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CHEMISTRY **0620/61**

Paper 6 Alternative to Practical **May/June 2025**

1 hour

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION
- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- Notes for use in qualitative analysis are provided in the question paper.

This document has **16** pages. Any blank pages are indicated.

DC (CE/CGW) 342083/2

1 A student prepares some crystals of pure potassium sulfate by reacting aqueous potassium carbonate with dilute sulfuric acid. The equation for the reaction is shown.

$$K_2CO_3(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + H_2O(l) + CO_2(g)$$

The student:
- places 25.0 cm^3 of aqueous potassium carbonate in a conical flask
- adds a few drops of a suitable indicator to the conical flask
- uses a burette to add dilute sulfuric acid to the conical flask until the end-point is reached and the indicator changes colour.

Table 1.1 shows the burette readings the student obtains.

Table 1.1

final burette reading / cm^3	18.8
initial burette reading / cm^3	4.2
volume of dilute sulfuric acid added / cm^3	

(a) Complete Table 1.1 by calculating the volume of dilute sulfuric acid added to the conical flask. [1]

(b) State which solution, aqueous potassium carbonate or dilute sulfuric acid, is the **least** concentrated. Give a reason for your answer.

least concentrated solution ....

reason ....
[1]

(c) Name a piece of apparatus suitable for measuring the 25.0 cm^3 of aqueous potassium carbonate.

.... [1]

(d) Name a suitable indicator and give the colour change of this indicator at the end-point.

indicator ....

colour change at end-point .... to ....
[2]

(e) As the student added the dilute sulfuric acid to the aqueous potassium carbonate they looked for a colour change.

State what the student should do as they add the dilute sulfuric acid to the aqueous potassium carbonate in the conical flask. Do **not** include observations in your answer.

....

.... [1]

(f) Describe what the student should now do to obtain crystals of pure potassium sulfate.

....

....

....

....

.... [3]

[Total: 9]

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2 A student investigates how the rate of reaction of magnesium ribbon with dilute acid changes as the concentration of the acid is changed. The student uses five solutions of the same acid, **A**, **B**, **C**, **D**, and **E**. Each solution has a different concentration. The acid is in excess in all experiments.

The student does five experiments.

Experiment 1

- Use a 50 cm^3 measuring cylinder to pour 30 cm^3 of acid **A** into a 100 cm^3 conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask and immediately start a stop-watch.
- Continually swirl the mixture in the conical flask until the magnesium ribbon disappears completely. Immediately stop the stop-watch and record the time in seconds to the nearest second.
- Empty and rinse the conical flask with distilled water.

Experiment 2

- Repeat Experiment 1 using 30 cm^3 of acid **B** instead of acid **A**.

Experiment 3

- Repeat Experiment 1 using 30 cm^3 of acid **C** instead of acid **A**.

Experiment 4

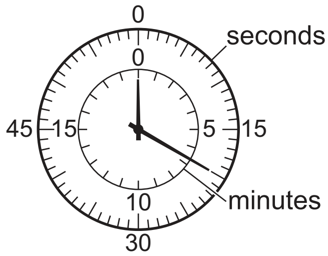
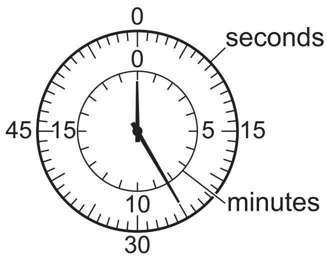
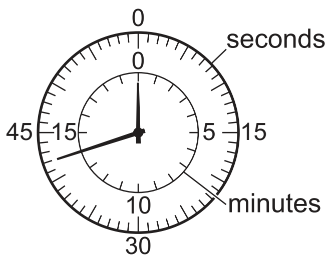
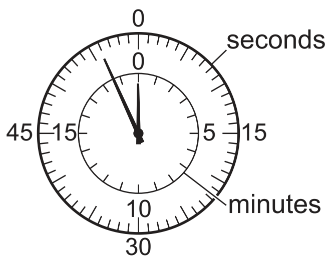
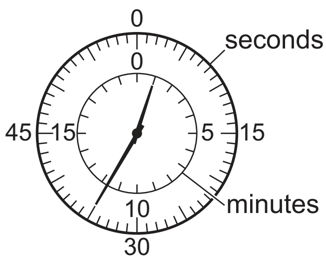
- Repeat Experiment 1 using 30 cm^3 of acid **D** instead of acid **A**.

Experiment 5

- Repeat Experiment 1 using 30 cm^3 of acid **E** instead of acid **A**.

