Candidate Name:	Class:	Index No.:

FUHUA SECONDARY SCHOOL
Secondary Four Express
PRELIMINARY EXAMINATION 2024

4E

CHEMISTRY **6092/2**

Paper 2

DATE	**16 August 2024**
TIME	**1045 - 1230**
DURATION	**1 hour 45 minutes**

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 staples, paper clips, 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.

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.

PARENT'S SIGNATURE

FOR EXAMINER'S USE		
Section A	Section B	**Total**
/70	**/10**	**/80**

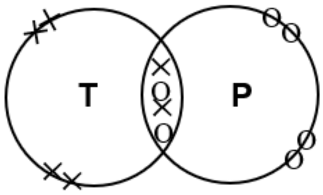
This document consists of **23** printed pages and **1** blank page.

Section A

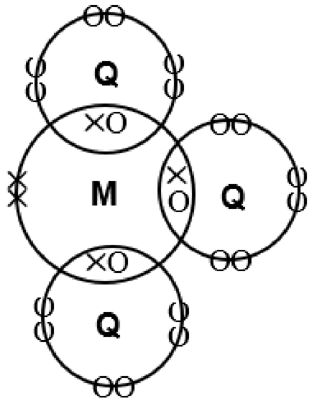
Answer **all** questions.

1 Fig. 1.1 shows 'dot-and-cross' diagrams for molecule 1, 2 and 3 that contain elements from Period 2 and 3 of the Periodic Table. The elements are represented by the letters **M**, **Q**, **R**, **T** and **Z**.

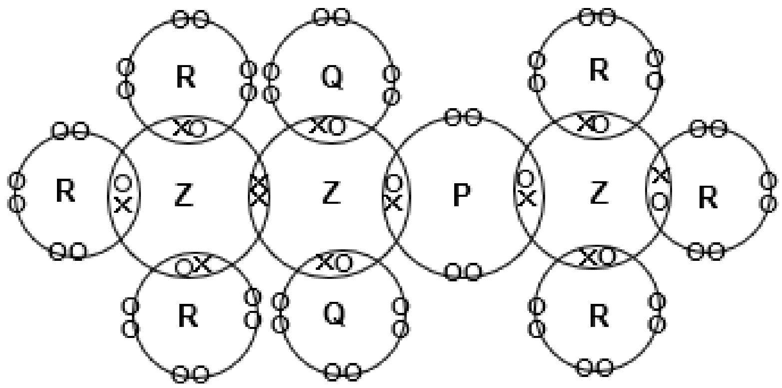
Each diagram shows outer electrons only.



molecule 1



molecule 2



molecule 3

Fig. 1.1

(a) Which elements are in Group 17?

.... [1]

(b) What is the formula of the compound formed between **Z** and **T**?

.... [1]

(c) **(i)** Draw a ‘dot-and-cross’ diagram to show the bonding of the compound formed between element **P** and **R**.

[2]

(ii) Draw a ‘dot-and-cross’ diagram to show the bonding of the compound formed between magnesium and element **M**.

[2]

(d) The following are some statements about the substances in Fig. 1.1.

Put a tick (✓) in **one** box in each row to show which statements are true and which are false.

	true	**false**
Molecule 3 has lower boiling point then molecule 2.		
Molecule 3 is a saturated organic compound.		
Only element **Z** reacts with oxygen to form acidic oxide.		
Elements **P** and **T** are in Group 16.		

[2]

[Total: 8]

2 Three experiments were carried out to measure the rate of reaction between excess barium carbonate powder and a strong monobasic acid. The reaction produces a gas which escapes from the reaction flask. The ionic equation for the reaction is

$$BaCO_3\,(s) + 2H^+\,(aq) \rightarrow Ba^{2+}\,(aq) + H_2O\,(l) + CO_2\,(g)$$

The rate of reaction was followed by measuring the change in mass of the reaction flask at regular time intervals.

The results of the three experiments are shown in the Fig. 2.1.

