Pasir Ris Secondary School

Name	Class	Register No.

SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2023

CHEMISTRY **6092/02**

Paper 2 **18 Aug 2023**

1 h 45 min

Friday 1035 – 1220

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 all **three** questions, the last question is in the form either/or.
Answer **all** questions 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 22.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	
B9	
B10	
B11	
Total	

This document consists of **22** printed pages, including the cover page.

Setter: Ms Chua Wei Tian **[Turn over**

Section A

Answer **all** the questions in the spaces provided.
The total mark for this section is 50.

A1 Fig. 1.1 shows the electronic configurations of five elements, **A**, **B**, **C**, **D** and **E**.

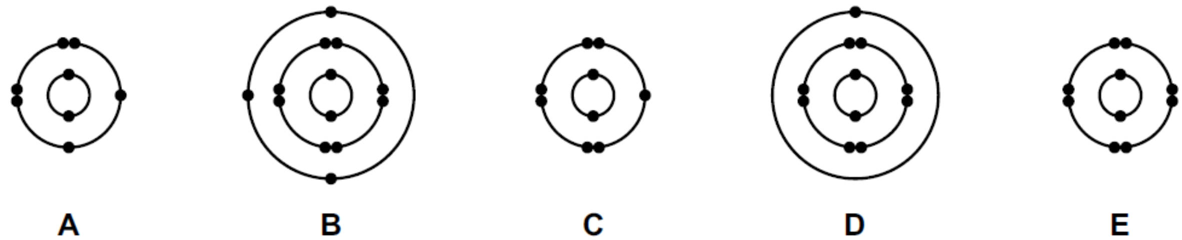


Fig. 1.1

(a) Use the letters **A**, **B**, **C**, **D** and **E** to answer the following questions.

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

(i) Which element is most likely to be a metal with low melting point?

.... [1]

(ii) Which element can be oxidised by oxygen to form an amphoteric oxide?

.... [1]

(iii) Which element can form a molecule with a double covalent bond?

.... [1]

(b) Element **E** exists as a single atom only. Explain why.

....

.... [1]

[Total: 4]

A2 Table 2.1 shows the formulae of oxides of elements across Period 2 and Period 3 in the Periodic Table.

Table 2.1

Period	Group						
	I	II	III	IV	V	VI	VII
2	Li_2O	BeO	B_2O_3	CO_2	NO_2	-	F_2O
3	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_2	Cl_2O

(a) Carbon and silicon are elements in Group IV of the Periodic Table. They form oxides with very different melting points.

Explain, in terms of structure and bonding, why the melting points of carbon dioxide and silicon dioxide are different.

....

....

....

....

.... [3]

(b) **(i)** Draw a 'dot-and-cross' diagram to show the bonding in Na_2O. Show only the valence electrons.

[2]

(ii) Discuss the differences in the type of bonding and the way bonds formed in Na_2O and Cl_2O.

....

....

....

.... [2]

[Total: 7]

A3 Mixture **S** contains one cation and two anions. A series of tests was performed on mixture **S** as shown in Fig. 3.1.

