Name:	Class:	Class Register Number:

中正中学

CHUNG CHENG HIGH SCHOOL (MAIN)

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PRELIMINARY EXAMINATION 2024
SECONDARY 4

CHEMISTRY **6092/02**

Paper 2 **21 August 2024**

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number clearly 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, glue or correction fluid.

Section A
Answer **all** questions 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.

For Examiner's Use	
Section A	/ 70
Section B	/ 10
Total	/ 80

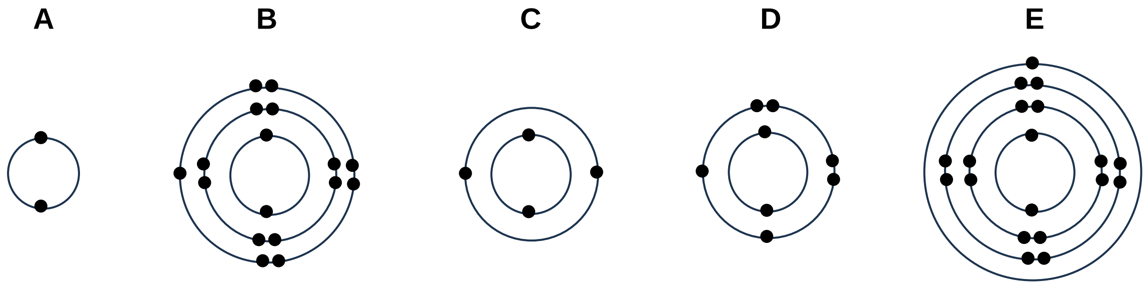
The use of an approved scientific calculator is expected, where appropriate.

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

Section A

Answer **all** questions.

1 The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



(a) Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E** represents:

(i) an atom of an element in Group 2 of the Periodic Table

……………………………………………………………………………………[1]

(ii) an atom of a very reactive metal

……………………………………………………………………………………[1]

(iii) an atom with a proton number of 17

……………………………………………………………………………………[1]

(iv) an atom that forms a stable ion with a charge of 2–

……………………………………………………………………………………[1]

(b) Atoms **B** and **C** reacts to form a compound. Draw a 'dot-and-cross' diagram to show the bonding between atoms **B** and **C**.

Show outer electrons only.

[2]

[Total: 6]

2 Silver dichromate, $Ag_2Cr_2O_7$, is a red insoluble salt.

Silver dichromate can be made by reacting silver nitrate solution with ammonium dichromate solution as shown by the equation below.

$$2AgNO_3 + (NH_4)_2Cr_2O_7 \rightarrow 2NH_4NO_3 + Ag_2Cr_2O_7$$

(a) **(i)** Describe how you can obtain pure and dry solid silver dichromate after mixing silver nitrate solution and ammonium dichromate solution.

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

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

(ii) Describe the steps that you would take to determine if silver nitrate solution is present in the reaction mixture after the reaction stops.

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

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

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

……………………………………………………………………………………………[3]

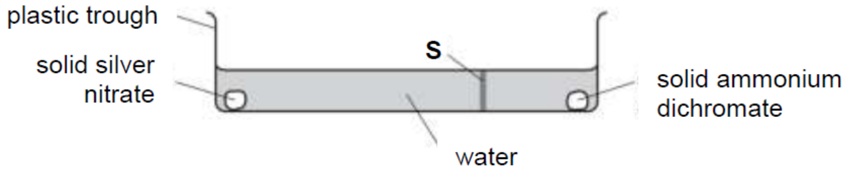
(b) **(i)** Deduce the oxidation state of chromium in $Ag_2Cr_2O_7$.

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

(ii) Write the ionic equation, with state symbols, for the formation of silver dichromate in this reaction.

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

(c) The apparatus shown below is set up.



After five minutes, a red solid appeared at the position marked **S** on the diagram.

(i) Explain why a red solid appeared at the position marked **S**.

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

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

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

[Turn over

(ii) The experiment is then repeated at a higher temperature.

What effect, if any, would this have on the time taken for the red solid to appear? Explain your answer.

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

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

[Total: 11]

3 A student investigated the change in mass when hydrated cobalt chloride is heated. The chemical equation for the reaction is:

$$CoCl_2 \bullet 6H_2O \rightarrow CoCl_2 + 6H_2O$$

This is the method used.