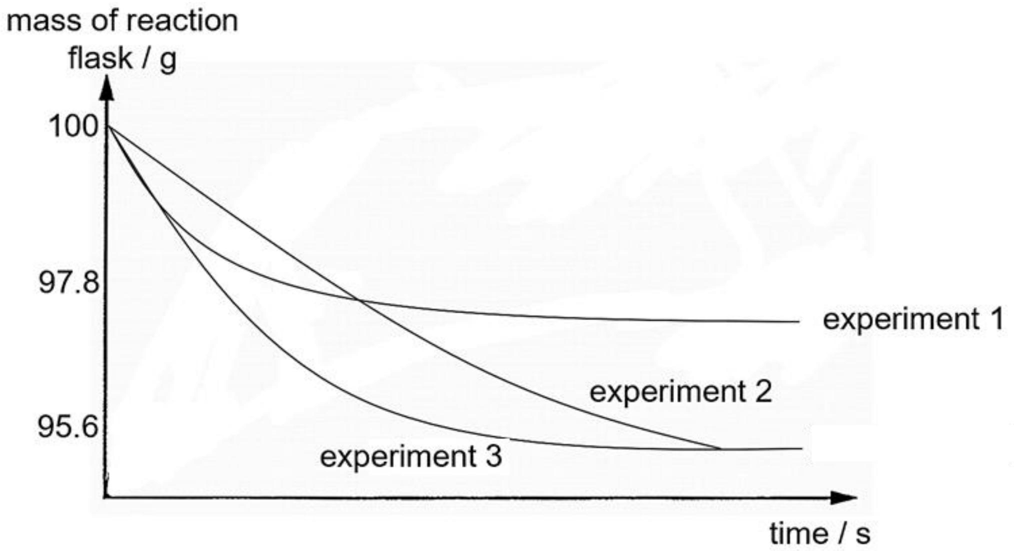


Fig. 2.1

(a) **(i)** Calculate the number of moles of carbon dioxide gas produced in experiment 1.

[1]

(ii) Hence, deduce and state the conditions of each experiment by completing the table below.

experiment	**particle size**	**volume of acid / cm^3**	**concentration of acid / $mol dm^{-3}$**
1	powder		2.0
2	lumps		1.0
3			

[3]

(b) Explain, in terms of reacting particles, how particle size of barium carbonate affects the rate of the reaction.

[2]

(c) The acid used is either hydrochloric acid or nitric acid. Describe a test to confirm the identity of the acid used.

[1]

(d) A further experiment, experiment 4, was carried out using ethanoic acid of the same volume and concentration as experiment 1.

Predict and explain how the rate of reaction and change in mass of the reaction flask of experiment 4 would be different from experiment 1.

[3]

[Total: 10]

3 Electrolysis is commonly used to give an object an attractive appearance or to prevent corrosion of a metal.

Fig. 3.1 shows a set-up prepared to electroplate an iron object using 200 cm^3 of aqueous copper (II) sulfate as the electrolyte.

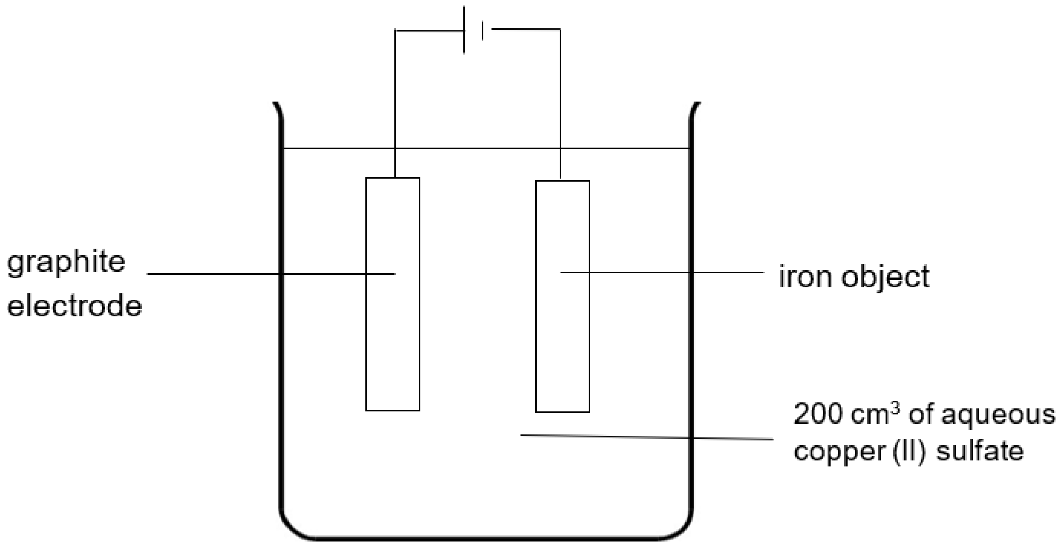


Fig. 3.1

Electrolysis was carried out and Fig. 3.2 shows the concentration of aqueous copper (II) sulfate against time.