(a) Use the stop-watch diagrams to complete Table 2.1

Table 2.1

experiment	acid	concentration of acid in mol / dm^3	stop-watch diagram	time for magnesium to disappear in s
1	**A**	2.0		
2	**B**	1.5		
3	**C**	1.0		
4	**D**	0.8		
5	**E**	0.5		

[2]

(b) Write a suitable scale on the *y*-axis and plot the results from Experiments 1 to 5 on Fig. 2.1.

Draw a line of best fit.

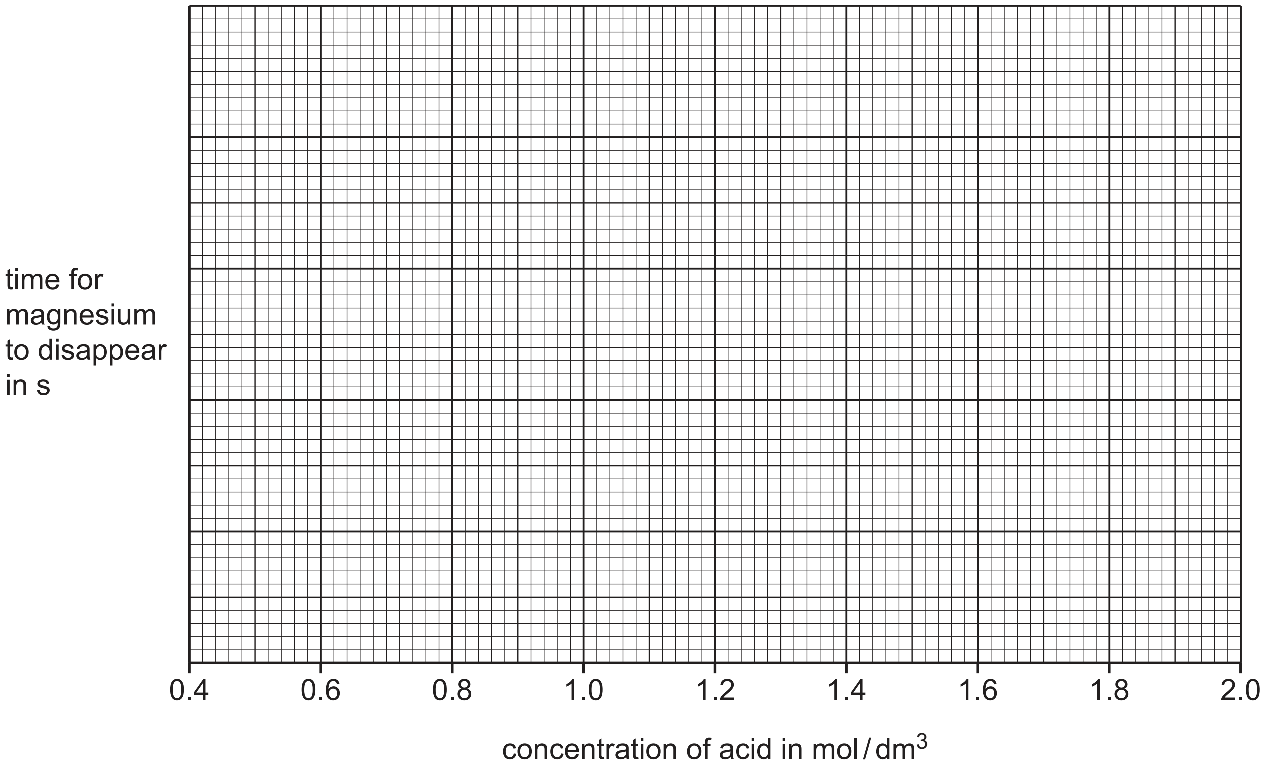


Fig. 2.1

[4]

(c) From your graph in Fig. 2.1, deduce the time for the magnesium to disappear when the concentration of the acid is 1.3 mol / dm^3.

Show clearly on Fig. 2.1 how you worked out your answer.

time for magnesium to disappear = ... s [2]

(d) The mean rate of reaction is calculated using the equation shown.

$$\text{mean rate of reaction} = \frac{\text{length of magnesium ribbon in cm}}{\text{time for magnesium to disappear in s}}$$

The length of each coil of magnesium ribbon used in all five experiments was 5 cm.

(i) Calculate the mean rate of reaction in Experiment 1. Give units for the rate you have calculated.

mean rate of reaction = ...

units ....

[2]

(ii) Deduce in which Experiment, 1, 2, 3, 4 or 5, the mean rate of reaction is the slowest.

.... [1]

(e) Explain why repeating each experiment is an improvement.

....