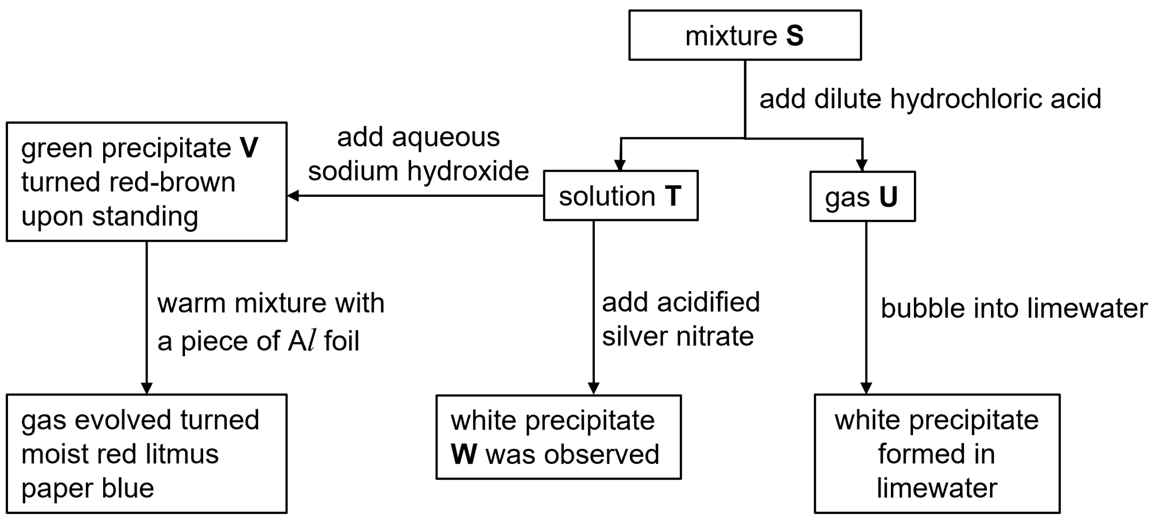


Fig. 3.1

(a) Identify the following unknown substances:

(i) **T**, ... [1]

(ii) **U**, ... [1]

(iii) **V**, ... [1]

(iv) **W**. .... [1]

(b) Suggest the likely identities of the ions present in mixture **S**.

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

(c) Write a balanced chemical equation to represent **one** of the reactions in Fig. 3.1.

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

[Total: 6]

A4 All Group I metals form metal hydroxides that are soluble in water. Most other metal hydroxides are insoluble in water.

Crystals of lithium chloride can be prepared using titration between aqueous hydrochloric acid and aqueous lithium hydroxide. Fig. 4.1. represents the experimental set-up.

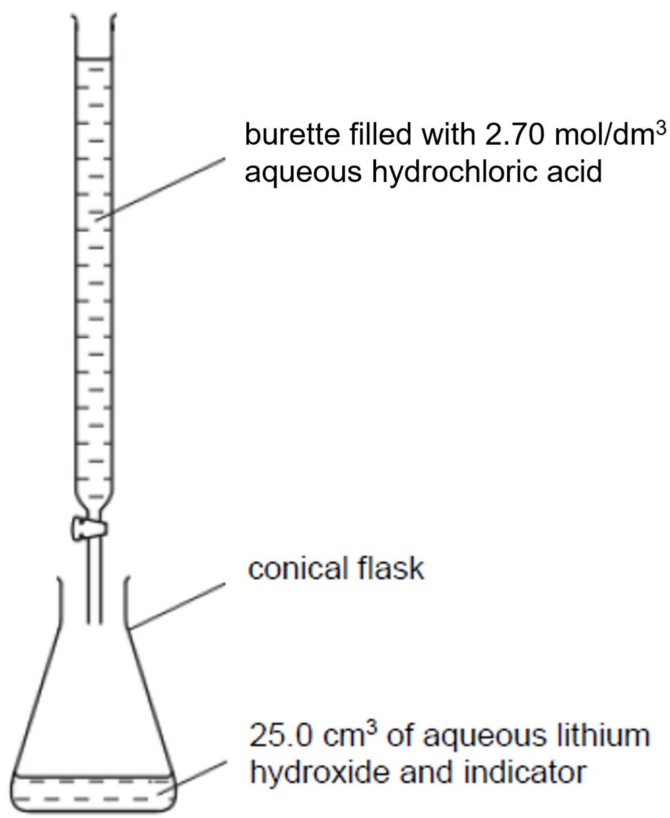


Fig. 4.1

25.0 cm^3 of aqueous lithium hydroxide is pipetted into the conical flask. A few drops of an indicator are added. Aqueous hydrochloric acid is added until the indicator just changes colour. The volume of acid required to completely neutralise lithium hydroxide is recorded.