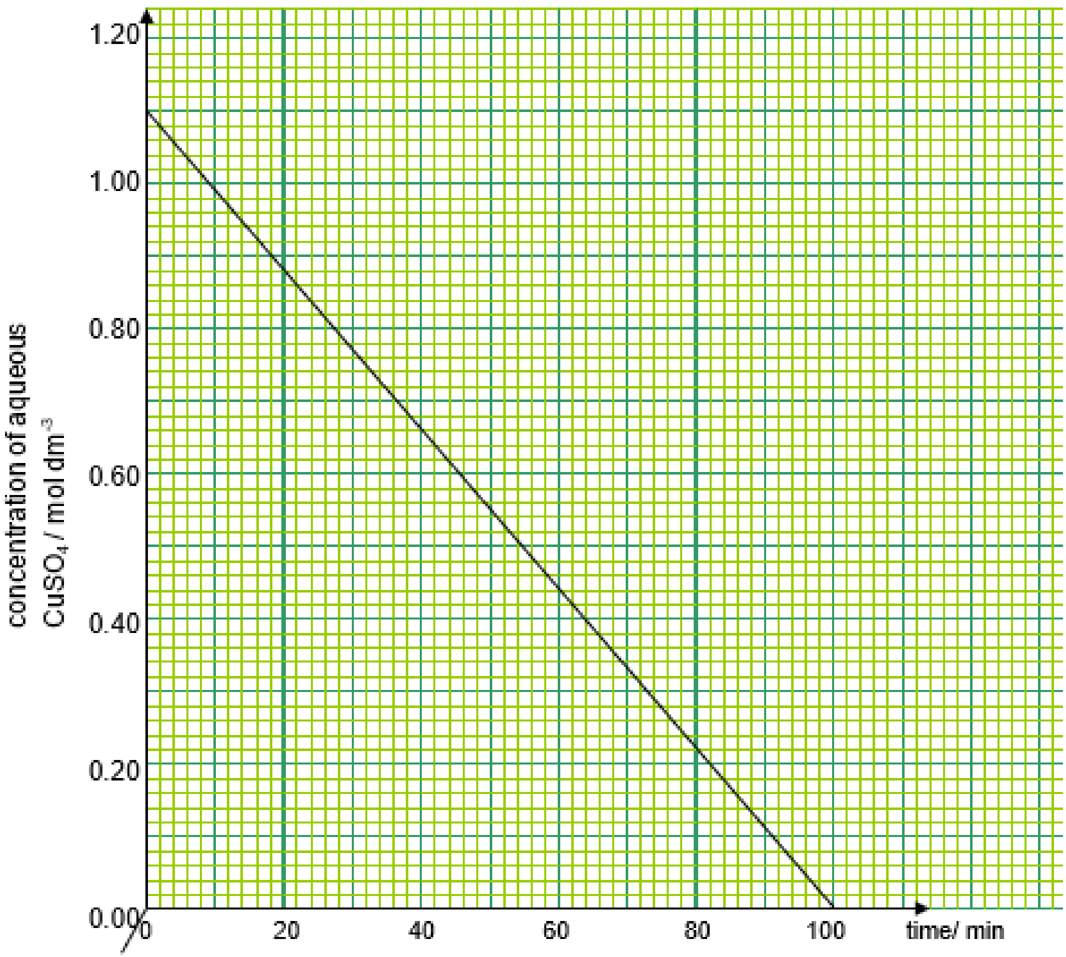


Fig. 3.2

(a) **(i)** Explain the shape of the graph by using an appropriate half-equation to support your answer.

....

....

.... [2]

(ii) Using data from the graph, calculate the increase in mass of the iron object after the electrolysis was conducted for 80 minutes.

[2]

(b) The set-up was modified as shown in Fig. 3.3 below.
Electrolysis was conducted using the same quantity of electricity as in the previous set-up.