1. Add 2.0 g of hydrated cobalt chloride to an empty test tube.
2. Measure the mass of the test tube and contents.
3. Heat the test tube and contents gently for 30 seconds.
4. Allow the test tube and contents to cool.
5. Measure the mass of the test tube and its contents.
6. Repeat steps 3 to 5 until the mass of the test tube and its contents do not change.

(a) Predict if the mass of the test tube and its contents increase or decrease after heating. Give a reason for your answer.

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

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

(b) Suggest why the test tube and its contents were heated until the mass did not change.

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

(c) **(i)** When 238 g of hydrated cobalt chloride is heated until the mass does not change, 88.1 kJ of energy is taken in.

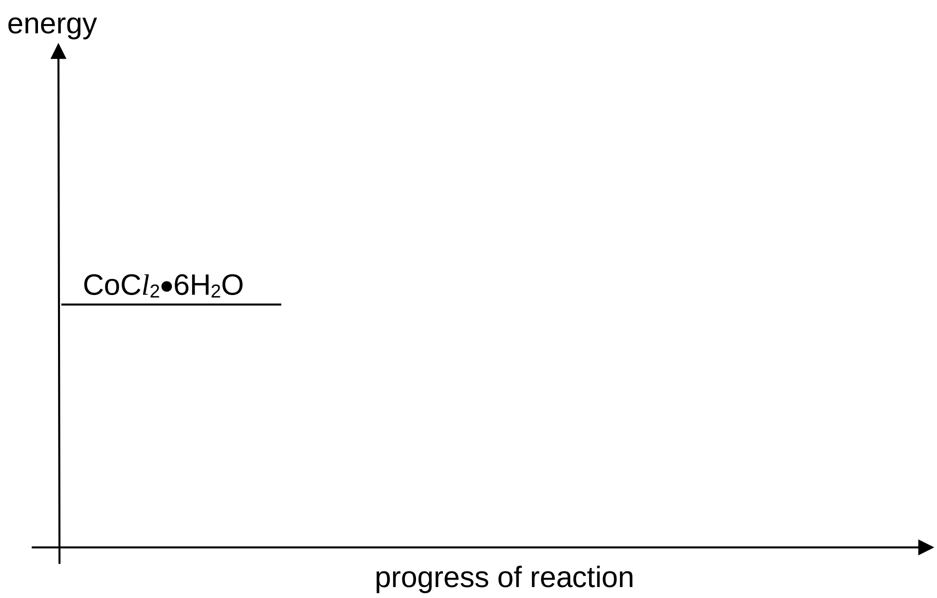
Calculate the energy taken in when the student heated 2.00 g of hydrated cobalt chloride until the mass did not change.

Energy taken in = ………………………..kJ [2]

[Turn over

(ii) Complete the energy profile diagram for the decomposition of hydrated cobalt chloride.

Your diagram should show:
- chemical formula of the products of the reaction,
- labels to show the activation energy and enthalpy change of the reaction.



[3]

[Total: 7]

4 The diagram shows a Group in a Periodic Table designed by John Newlands in 1864. The Group contains elements found in Group 17 (the halogens) of the modern Periodic Table and other elements.

H
F
C*l*
Co/Ni
Br
Pd
I
Pt/Ir

(a) Use the modern Periodic Table to suggest why Newlands put cobalt and nickel in the same place.

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

(b) Cobalt, nickel, palladium, platinum and iridium are now classified as transition elements. State two ways in which the properties of transition elements are different from halogens.

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

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

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

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

(c) Hydrogen is difficult to be placed in the modern Periodic Table.

(i) State one way in which hydrogen is similar to the elements in Group 1.

……………………………………………………………………………………………

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

(ii) State one property of hydrogen which makes it similar to the elements in Group 17.

