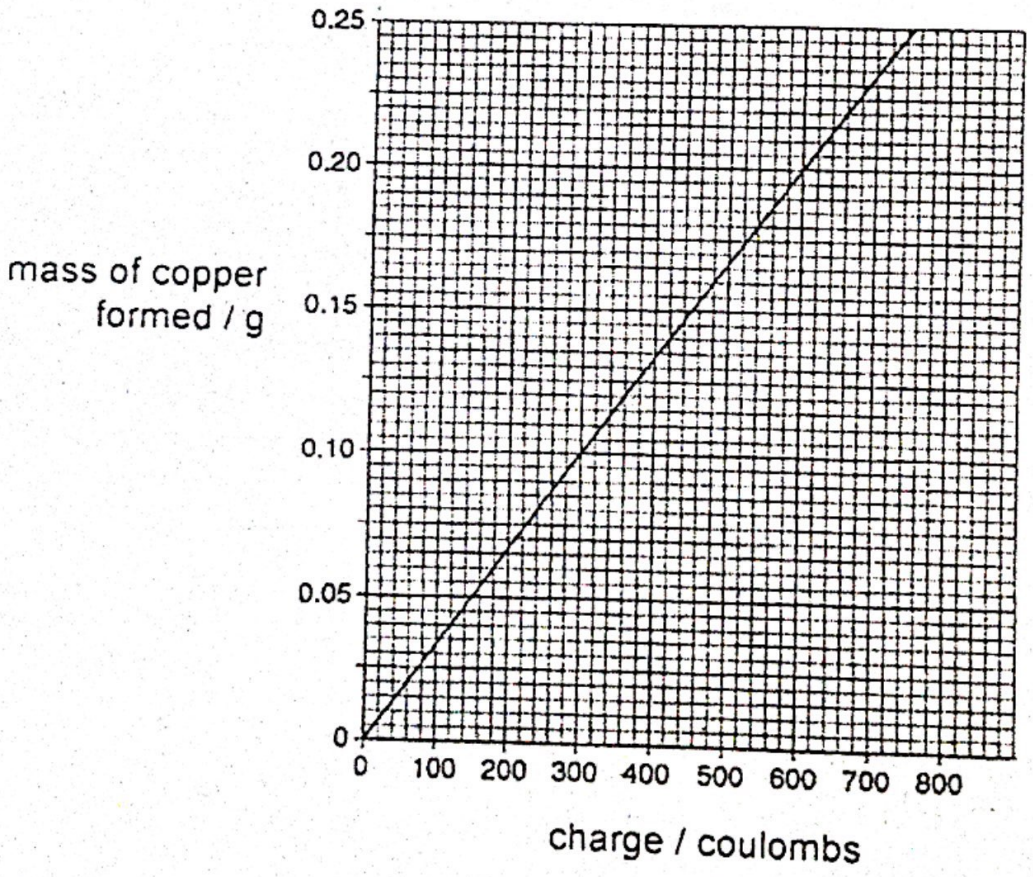


Fig. 10.2

(i) Deduce the mass of copper formed when a charge of 600 coulombs is passed through the solution.

.....

[1]

(ii) Use information given in Fig. 10.2 to predict the charge needed to form 1 g of copper and hence deduce the charge needed to deposit 1 mole of copper.

[2]