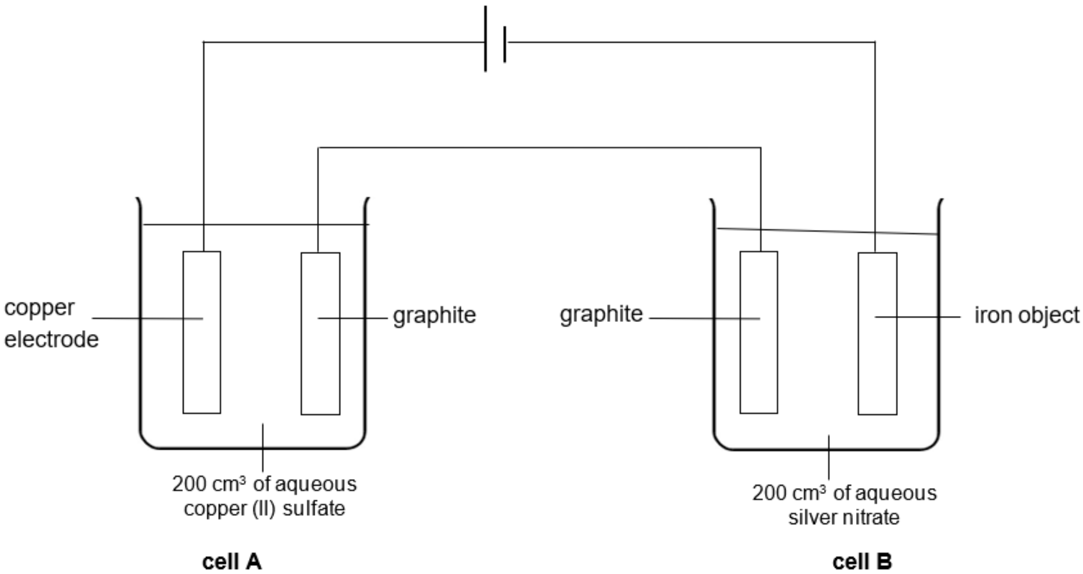


Fig. 3.3

(i) Sketch a graph, on Fig. 3.2, to show the concentration of aqueous copper (II) sulfate against time in **cell A** for the set-up in Fig. 3.3.
The initial concentration of aqueous copper (II) sulfate was same as the set-up in Fig. 3.1. Label your graph clearly.

[1]

(ii) Describe the observations at the graphite and iron electrodes in **cell B**.

....

.... [2]

(c) Sheets of iron are coated in tin and made into tin cans. The cans are filled with pineapple pieces and water. One of the cans becomes “dented” and the tin coating is scratched.
Suggest why the can corrodes more rapidly when it has a dent on its side compared to a pure iron can.

....

....

.... [2]

[Total: 9]

4 **(a)** Table 4.1 shows information about some organic compounds.
Complete the table by filling in the missing names, formulae and by completing the description of the processes.

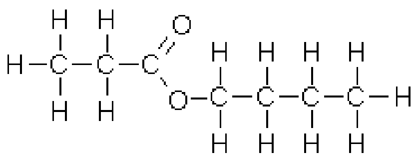
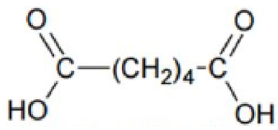
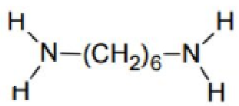
name of compound	structural formula	process(es) used to produce the compound
		Warming of ________________ and ____________________ with concentrated sulfuric acid.
propane		Catalytic ____________________ to propene.
polybutene		____________________ of butene
nylon-6,6		____________________ of monomers  and  .

Table 4.1

[5]

(b) Alkyl halides are a homologous series of organic compounds. They are formed when one halogen atom (X = C*l*, Br, I) bonds with carbon atoms.
Table 4.2 shows the condensed formulae and boiling points of some alkyl halides.

condensed formula	boiling point / °C		
	X		
	C*l*	Br	I
CH_3X	-24.2	3.6	42.4
CH_3CH_2X	12.3	38.4	72.3
$CH_3CH_2CH_2X$	46.6	71.0	102.5
$CH_3CH_2CH_2CH_2X$	78.4	101.6	130.5

Table 4.2

(i) Besides having the same functional group, use the information in the table to give two other pieces of evidence that suggest that the alkyl halides are a homologous series.

....

....

....

.... [2]

(ii) Describe and explain the trend in boiling points of alkyl halides when the halogen atom changes from C*l* to I.

....

....

....

....

....

....

.... [3]

(iii) Alkyl halides can be prepared by the reaction of halogen acids with alcohols. For example, hydrochloric acid reacts with methanol to produce methyl chloride and water.

Write an equation for the preparation of **ethyl iodide**, showing all the displayed formulae of all organic compounds.

[2]

[Total: 12]

5 Experiments on three metals (copper, manganese and chromium) were conducted.

Table 5.1 shows the appearance of the metals and the results of their reactions with air.

metal	appearance	reaction with air
copper	reddish-brown solid	Burns in air to form black copper (II) oxide.
manganese	shiny grey solid	Burns in air with an intense white light forming a red solid, manganese (II,III) oxide, Mn_3O_4.
chromium	shiny grey solid	Burns in air to form green chromium (III) oxide, Cr_2O_3.