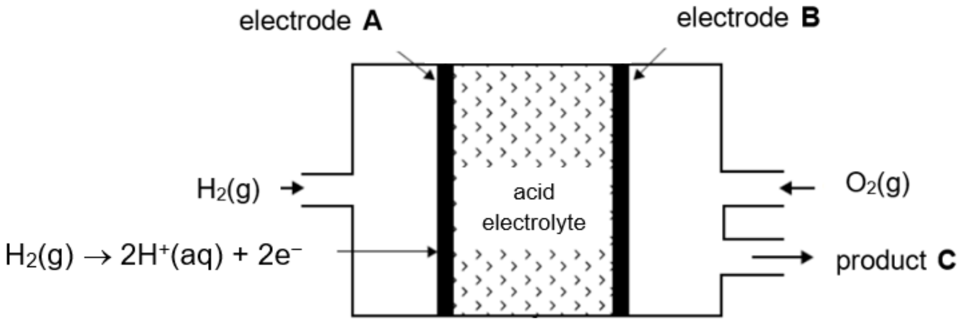
……………………………………………………………………………………………

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

[Total: 5]

[Turn over

5 A car manufacturer is planning to sell hybrid cars powered by a type of hydrogen fuel cell that uses acid electrolyte. A representation of the hydrogen fuel cell is given below.



The overall cell reaction is $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

(a) State if oxidation or reduction has occurred at electrode **A**. Explain your answer.

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

(b) Identify product **C**.

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

(c) Write an equation for the reaction that occurs at electrode **B** when the switch is closed.

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

(d) Identify one advantage and one disadvantage of using this fuel cell instead of a petrol engine to power the car.

advantage……………………………………………………………………………….

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

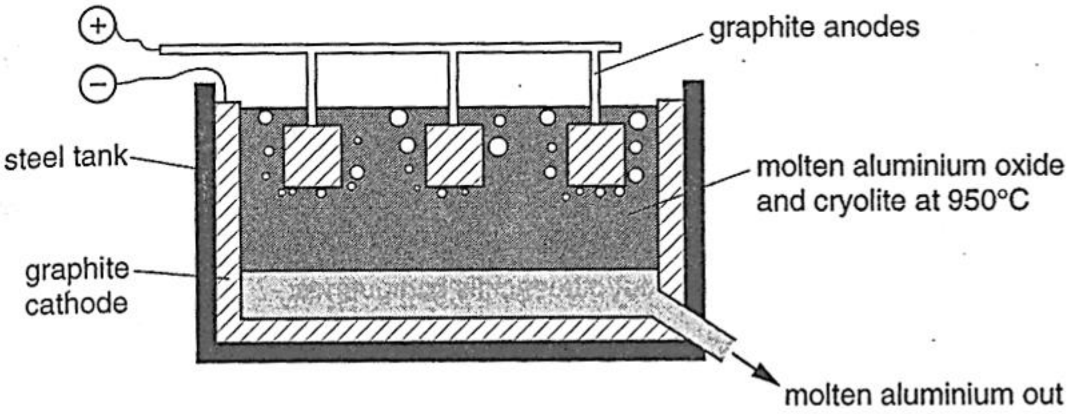
disadvantage……………………………………………………………………………

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

[2]

[Total: 5]

6 This diagram shows an electrolysis tank used industrially to produce aluminium from aluminium oxide. Pure aluminium oxide melts at 2045 °C.



(a) One reason that this process is expensive is that the graphite anodes need replacing regularly.

Explain why the graphite anodes need replacing regularly.

………

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

(b) Adding molten cryolite reduces the cost of the process by lowering energy demand. Explain how adding molten cryolite reduces the energy demand of the process.

………

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

(c) Aluminium has many uses because of its resistance to corrosion.

Aluminium resists corrosion because it reacts with the air to form a thin layer of aluminium oxide.

The thickness of this layer can be increased artificially by placing pure aluminium as the positive electrode in the electrolysis of dilute sulfuric acid. Oxygen produced forms on the surface of the aluminium and reacts with the metal to form a thicker oxide layer.

Explain, with the help of half equation, how oxygen is formed on the surface of aluminium during the electrolysis of dilute sulfuric acid.

