Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

4004365857

CHEMISTRY **5070/41**

Paper 4 Alternative to Practical **October/November 2023**

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 **12** pages.

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1 A student investigates the rate of reaction between calcium carbonate and dilute hydrochloric acid.

Fig. 1.1 shows part of the apparatus the student uses.

The student determines the rate of reaction by measuring the volume of carbon dioxide produced in a fixed time.

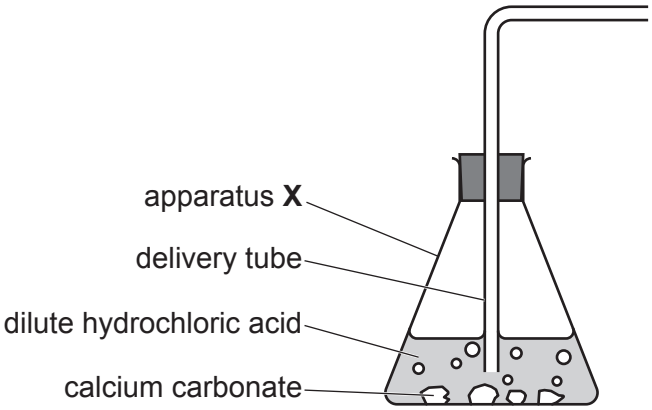


Fig. 1.1

(a) Name apparatus **X**.

..... [1]

(b) The student has incorrectly positioned the delivery tube in the apparatus shown in Fig. 1.1.

Complete Fig. 1.2 to show:
- the correct position of the delivery tube
- the rest of the apparatus the student uses to collect and measure the volume of gas produced.

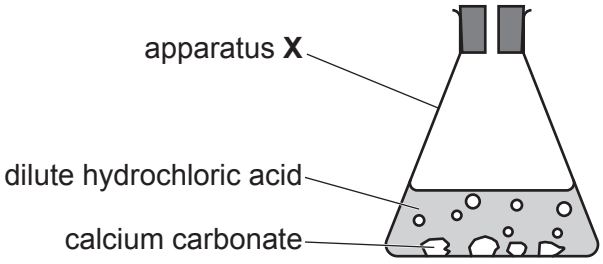


Fig. 1.2

[3]

(c) The student collects 48.0 cm^3 of carbon dioxide during the first 2 minutes.

Calculate the mean rate of reaction, in cm^3/s, during the first 2 minutes.

mean rate of reaction ..... cm^3/s [2]

[Total: 6]

2 Hydrochloric acid, HCl, is neutralised when it is added to aqueous potassium hydroxide, KOH.

$$KOH + HCl \rightarrow KCl + H_2O$$

The reaction is exothermic.

P is aqueous potassium hydroxide.
Q is 2.24 mol / dm^3 hydrochloric acid.

A student determines the concentration of potassium hydroxide in **P**.

The student does six experiments.

The student:

Step 1. uses a volumetric pipette to add 25.0 cm^3 of **P** to a plastic cup
Step 2. uses a measuring cylinder to add 20 cm^3 of distilled water to the plastic cup
Step 3. stirs the mixture in the cup with a thermometer and records its temperature to the nearest 0.5 °C
Step 4. uses a burette to add 5.0 cm^3 of **Q** to the plastic cup and stirs
Step 5. records the highest temperature reached
Step 6. empties the plastic cup and rinses it with water
Step 7. repeats steps 1–6 using five different volumes of distilled water and **Q** so that the total volume in the cup is always 50 cm^3.

The student's results are in Table 2.1.

Table 2.1

experiment number	volume of **P** / cm^3	volume of water / cm^3	volume of **Q** / cm^3	initial temperature of **P** / °C	highest temperature reached / °C	temperature rise / °C
1	25.0	20	5.0	24.0	26.0	2.0
2	25.0		10.0	24.5	28.5	4.0
3	25.0	10	15.0	25.0	31.0	6.0
4	25.0	7		25.0	31.5	6.5
5	25.0	5	20.0	26.0	32.5	6.5
6	25.0	0	25.0	26.5	33.0	

(a) Complete Table 2.1 by filling in the three missing values. [3]

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(b) Parts of the thermometer used in Experiment 5 are shown in Fig. 2.1.