(a) A neutral solution of lithium chloride containing the indicator is left at the end of titration. It is known that lithium chloride is unstable to heat and melts at 617°C. Describe how you could obtain a **pure** dry sample of lithium chloride crystals.

……...

……...

……...

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

(b) Suggest why magnesium chloride could **not** be prepared using the same method as lithium chloride.

……...

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

(c) The concentration of aqueous hydrochloric acid is 2.70 mol/dm^3. 22.50 cm^3 of aqueous hydrochloric acid is required to neutralise 25.0 cm^3 of aqueous lithium hydroxide.

Calculate the concentration of aqueous lithium hydroxide.

[2]

[Total: 5]

A5 Table 5.1 shows the melting points and boiling points of Group VII elements.

Table 5.1

Group	element	melting point / °C	boiling point / °C
VII	chlorine	–101	–35
	bromine	–7	59
	iodine	114	184

(a) Describe the trend of melting points and boiling points of elements down Group VII. Use ideas about bonding to explain why.

....

....

....

.... [2]

(b) Sea water contains potassium bromide. Bromine can be produced from sea water by displacement.

(i) Name an element that can displace bromine. Explain your answer.

....

.... [2]

(ii) Write an ionic equation to represent the equation.

.... [1]

[Total: 5]

A6 Copper is a transition element. It can act as a catalyst in the form of an element or a compound.

(a) State **two** other chemical properties of transition elements which make them different from Group I elements.

1 ....

2 .... [2]

(b) Copper can exist in the form of copper(II) oxide. When copper(II) oxide is heated at 800°C, it decomposes to form two products as shown in the following chemical equation.

$$4CuO \longrightarrow 2Cu_2O + O_2$$

(i) Explain, in terms of electron transfer, why CuO is described as an oxidising agent.

....

.... [1]

(ii) Explain, in terms of oxidation states, why CuO is described as a reducing agent.

....

.... [1]

(c) Copper metal is obtained when scrap iron is added to aqueous copper(II) sulfate.

(i) Describe **two** observations and explain why this is possible. Include a chemical equation to support your answer.

....

....

....

.... [3]

(ii) Identify **another** method for obtaining copper metal from aqueous copper(II) sulfate.

.... [1]

[Total: 8]

A7 Electrolysis and simple chemical cells both involve chemical reactions and electricity. Some students investigated the electrolysis of copper(II) nitrate solution using inert electrodes. Fig. 7.1 shows the experimental set-up.

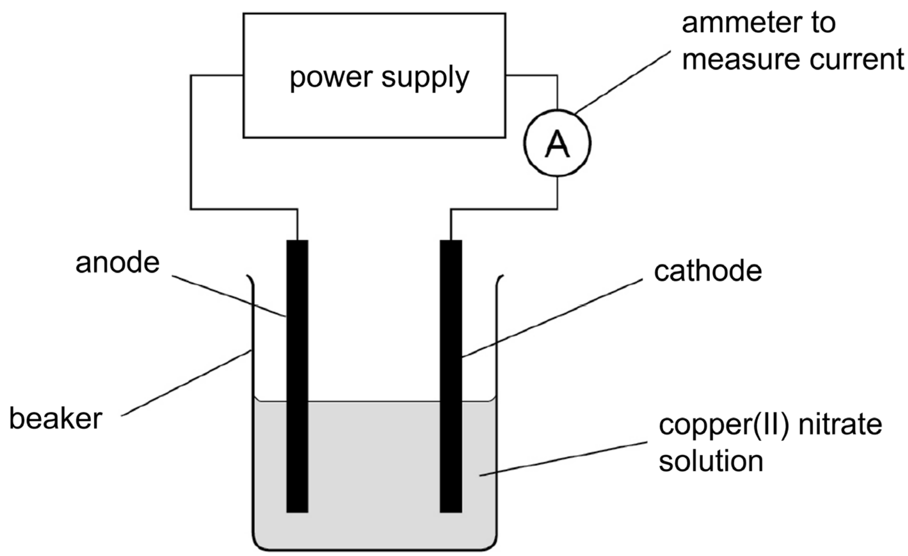


Fig. 7.1

(a) Explain the differences between an electrolytic cell and a simple chemical cell.