………

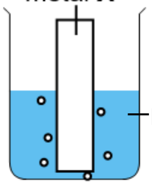
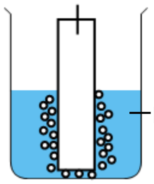
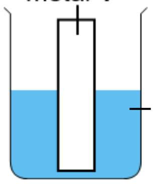
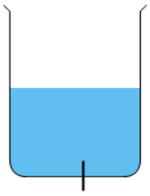
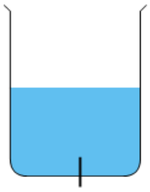
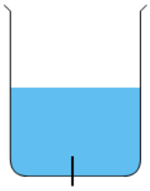
………

………

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

[Turn over

(d) The diagrams below show the experimental results when metal **X**, aluminium and metal **Y** are added to dilute hydrochloric acid respectively.

experiment no.	1	2	3
during experiment			
after experiment			

(i) Arrange the metals, metal **X**, aluminium and metal **Y**, from the most reactive to the least reactive.

....[1]

(ii) Describe the observation that will be made when aluminium is placed in the green solution obtained from experiment 1.

....

....[2]

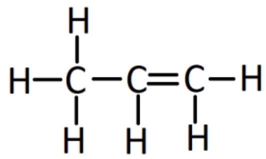
(iii) Provide an explanation for the observation made in **(d)(ii)**.

....

....[2]

[Total: 11]

7 The diagram shows a monomer that can undergo addition polymerisation.



(a) Name the polymer formed when this molecule polymerises and draw the structure of the repeat unit of the polymer.

Name: …………………………………………………..

Structure of repeat unit:

[2]

(b) Depolymerisation is one of the chemical methods used when recycling plastics.

(i) Define *depolymerisation*.

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

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

(ii) Discuss the social and economic issues related to recycling plastics.

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

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

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

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

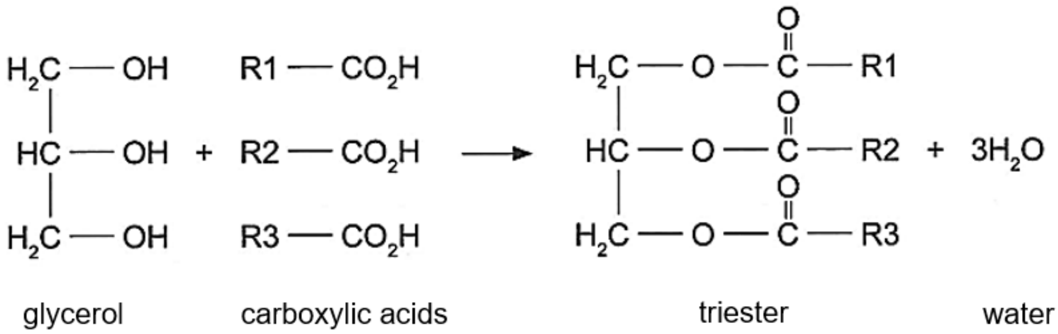
…………………………………………………………………………………………………..

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

[Total: 5]

[Turn over

8 Olive oil contains a mixture of triesters formed from glycerol and three long-chain carboxylic acids, as shown by the general equation.



The groups R1, R2 and R3 represent hydrocarbon chains each containing either 15 or 17 carbon atoms. A given oil molecule (triester) can be formed from any combination of the following carboxylic acids.

name	**formula**	**number of C atoms in molecule**	**M_r**	**melting point / °C**
palmitic acid	$CH_3(CH_2)_{14}COOH$	16	256	63
stearic acid	$CH_3(CH_2)_{16}COOH$	18	284	69
oleic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	18	282	13
linoleic acid	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	18	280	–5
linolenic acid	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	18	278	–11

(a) **(i)** Explain why the melting point of stearic acid is higher than that of palmitic acid.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

(ii) State how the presence of carbon-carbon double bonds affects the melting point of the carboxylic acids.

……………………………………………………………………………………………………

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

(iii) Describe a chemical test to show the presence of carbon-carbon double bonds in carboxylic acids.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

(b) Draw the oil molecule (triester) formed when one glycerol molecule reacts with three molecules of palmitic acid.

[1]

(c) The average number of carbon-carbon double bonds per molecule in different oils can be compared experimentally by determining the mass of iodine that reacts with 100 g of the oil.

In one experiment, 0.256 g of olive was found to react with 0.237 g of iodine.

(i) Calculate the mass of iodine that would react with 100 g of olive oil.

[1]

(ii) Use your answer from **(c)(i)** to calculate the average number of carbon-carbon double bonds in each oil molecule in olive oil. The average M_r of an olive oil molecule is 782.