The liquid levels inside the thermometer are missing.

Complete Fig. 2.1 by drawing in the liquid level to show:
- the initial temperature of **P** in Experiment 5
- the highest temperature reached in Experiment 5.

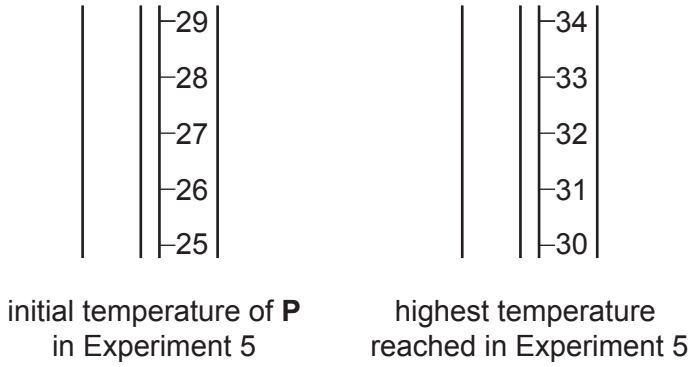


Fig. 2.1

[1]

(c) Draw a graph of temperature rise against volume of **Q** on the grid in Fig. 2.2.

You should:
- plot the point (0,0) as there is no temperature rise when no **Q** is added
- plot the temperature rises and volumes of **Q** from Table 2.1
- draw a straight line of best fit for the first four points
- draw a straight line of best fit for the last three points
- extend the lines so that they intersect.

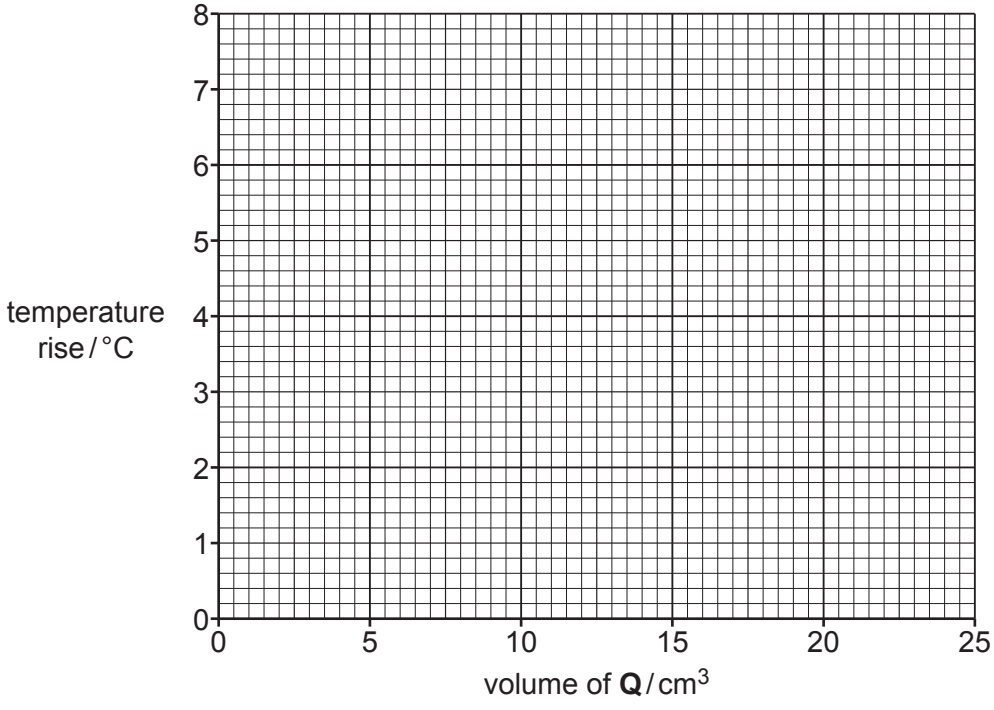


Fig. 2.2

[3]

(d) The point where the two lines intersect indicates the volume of **Q** that exactly neutralises 25.0 cm^3 of **P**.