………

………

…… [2]

(b) Write ionic equations for the reactions at the cathode and anode.

(i) cathode: ……………………………………………………………………………………… [1]

(ii) anode: ………………………………………………………………………………………… [1]

(c) Describe and explain **two** observations that could be made during the experiment.

………

………

…… [2]

(d) When the anode was replaced with a piece of zinc electrode, some gas bubbles were observed around the zinc electrode. Suggest a reason for this observation.

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

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

[Total: 7]

A8 The reaction between hydrogen sulfide and oxygen is exothermic. It can be represented by the following equation.

$$2H_2S(g) + 3O_2(g) \longrightarrow 2H_2O(g) + 2SO_2(g)$$

(a) **(i)** Fig. 8.1 shows part of the energy profile diagram for the reaction.

Complete Fig. 8.1. Your diagram should include:

- the reactants and products of the reaction,
- labels to show the enthalpy change of reaction and the activation energy.

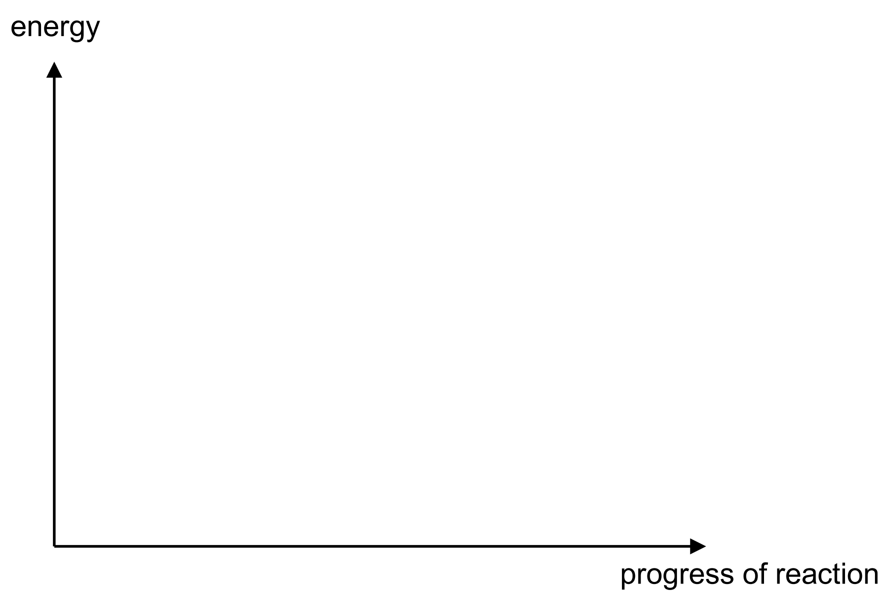


Fig. 8.1

[3]

(ii) Use ideas about breaking and forming bonds to explain why the overall reaction is exothermic.

………

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

(b) Table 8.2 shows some of the bond energies.

Table 8.2

bond	bond energy / kJ/mol
H–S	364
O=O	498
H–O	464
S=O	**X**

Given that the enthalpy change of the reaction is –1034 kJ/mol, calculate the bond energy **X** for the S=O bond.

[3]

[Total: 8]

Section B

Answer all **three** questions from this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.
The total mark for this section is 30.

B9 Depletion of fossil fuels

Fossil fuels are formed naturally from the remains of dead plants and animals. When fossil fuels are burnt, they produce large amounts of energy which can be used to produce electricity in power stations, or to power engines in vehicles. Fossil fuels take millions of years to form, and the global high demand for fossil fuels has accelerated its depletion. As such, there is a need to source for alternative energy sources that are renewable and more sustainable.

Biofuels as alternative fuels

Biofuels are derived from biomass, which is material originally from living organisms. This could either be animal or plant derived. Some common examples of biofuels include ethanol and biodiesel. While the production and combustion of biofuel produces carbon dioxide, the use of biofuel is described as *carbon neutral*.