Give your answer to three significant figures.

[3]

[Total: 10]

[Turn over

9 Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide.

Two carbon sequestration technologies are discussed below.

Geological sequestration

Geological sequestration refers to the storage of carbon dioxide in underground rock formations containing highly concentrated salt solutions.

condensation of carbon dioxide from power plants and refineries under high pressure

↓

transportation of carbon dioxide to storage site using pipelines

↓

injection of liquid carbon dioxide to storage site, typically 1 km underground

While trapped in a rock formation, carbon dioxide can react with minerals such as forsterite, Mg_2SiO_4 to form carbonate and silicon dioxide.

The limitation to this technology is that the movement of Earth plates may cause the release of stored carbon dioxide gas into the ocean or atmosphere.

Iron fertilisation

Iron fertilisation is the intentional introduction of iron to the upper ocean to promote a plankton bloom. This will in turn increase the rate of atmospheric carbon dioxide removal through photosynthesis of plankton.

transportation of large quantity of iron compounds to ocean site using vessels

↓

release of iron compounds into the ocean site to boost plankton growth

↓

absorption of carbon dioxide by plankton during photosynthesis

Plankton generates calcium or silicon carbonate skeletons. When these organisms die their carbonate skeletons sink relatively quickly and form a major component of the carbon-rich deep-sea precipitation.

The Redfield ratio describes the relative atomic concentrations of critical nutrients in plankton biomass and is represented as “106 C: 16 N: 1 P." This expresses the fact that one atom of phosphorus and 16 atoms of nitrogen are required to "fix" 106 carbon atoms.

Recent research has expanded this constant to "106 C: 16 N: 1 P: 0.001 Fe" signifying that in iron deficient conditions each atom of iron can fix 106 000 atoms of carbon, or on a mass basis, 1 kg of iron can fix 83 000 kg of carbon dioxide.

However, the complete effect on marine ecosystem is unknown to date.

(a) Suggest a reason why there is a need to remove excess carbon dioxide from the atmosphere.

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

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

(b) Suggest why carbon dioxide is liquefied before it is transported to the storage site.

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

(c) **(i)** Write a balanced chemical equation, with state symbols, for the reaction between carbon dioxide and forsterite.

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

(ii) What problem might arise during the injection of carbon dioxide into rock formations containing high minerals concentration?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(d) A company selling iron fertilisation technology claims that this technology is completely non-polluting.

Explain why this claim is false.

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

[Turn over

(e) By means of calculation, prove that the Redfield ratio shows 1 kg of iron can fix 83 000 kg of carbon dioxide.

[3]

[Total: 10]

Section B

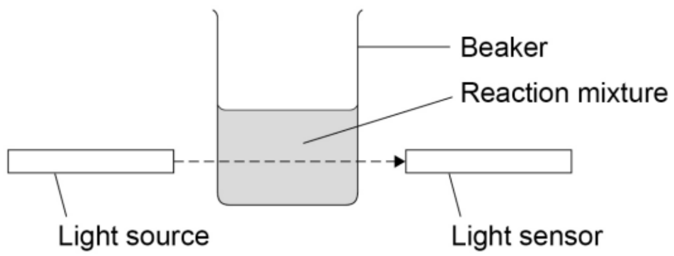
Answer **one** question from this section.

10 A student investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction between sodium thiosulfate solution and dilute hydrochloric acid. The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$$