Determine the volume of **Q** where the two lines on the graph intersect.

volume of **Q** ..... cm^3 [1]

(e) **Q** is 2.24 mol/dm^3 hydrochloric acid.

Use your answer to **(d)** to calculate the concentration of potassium hydroxide in **P**.

$$KOH + HCl \rightarrow KCl + H_2O$$

concentration of potassium hydroxide in **P** ..... mol/dm^3 [2]

(f) A measuring cylinder is used to measure the volumes of water.

Suggest why the volumes of water in Table 2.1 are **not** given to one decimal place.

.....

..... [1]

(g) State and explain why a plastic cup rather than a metal cup is used in these experiments.

.....

.....

..... [2]

(h) State why the mixture is stirred before measuring the temperature in these experiments.

.....

..... [1]

[Total: 14]

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3 A student investigates solution **X** and solution **Y**. Both solutions are colourless.

(a) The student does some tests on **X**.

Table 3.1 shows the notes the student makes about these tests.

Table 3.1

	tests on solution **X**	observations
1	Add one drop of aqueous sodium hydroxide to **X** in a test-tube.	white precipitate which then dissolves
2	Add aqueous sodium hydroxide to **X** in a boiling tube. Warm the mixture and test the gas produced with damp litmus paper.	pungent smell of ammonia no change to the litmus paper
3	Add aqueous dilute nitric acid and aqueous barium nitrate to solution **X** in a test-tube.	white precipitate

(i) Part of the method for test 1 is missing.

Describe the missing part of the method that is needed to give the observations shown.

..... [1]

(ii) The observations for test 1 are incomplete.

State one **other** observation which is made for test 1.

..... [1]

(iii) Suggest why the ammonia produced in test 2 has no effect on the litmus paper.

..... [1]

(iv) Solution **X** contains two cations. Identify the cation in solution **X** which produces ammonia in test 2.

..... [1]

(v) Explain why the student cannot identify the second cation in solution **X** from the tests and observations in Table 3.1.

.....

..... [2]

(vi) Identify the anion in **X**.

..... [1]

(b) (i) The student adds universal indicator to solution **Y** in a test-tube.

The universal indicator turns red.

Identify the cation present in **Y**.

..... [1]

(ii) The student adds a piece of magnesium ribbon to **Y**.

Hydrogen is produced.

Suggest **two** observations the student makes.

1. .....

2. .....
[2]

(iii) Describe how the student tests the gas to show that it is hydrogen.

test .....

observation if hydrogen present .....
[2]

(c) The student adds dilute nitric acid and then adds aqueous silver nitrate to **Y**.

A white precipitate is observed.

(i) Identify the anion present in **Y**.

..... [1]

(ii) Identify **Y**.

..... [1]

[Total: 14]

4 Ammonium sulfate is a salt used in fertilisers.

Ammonium sulfate is prepared by neutralising dilute sulfuric acid with aqueous ammonia.

Plan an experiment to prepare pure dry crystals of ammonium sulfate.

Your plan should include the use of:

- common laboratory apparatus
- dilute sulfuric acid
- aqueous ammonia
- methyl orange indicator.

No other chemicals should be used.

Your plan should include:

- the apparatus needed
- the method to use.

You may draw a diagram to help answer the question.

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[6]

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

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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
copper(II), Cu^{2+}	blue-green
calcium, Ca^{2+}	orange-red
barium, Ba^{2+}	light green

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