Ethanol as biofuel

Ethanol can be created by fermenting biomass that contains carbohydrates such as sucrose, glucose, and starch. Fermentation of glucose solution, in the presence of yeast, produces ethanol and can be represented by the following chemical equation.

$$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Biodiesel as biofuel

Researchers discovered a method to transform waste vegetable oils to biodiesel for use as an alternative fuel. In fact, waste vegetable oil is the main raw material used for biodiesel production in the United States. As compared to fossil fuels, biodiesel produces less soot, carbon monoxide and unburnt hydrocarbons. Fig. 9.1 summarises some of the key processes involved in the production of biodiesel.

collection of waste vegetable oils from households and restaurants

↓ process **1**: filtration

purified used vegetable oils

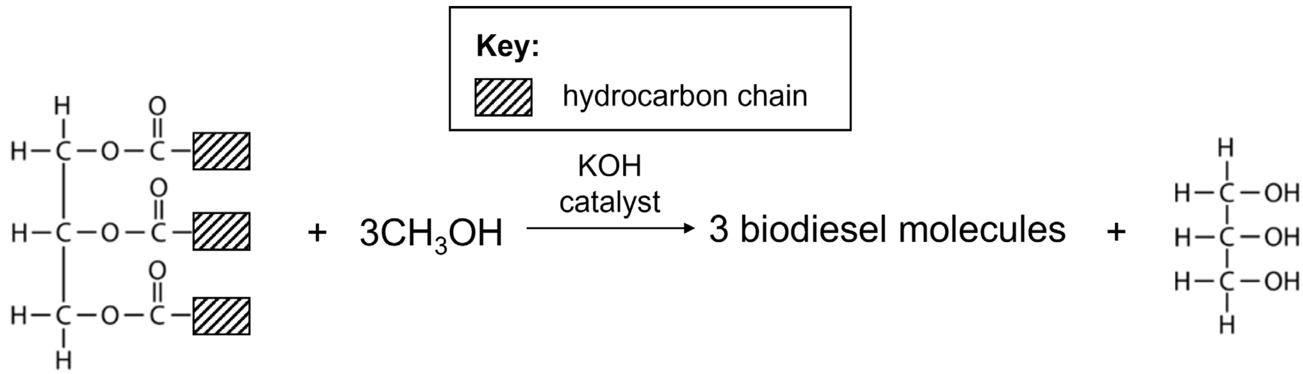
↓ process **2**: transesterification

conversion to biodiesel

Fig. 9.1

Transesterification

Vegetable oils are tri-esters with long hydrocarbon chains. It can react with methanol, in the presence of potassium hydroxide as catalyst, to form biodiesel and glycerol. Fig. 9.2 shows the structures of some of the molecules involved in the reaction. **Biodiesel is an ester.**



vegetable oil methanol glycerol

Fig. 9.2

Waste vegetable oils, that were previously exposed to high temperatures during cooking, usually contain acids. The presence of acid in the waste vegetable oils makes it challenging to convert them into biodiesel, taking a longer time than waste vegetable oil without acid.

Comparison between fossil fuel and biofuel

Table 9.3 compares some of the properties between fossil fuel and biofuel.

Table 9.3

type of fuel	fossil fuel (e.g. petrol obtained after refining petroleum)	biofuel	
		ethanol	biodiesel
energy produced/ kJ per g	approx. 46.0	26.8	37.8
biodegradability	non-biodegradable	biodegradable	biodegradable
production process	• takes millions of years to form • requires fossil fuel to be refined before it is useful	• takes a few hours, slow rate of reaction • requires crops (e.g. corn) to be grown for fuel	• presence of acid decreases the rate of reaction • requires crops (e.g. corn) to be grown for fuel
incomplete combustion	more likely	less likely	less likely

Reference: Topi, D. Transforming waste vegetable oils to biodiesel, establishing of a waste oil management system in Albania. SN Appl. Sci. 2, 513 (2020).