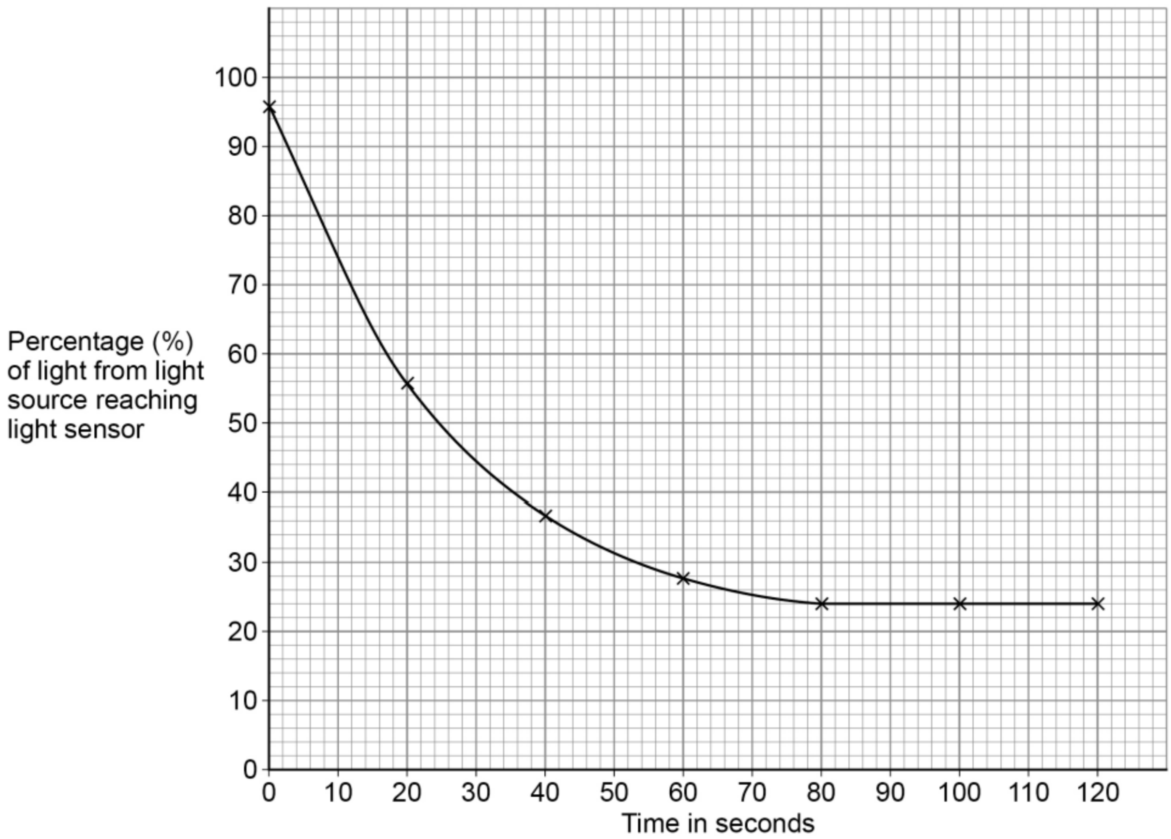
Fig. 10.1 shows the apparatus used.

Fig. 10.1



The student added 10 cm^3 of hydrochloric acid into a beaker containing 50 cm^3 of 0.10 mol/dm^3 sodium thiosulfate solution. The sodium thiosulfate solution was used in excess in this investigation. He recorded the percentage of light from the light source that reaches the light sensor every 20 seconds for 120 seconds. Fig. 10.2 shows his results.

Fig. 10.2



[Turn over

(a) Explain why percentage of light from the light source reaching the light sensor decreases with time.

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

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

(b) **(i)** In terms of concentration, explain why the rate of reaction changes between 0 and 60 seconds.

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

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

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

(ii) The line of best fit on **Fig. 10.2** is horizontal between 80 and 120 seconds because the reaction stopped.

Why did the reaction stop?

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

(c) The student repeated the experiment using 0.20 mol/dm^3 sodium thiosulfate solution.

Sketch a line on **Fig. 10.2** to show the results you would predict for 0.20 mol/dm^3 sodium thiosulfate solution. [1]

(d) Another student conducted the experiment using 0.10 mol/dm^3 sodium thiosulfate solution at a higher temperature. He observed that the reaction ended before 80 seconds.

In terms of reacting particles, explain why his result is different.