Table 5.1

Small amounts of the three metals were also added to their aqueous metal nitrate solutions. The results are shown in Table 5.2.

metal	aqueous chromium (III) nitrate	aqueous manganese (II) nitrate	aqueous copper (II) nitrate
manganese	Green solution turned pale pink and grey metal coated with a silvery solid.		Blue solution turned pale pink and grey metal coated with a reddish-brown solid.
chromium		No visible change observed.	
copper	No visible change observed.	No visible change observed.	

Table 5.2

(a) Chromium metals are heated with manganese (II,III) oxide and copper (II) oxide in two separate experiments.
State and explain what you would expect to see in each experiment.

....

....

....

....

.... [3]

(b) Construct an ionic equation for the reaction involving manganese and chromium (III) nitrate.

.... [1]

(c) Complete Table 5.2 by stating the observations when chromium is added to aqueous copper (II) nitrate.

[1]

[Total: 5]

6 This question is on elements in Group 17.

(a) Complete Table 6.1 to show the colour and state of chlorine, bromine and iodine at room temperature and pressure.

	colour and state at room temperature and pressure
chlorine	
bromine	
iodine	

Table 6.1

[2]

(b) A brown solution is formed in two separate experiments. In the first experiment, aqueous bromine is added to aqueous iodide ions and in the second experiment, aqueous iodine is added to aqueous chloride ions.
Explain why.

[2]

(c) Chlorine reacts with the OH^- ion to form chloride ions and hypochlorite (OCl^-) ions.

$$Cl_2\ (aq) + 2OH^-\ (aq) \rightarrow Cl^-\ (aq) + OCl^-\ (aq) + H_2O\ (l)$$

This is a disproportionation reaction in which chlorine is oxidised and reduced simultaneously.

Use oxidation state to explain why this is a disproportionation reaction.

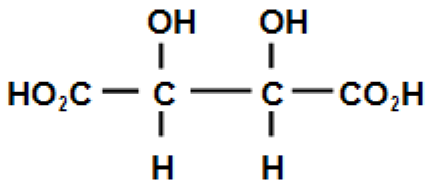
[2]

[Total: 6]

7 Both phosphoric acid and tartaric acid are weak acids. The formulae of both acids are given as follows:

H_3PO_4

phosphoric acid



tartaric acid

(a) Describe a simple test that can be used to show that tartaric acid or phosphoric acid is a weak acid.

....

.... [1]

(b) A solution of 0.200 mol / dm^3 potassium hydroxide was titrated against phosphoric acid and tartaric acid separately.

Deduce the ratio of the volume of potassium hydroxide used in titrating fixed volumes and concentrations of phosphoric acid and tartaric acid respectively.

.... [1]

(c) Tartaric acid and its salts have many applications.
One such salt is copper (II) tartarate which is insoluble in water.

Describe how you will prepare a pure and dry sample of this salt in the laboratory,

....

....

....

....

.... [2]

(d) **(i)** A 2.0 cm length of magnesium ribbon was added to 100 cm^3 of 2.00 mol / dm^3 phosphoric acid. All the magnesium reacted and the temperature of the acid increased by 6.0°C.

Predict the temperature change when 2.0 cm length of magnesium ribbon was reacted completely with 100 cm^3 of 2.00 mol / dm^3 tartaric acid. Explain your answer.

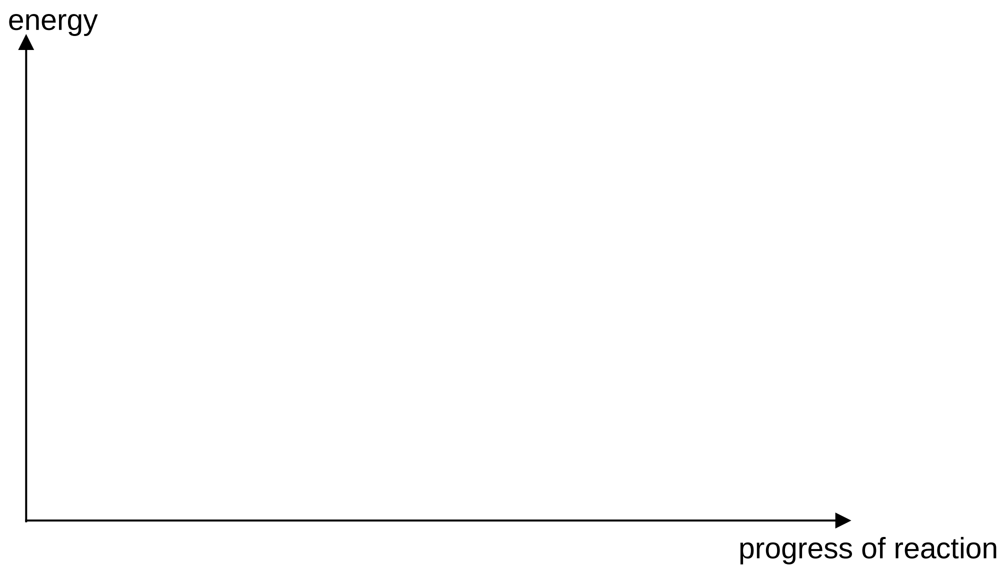
....