(a) **(i)** Explain why the use of biofuel is described as *carbon neutral.*

....

....

.... [2]

(ii) With reference to Fig. 9.1, suggest **one** improvement that could be included in process **1** to produce a greater yield of biodiesel.

....

.... [1]

(b) **(i)** Describe, in general, the meaning of transesterification. Include the functional group(s) involved.

....

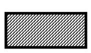
.... [1]

(ii) Suggest why vegetable oils are called *tri-esters*.

....

.... [1]

(iii) One molecule of vegetable oil reacts to form three molecules of biodiesel. Suggest the structure of one molecule of biodiesel.

Use  to represent the hydrocarbon chain.

[2]

(c) Explain how and why the presence of acid in the waste vegetable oils will take a longer time for its conversion into biodiesel.

……..

……..

…… [2]

(d) Explain why the production of ethanol is a slow process.

……..

…… [1]

(e) *"Biofuel is a better source of fuel than fossil fuel."*

With reference to Table 9.3, justify if you agree with the statement.

……..

……..

……..

…… [2]

[Total: 12]

B10 Alkynes and alkenes are homologous series of unsaturated hydrocarbons. All alkynes contain C≡C triple bond. Table 10.1 shows information about the first three alkynes.

Table 10.1

formula	C_2H_2	C_3H_4	C_4H_6
structure	H–C≡C–H	H–C≡C–CH_3	H–C≡CH_2–CH_3
names	ethyne	propyne	butyne

(a) Compounds in the same homologous series have the same general formula.

(i) Give **two** other characteristics of members of a homologous series.

1 ……………………………………………………………………………………………………

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

(ii) Alkynes are unsaturated. Describe a test for unsaturation.

test ……………………………………………………………………………………………………

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

(b) Explain why methyne and methene do **not** exist.

…… [1]

(c) Ethene can be converted to ethanoic acid by a two-stage process in the laboratory. In stage one, ethene is converted to ethanol by catalytic addition.

(i) Identify the catalyst used in stage one.

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

(ii) Deduce the type of reaction involved in stage two to produce ethanoic acid. Include the necessary chemical reagent.

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

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

[Total: 8]

EITHER

B11 Hydrogen is used to produce ammonia in the Haber process. The hydrogen is made in two stages. In each process, hydrogen is the useful product.

Stage 1 involves the reaction between methane and steam to produce carbon monoxide and hydrogen. This reaction can be represented by the following equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

Stage 2 uses the carbon monoxide produced in **stage 1**.

The carbon monoxide is reacted with more steam to produce carbon dioxide and more hydrogen. This reaction can be represented by the following equation.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

The atom economy of a process is a measure of the percentage by mass of the products that are useful.

atom economy = [(total M_r of useful product) ÷ (total M_r of products)] × 100%

(a) Calculate the atom economy for the formation of hydrogen in **stage 1**.

[2]

(b) What is the effect of increasing the pressure on the equilibrium yield and the rate of formation of hydrogen in **stage 2**? Use ideas about energy and collisions to explain why.

……..

……..

……..

…… [3]

(c) Fig. 11.1 shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process. A temperature of 450°C and a pressure of 200 atm are commonly used in the Haber process.