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

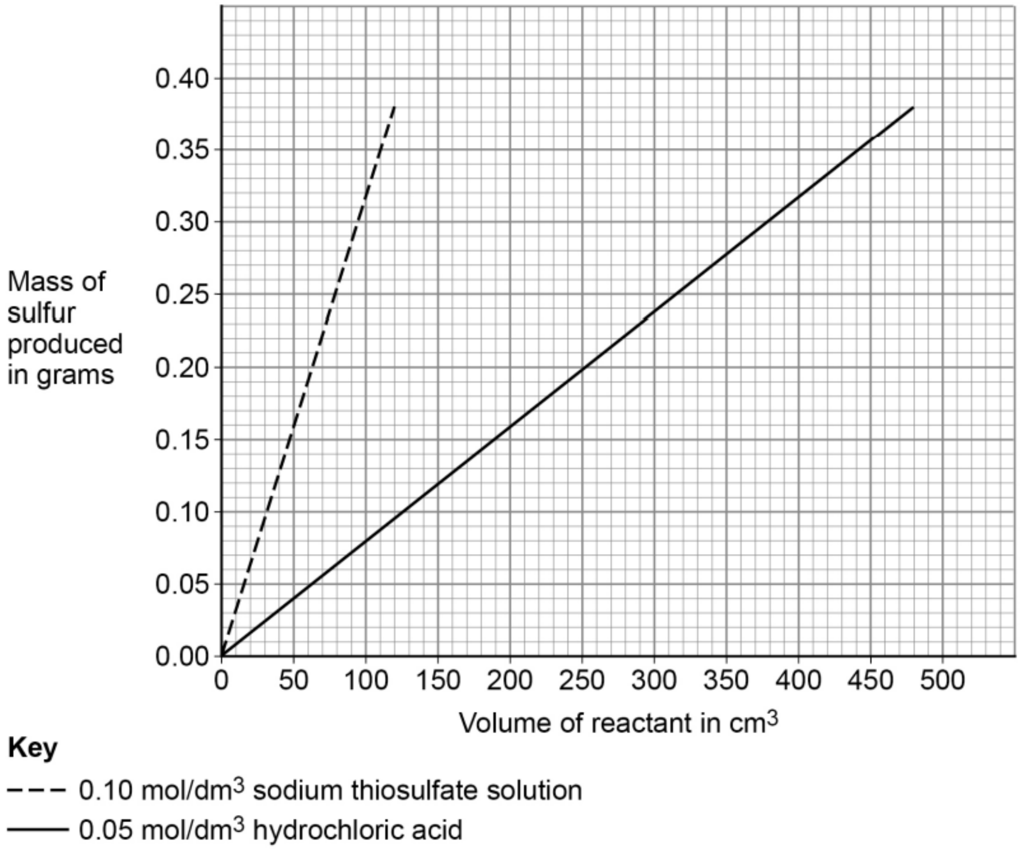
……………………………………………………………………………………….…………...

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

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

(e) **Fig. 10.3** shows the different masses of sulfur produced when different volumes of 0.10 mol/dm^3 sodium thiosulfate solution and 0.05 mol/dm^3 hydrochloric acid are completely reacted with each other.

Fig. 10.3



With reference to **Fig. 10.3**, determine the simplest whole number ratio of the volumes of

sodium thiosulfate solution : hydrochloric acid

which completely react with each other.

Simplest whole number ratio = ______________ : ________________ [2]

[Total: 10]

[Turn over

11 A student investigated how a change in concentration affects the rate of the reaction between zinc carbonate powder and sulfuric acid. The equation for the reaction is:

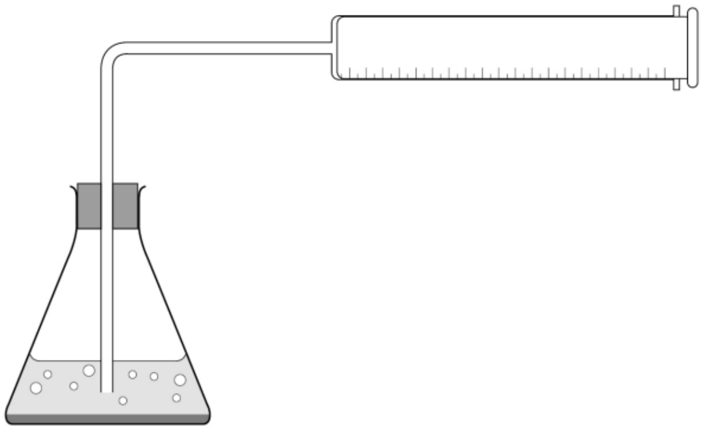
$$ZnCO_3(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + CO_2(g) + H_2O(l)$$

The student added 0.5 g of zinc carbonate powder into a conical flask containing 50 cm^3 of 0.050 mol/dm^3 sulfuric acid. He measured the volume of gas collected every 30 seconds for 5 minutes.