....

.... [2]

(ii) Complete the energy level diagram for reaction between magnesium ribbon and phosphoric acid.
Your diagram should include

- formulae of reactants and products
- enthalpy change of reaction
- activation energy



[2]

[Total: 8]

8 Chlorofluorocarbons (CFCs)

Chlorofluorocarbons (CFCs) are compounds containing chlorine, fluorine and carbon. CFCs are also known as freons. They were widely used in refrigerants and aerosol products before the 1990s, until they were phased out in several countries due to their negative impact on the ozone layer. When CFCs are released into the environment, they vapourise and move up the atmosphere.

Ozone Depleting Potential (ODP)

Ozone depleting potential (ODP) is a measure of how much damage a chemical can cause to the ozone layer compared with a similar mass of trichlorofluoromethane (CFC-11).
CFC-11, with an ozone depleting potential of 1.00, is used as the base figure for measuring ozone depleting potential.

Global Warming Potential (GWP)

Global Warming Potential (GWP) of a refrigerant is its global warming impact relative to the impact of the same quantity of carbon dioxide over a 100 year period. All effects beyond 100 years are disregarded.
Table 8.1 gives the ODP and GWP of some common CFCs.

CFC	structural formula	ODP	GWP
CFC-11	CCl_3F	1.00	4000
CFC-12	CCl_2F_2	0.82	8500
CFC-113	$C_2F_3Cl_3$	0.90	11700
CFC-114	?	0.85	5000

Table 8.1

Alternatives to CFCs

Two of the chemical classes under consideration for replacing CFCs are hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Use of HCFCs and HFCs as transitional refrigerants allows industries to phase out the production of CFCs and offer environmental benefits over the continued use of CFCs. Because they contain hydrogen, HCFCs and HFCs break down more easily in the atmosphere than do CFCs.

Table 8.2 gives the ODP and GWP of some common HCFCs and HFCs.

HCFC	structural formula	ODP	GWP
HCFC-22	$CHClF_2$	0.04	1700
?	$C_2HCl_2F_3$	0.014	93
HFC-23	CHF_3	$< 4 \times 10^{-4}$	12100
HFC-125	?	$< 3 \times 10^{-5}$	3200

Table 8.2

Naming of CFCs, HCFCs and HFCs

The naming of CFCs follows the rule of 90 which determines the number of chlorine, fluorine and carbon atoms in the molecule.

Fig. 8.3 gives the example of the naming of trichlorofluoromethane (CCl_3F). Adding 90 to 11 gives 101. The first digit gives the number of carbon atoms, second digit gives the number of hydrogen atoms and the third digit gives the number fluorine atoms. Given that all carbon atoms must have four bonds, any other bonds left is a carbon-chlorine bond. Trichlorofluoromethane (CCl_3F) is named CFC-11.

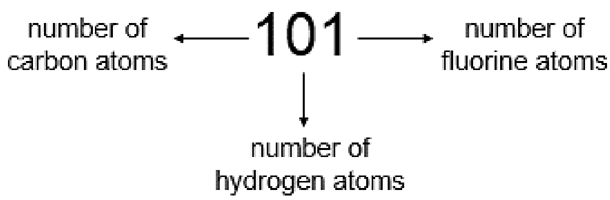


Fig. 8.3

The naming of HCFCs and HFCs follows the same format except with the addition of 'H' at the front.

Bond energy values

Table 8.4 gives some bond energy values for some carbon-hydrogen and carbon-halogen bonds.

bond	bond energy / kJ mol^{-1}
C - C*l*	328
C - F	485
C - H	413

Table 8.4

(a) Referring to Table 8.1, Table 8.2 and Fig. 8.3 and using the rule of 90, answer the following questions.