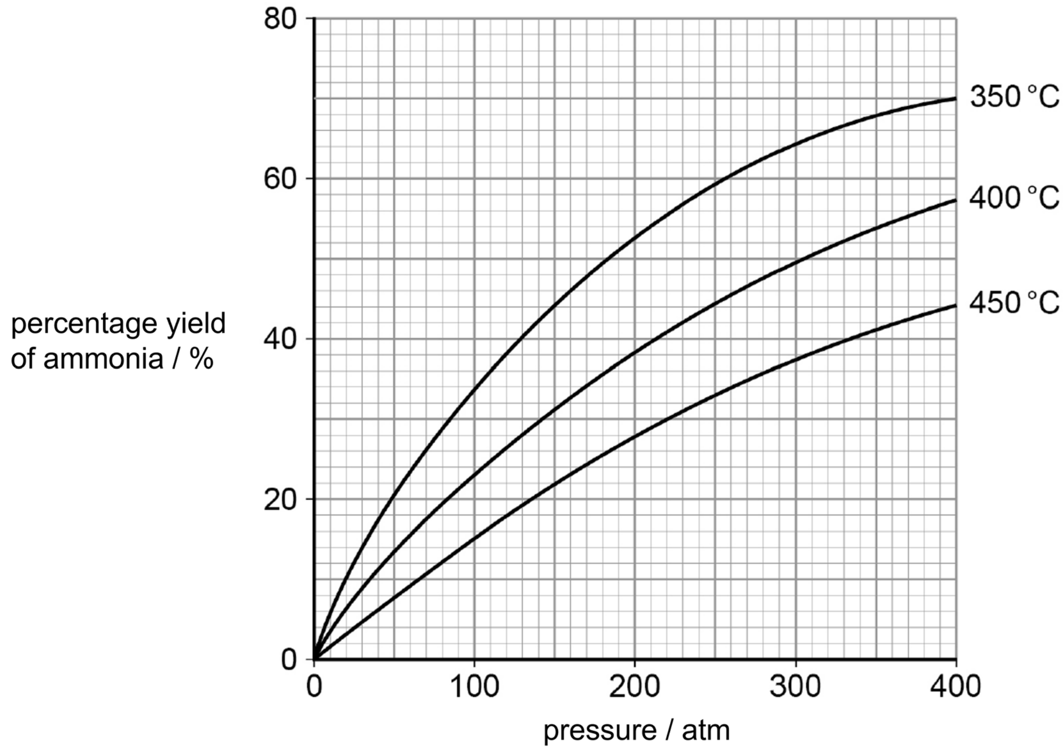


Fig. 11.1

(i) A student proposed that a temperature of 350°C and a pressure of 285 atm could be used instead of those used in the Haber process.

Determine how many times greater the percentage yield of ammonia obtained would be.

.... [1]

(ii) Suggest why the proposed conditions by the students are **not** ideal for industrial purpose.

....

....

.... [2]

(d) World production of ammonia is now about 50 times greater than it was in the 1940s. Suggest why the demand for ammonia has increased.

……..

……..

…… [2]

[Total: 10]

OR

B11 Some students investigated the rate of decomposition of hydrogen peroxide, H_2O_2.

The reaction can be represented by the following chemical equation. However, the equation is unbalanced with a missing state symbol.

$$\ldots\ldots\ H_2O_2\ (\ldots\ldots) \longrightarrow \ldots\ldots\ H_2O\ (l) + \ldots\ldots\ O_2\ (g)$$

The catalyst for the reaction is manganese(IV) oxide.

(a) Balance the above chemical equation. Include the missing state symbol. [1]

(b) Student **X** investigated the effect of the particle size of manganese dioxide on the rate of the reaction. The following method is used.

1. Measure 25 cm^3 of 0.30 mol/dm^3 hydrogen peroxide solution into a conical flask.
2. Add a spatula of fine manganese(IV) oxide powder to the conical flask.
3. Measure the volume of gas produced every minute for 10 minutes.
4. Repeat steps 1 to 3 with some coarse manganese(IV) oxide lumps.

The method student **X** used did **not** give valid results.

Suggest **two** improvements that student **X** could make to the method to give valid results.

……..

……..

…… [2]

(c) Student **Y** used a method which gave valid results.

Student **Y** performed the experiment using 25 cm^3 of 0.30 mol/dm^3 hydrogen peroxide solution with fine manganese(IV) oxide powder.

Student **Y** repeated the experiment with coarse manganese(IV) oxide powder.

Fig. 11.2 shows student **Y**'s results.