He repeated the experiment with sulfuric acid of concentration 0.062 mol/dm^3.

Fig. 11.1 shows the apparatus used.

Fig. 11.1



(a) The student made an error in setting up the apparatus in **Fig. 11.1**.

What error did the student make?

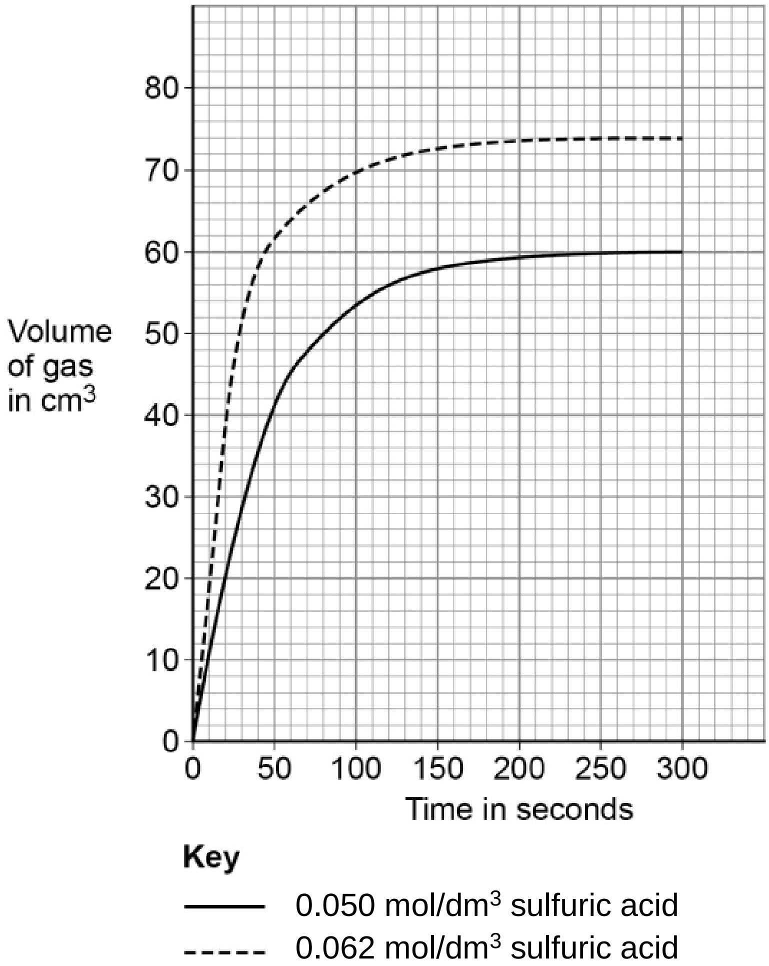
……………………………………………………………………………………………………...

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

(b) The student corrected the error.

Fig. 11.2 shows the student's results.

Fig. 11.2



(i) Using the results shown in **Fig. 11.2**, deduce the limiting reactant in this investigation.

Explain your answer.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) How does **Fig. 11.2** show that zinc powder reacts more slowly with 0.050 mol/dm^3 sulfuric acid than with 0.062 mol/dm^3 sulfuric acid?

…………………………………………………………………………………………………

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

(c) The student repeated the experiment using 0.5 g of zinc carbonate granules and 50 cm^3 of 0.05 mol/dm^3 sulfuric acid.

Sketch a line on **Fig. 11.2** to show the results you would predict for 0.5 g of zinc carbonate granules. [1]

(d) When 0.5 g of zinc carbonate powder is added into 50 cm^3 of 0.05 mol/dm^3 sulfuric acid, rapid effervescence is observed.

Describe and explain what the student would observe if he repeated the experiment with 0.5 g of calcium carbonate powder.

……

……[2]

(e) Another student conducted the experiment using 0.5 g of zinc carbonate powder and 0.05 mol/dm^3 hydrochloric acid. He observed that the reaction is much slower and took almost 10 minutes to complete.

In terms of reacting particles, explain why his result is different.

……

……

……

……

……[3]

[Total: 10]

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The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

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											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}