(i) Derive the naming for $C_2HCl_2F_3$.

.... [1]

(ii) State the structural formula for

CFC-114 HFC-125

....

[2]

(b) Using evidence from the information, compare the alternative use of HCFCs and HFCs against CFCs in relation to the impact on ozone layer depletion and global warming.

[4]

(c) CFCs break down ozone in several steps. The first step occurs when energy from the sunlight breaks a bond in CFC to produce a chlorine atom.

$$CCl_3F \rightarrow CCl_2F + Cl$$

Chlorine atoms break down the ozone in two steps.

$$Cl + O_3 \rightarrow ClO + O_2$$
$$ClO + O_3 \rightarrow Cl + 2O_2$$

(i) Explain how the equations show that one molecule of CFC can destroy thousands of ozone molecules.

[2]

(ii) A student made the following comment.
'HFCs have lower ODP values than CFCs because of the bond energy values.'
Explain whether you agree with the student.

[2]

(d) Although not as effective, ammonia and carbon dioxide are also used as refrigerants and both have ODP values of 0.00.
Explain why.

[1]

[Total: 12]

Section B

Answer **one** question from this section.

9 **(a)** Fig. 9.1 gives the reaction scheme of organic compound **A**.

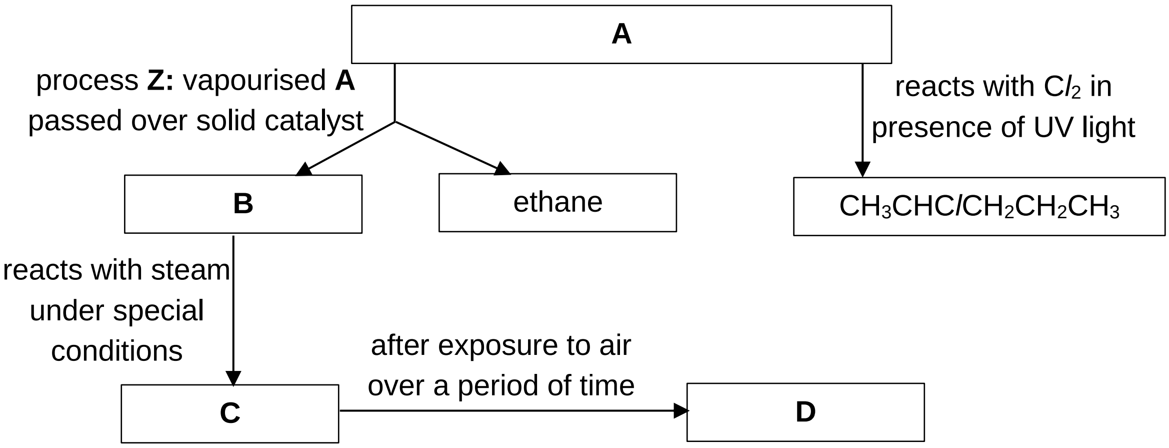


Fig. 9.1

(a) **(i)** Construct a balanced chemical equation for process **Z**.

.... [1]

(ii) Describe a test to differentiate compound **A** from **B**.

....

....

.... [2]

(iii) Draw the displayed formula of the compound formed when **C** and **D** are heated with concentrated sulfuric acid.

[1]

(b) Table 9.2 gives structures of two polymers **X** and **Y** are shown below.

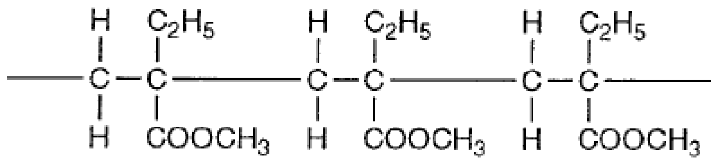
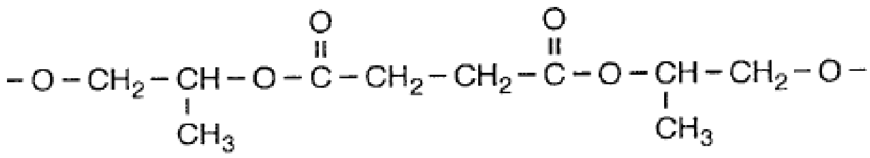
polymer **X**	
polymer **Y**	

Table 9.2

(i) A potential customer requires the chain length of the polymer **X** to be controlled so that the polymer molecules have an average relative molecular mass in the range of 16 000 to 50 000.