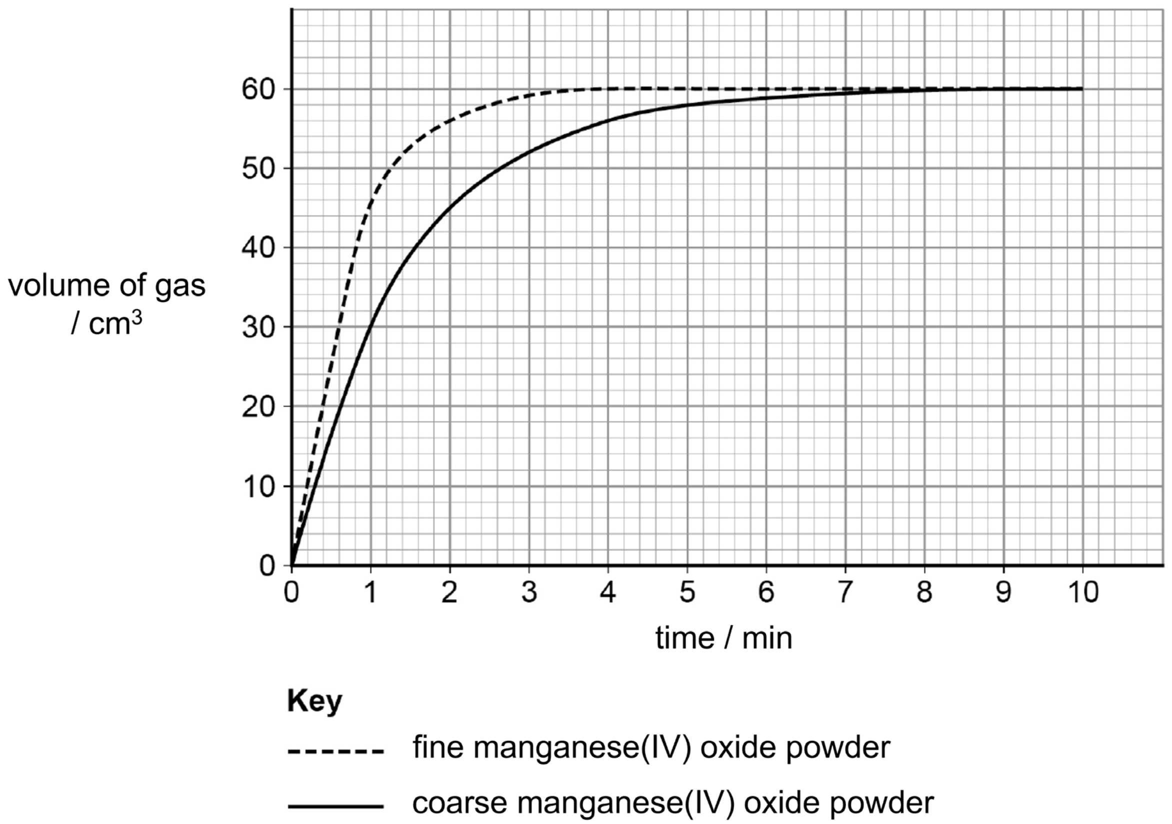


Fig. 11.2

(i) Describe the change in the rate of reaction when the experiment was repeated with coarse manganese(IV) oxide powder.

Use ideas about energy and collisions to explain why.

....

....

....

.... [3]

(ii) Student **Y** repeated the experiment with coarse lumps of manganese(IV) oxide.

Student **Y** used the same volume of 0.15 mol/dm^3 hydrogen peroxide instead of 0.30 mol/dm^3 hydrogen peroxide.

Sketch on Fig. 11.2 the curve you would expect to see. Assume that the reaction is complete after 9 minutes. [2]

(iii) Determine the volume of distilled water required to prepare 0.15 mol/dm^3 hydrogen peroxide from 1 dm^3 of 0.30 mol/dm^3 hydrogen peroxide. Show all your workings clearly.

[2]

[Total: 10]

End of Paper

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		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											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 –		

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.).