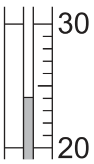
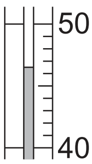
.... [1]

(f) The student does another experiment to find the temperature change when magnesium reacts with acid **A**.

- Use the measuring cylinder to pour 30 cm^3 of acid **A** into the 100 cm^3 conical flask.
- Measure the initial temperature of the acid in the conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask.
- Continually swirl the conical flask until the magnesium ribbon disappears completely.
- Measure the final temperature of the acid in the conical flask.

(i) Use the thermometer diagrams to complete Table 2.2.

Table 2.2

thermometer diagram for initial temperature	initial temperature / °C	thermometer diagram for final temperature	final temperature / °C	temperature change / °C
				

[2]

(ii) Explain why controlling the temperature of the acid so that it remains constant is an improvement.

....

.... [1]

(iii) Explain why using a polystyrene cup instead of the 100 cm^3 conical flask does **not** control the temperature of the acid.

....

.... [1]

(iv) Describe how the temperature of the acid can be controlled and kept constant.

....

.... [1]

[Total: 17]

3 A student tests two solids: solid **F** and solid **G**.

Tests on solid F

Solid **F** is calcium carbonate.

(a) The student adds about 15 cm^3 of dilute hydrochloric acid to the sample of solid **F** in a boiling tube and tests any gas produced.

observations ....

....

.... [2]

(b) The student filters the product from **(a)** to obtain solution **H** as the filtrate.
The student divides solution **H** into three approximately equal portions in three test-tubes.

(i) To the first portion of solution **H**, the student adds about 1 cm depth of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations ....

.... [1]

(ii) To the second portion of solution **H**, the student adds aqueous sodium hydroxide dropwise and then in excess.

observations when added dropwise ....

observations in excess ....
[2]

(iii) To the third portion of solution **H**, the student adds about 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate.

observations ....

.... [1]

Tests on solid G

Table 3.1 shows the tests and the student's observations for solid **G**.

Table 3.1

tests	observations
test 1 Do a flame test on solid **G**.	lilac coloured flame
test 2 Dissolve the remaining solid **G** in water to form solution **G**. Divide solution **G** into three portions. To the first portion of solution **G**, add about 1 cm^3 of aqueous chlorine.	orange solution forms
test 3 To the second portion of solution **G**, add about 1 cm^3 of aqueous sodium hydroxide.	remains colourless
test 4 To the third portion of solution **G**, add about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.	cream precipitate forms

(c) Identify solid **G**.

....

.... [2]

[Total: 8]

4 Solid sodium hydrogencarbonate, $NaHCO_3$, reacts with dilute hydrochloric acid and with dilute ethanoic acid.

$$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$$

$$NaHCO_3(s) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + CO_2(g) + H_2O(l)$$

These two reactions are endothermic.

Plan an investigation to find which of the two reactions is the most endothermic. Your plan must include how you can use the results to find which reaction is the most endothermic.

You are provided with solid sodium hydrogencarbonate, dilute hydrochloric acid, dilute ethanoic acid and common laboratory apparatus.

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.... [6]

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Notes for use in qualitative analysis

Tests for anions

anion	test	test result
carbonate, CO_3^{2-}	add dilute acid, then test for carbon dioxide gas	effervescence, carbon dioxide produced
chloride, Cl^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide, Br^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
iodide, I^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate, NO_3^- [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate, SO_4^{2-} [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.
sulfite, SO_3^{2-}	add a small volume of acidified aqueous potassium manganate(VII)	the acidified aqueous potassium manganate(VII) changes colour from purple to colourless

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
aluminium, Al^{3+}	white ppt., soluble in excess, giving a colourless solution	white ppt., insoluble in excess
ammonium, NH_4^+	ammonia produced on warming	–
calcium, Ca^{2+}	white ppt., insoluble in excess	no ppt. or very slight white ppt.
chromium(III), Cr^{3+}	green ppt., soluble in excess	green ppt., insoluble in excess
copper(II), Cu^{2+}	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II), Fe^{2+}	green ppt., insoluble in excess, ppt. turns brown near surface on standing	green ppt., insoluble in excess, ppt. turns brown near surface on standing
iron(III), Fe^{3+}	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc, Zn^{2+}	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	test and test result
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	turns limewater milky
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

Flame tests for metal ions

metal ion	flame colour
lithium, Li^+	red
sodium, Na^+	yellow
potassium, K^+	lilac
calcium, Ca^{2+}	orange-red
barium, Ba^{2+}	light green
copper(II), Cu^{2+}	blue-green