What is the range of the average number of repeat units in the polymer molecules? Show your working.

[2]

(ii) Draw the displayed formulae of the monomers where polymer **Y** could be made with.

[2]

(iii) Calculate the mass of polymer Y produced when 1 kg of each of the monomers reacted.

[2]

[Total: 10]

10 **(a)** Three reactions take place in the catalytic converter installed in car exhaust systems.

1. Conversion of nitrogen oxides (NO, NO_2) into nitrogen.
2. Conversion of carbon monoxide into carbon dioxide.
3. Conversion of hydrocarbons into carbon dioxide and water.

The air/fuel ratio in the car engine affects how the conversion efficiency of the catalytic converter. A 'lean' air/fuel mixture to the engine has a higher ratio of air to fuel while a 'rich' air/fuel mixture has a lower ratio of air to fuel.

Fig. 10.1 gives the conversion efficiency of a converter based on air/fuel ratio.

HC: hydrocarbon
NO_x: oxides of nitrogen
CO: carbon monoxide

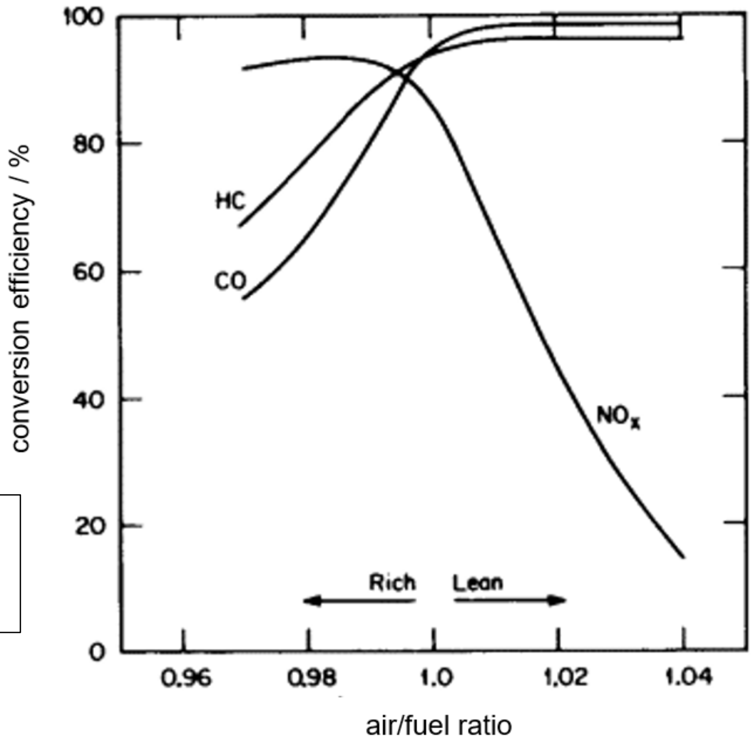


Figure 10.1

(i) Describe and explain how changing the air/fuel ratio from 'rich' to 'lean' affects the conversion efficiency of carbon monoxide, nitrogen monoxide and hydrocarbons in the catalytic converter.

....

....

....

....

....

....

....

.... [4]

(ii) The exhaust gas from vehicles without catalytic converters cause more harm to human health than those from vehicles fitted with catalytic converters.
Explain why this is true.

....

....

.... [2]

(b) The chloro-alkali industry is a chemical industry manufacturing chlorine, sodium hydroxide and other products, by the electrolysis of brine (concentrated sodium chloride solution). Sodium chloride is a readily available mineral existing as sea salt.

This mineral is, however, often contaminated with mud, Ca^{2+}, Mg^{2+}, Fe^{3+} and SO_4^{2-} ions, all of which must be removed before the purified salt is to be put into the electrolytic bath.

The first step of purification of sea salt involves dissolution and filtration of mud. The collected filtrate is then treated with the following chemicals in the order as shown below.

step 1: aqueous barium chloride solution
step 2: aqueous sodium carbonate solution
step 3: substance **Z**

(i) Explain the purpose of treating the filtrate with the chemicals listed in step 1 and step 2 above in order to obtain a reasonably pure sample of brine for the electrolytic process.

step 1:

....

....

step 2:

....

.... [2]

(ii) The filtrate is treated with substance **Z** in step 3 to remove excess carbonate ions from step 2. Identify substance **Z**.
Explain your choice

....

....

.... [2]

[Total: 10]

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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											13 A*l* aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 C*l* 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 T*l* 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 F*l* 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, $L = 6.02 \times 10^{23} mol^{-1}$