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Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

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CHEMISTRY **5070/41**

Paper 4 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 **12** pages.

DC (PQ/FC) 342180/4

1 (a) A student determines the solubility of solid ammonium chloride in water at 60 °C.

The student:

step 1 puts 100 cm^3 of water into a beaker
step 2 heats the water
step 3 measures the mass of a weighing bottle containing ammonium chloride
step 4 adds some of this ammonium chloride to the water
step 5 stirs the mixture to dissolve the solid
step 6 repeats steps 4 and 5 until a small amount of undissolved solid remains in the beaker
step 7 measures the mass of the weighing bottle and unused ammonium chloride
step 8 calculates the mass of ammonium chloride added to the water.

(i) State **one** extra measurement the student must make to calculate the solubility.

.... [1]

(ii) The student's results are shown in Table 1.1.

Table 1.1

initial mass in step 3 / g	173.7
final mass in step 7 / g	115.5

Use the results to calculate the solubility of ammonium chloride at 60 °C in g / dm^3.

solubility .... g / dm^3 [2]

(iii) Explain why the method the student uses gives a higher value for the solubility than the true value.

....

....

.... [1]

(b) The student repeats the experiment at different temperatures.

The results are shown in Table 1.2.

Table 1.2

ammonium chloride	
temperature in °C	solubility in g/dm^3
0	300
40	480
80	660

Estimate the solubility of ammonium chloride at 20 °C.

solubility .... g/dm^3 [1]

(c) The student also wants to measure the solubility of ammonia.

Suggest why the method used for ammonium chloride is **not** suitable for determining the solubility of ammonia.

.... [1]

[Total: 6]

2 Solid **A** is impure calcium carbonate.

A student determines the number of moles of calcium carbonate in a sample of **A**.

(a) The student:

- places the sample of **A** into a beaker
- uses a measuring cylinder to add $100\,cm^3$ of $0.250\,mol/dm^3$ hydrochloric acid, HCl, to the beaker
- stirs the mixture until no further effervescence is observed
- labels the mixture **B**.

Calculate the number of moles of HCl added to the beaker.

number of moles .... [1]

(b) The student:

- rinses a burette with water and then with $0.100\,mol/dm^3$ sodium hydroxide, $NaOH$
- fills the burette with $0.100\,mol/dm^3$ $NaOH$
- adds $25.0\,cm^3$ of **B** and five drops of methyl orange indicator to a conical flask
- adds $NaOH$ from the burette to the conical flask until the methyl orange indicator just changes colour
- repeats this titration two more times.

Fig. 2.1 shows the initial and final burette readings for titration 1.

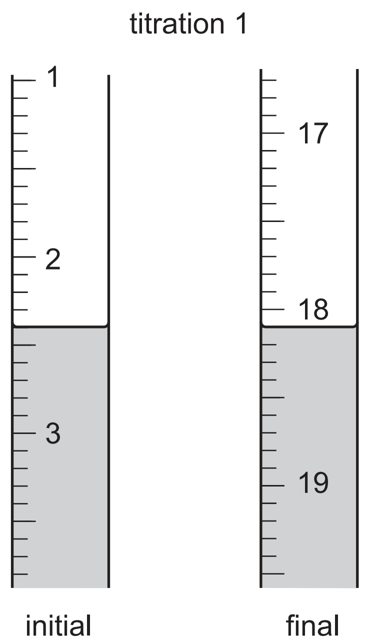

Fig. 2.1

Table 2.1 shows some of the student's results.

(i) Complete Table 2.1 by:

- writing the initial and final readings for titration 1
- calculating the volume of NaOH used in each titration
- ticking (✓) the best titration results.

Table 2.1

	titration 1	titration 2	titration 3
final burette reading / cm^3		15.4	30.8
initial burette reading / cm^3		0.2	15.4
volume used / cm^3			
best titration results (✓)			

[3]

(ii) Use the best titration results (✓) to calculate the average volume of NaOH used.

average volume .... cm^3 [1]

(c) The acid used in **(a)** to prepare mixture **B** is in excess.

Use your answer to **(b)(ii)** to calculate the number of moles of 0.100 mol / dm^3 NaOH that react with 25.0 cm^3 of **B**.

number of moles .... [1]

(d) Calculate the number of moles of NaOH that react with 100 cm^3 of **B**.

number of moles .... [1]

(e) The answer to **(d)** is equal to the number of moles of HC*l* that remain in the beaker after the acid reacts with the calcium carbonate in the sample of **A**.

Use your answers to **(a)** and **(d)** to calculate the number of moles of HC*l* that react with the calcium carbonate in the sample of **A**.

number of moles .... [1]

(f) The equation for the reaction between hydrochloric acid and calcium carbonate is shown.

$$2HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$$

Calculate the number of moles of calcium carbonate in the sample of **A**.

number of moles .... [1]

(g) In **(a)** the mixture of **A** and acid is stirred until effervescence stops.

(i) Give a reason for mixing the reactants by stirring.

.... [1]

(ii) Give a reason for waiting for the effervescence to stop.

.... [1]

(h) In **(a)** a measuring cylinder is used to add 100 cm^3 of 0.250 mol / dm^3 HCl to the beaker.

Explain why using the measuring cylinder makes the volume of HCl used inaccurate. Suggest an improvement.

explanation ....

....

improvement ....
[2]

(i) In **(b)** the burette is rinsed with water and then with 0.100 mol / dm^3 NaOH.

Explain why the burette is rinsed with sodium hydroxide after rinsing with water.

....

.... [1]

[Total: 14]

DO NOT WRITE IN THIS MARGIN

3 A student tests two aqueous solutions, **W** and **X**.

(a) **(i)** The student adds aqueous chlorine to **W** and concludes that **W** contains iodide ions.

Describe the observation that the student makes that leads to this conclusion.

Explain how this shows that **W** contains iodide ions.

observation ....

....

explanation ....

.... [2]

(ii) Describe another test and the observation that confirms that **W** contains iodide ions.

test ....

....

observation ....

.... [2]

(b) The student does a flame test on **W** and observes a lilac flame.

Describe how the student does the flame test on **W**.

....

....

.... [2]

(c) Identify **W**.

.... [1]

(d) **X** contains one anion and one cation.

The student:

- adds aqueous sodium hydroxide to **X** in a test-tube
- warms the mixture
- holds a piece of damp red litmus paper above the test-tube.

A white precipitate, soluble in excess aqueous sodium hydroxide, is formed.

The litmus paper does **not** change colour.

State **three** conclusions that are made from these observations.

....

.... [2]

(e) The conclusions in **(d)** identify cations that may be present in **X**.

Describe another test that the student does and its observations to identify the cation in **X**.

test ....

....

observations ....

....

....
[3]

(f) (i) The student adds excess aqueous sodium hydroxide to **X**, then adds a piece of aluminium foil and warms the mixture.

Ammonia gas is given off and tested with damp red litmus paper.

Describe what happens to the litmus paper.

.... [1]

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

.... [1]

[Total: 14]

4 **Q** is a mixture of solid magnesium oxide and solid barium sulfate.

Magnesium oxide is insoluble in water. It reacts with dilute hydrochloric acid to make a solution of magnesium chloride.

Barium sulfate is insoluble in water and does **not** react with dilute hydrochloric acid.

Plan an investigation to obtain pure magnesium chloride crystals and pure barium sulfate solid from **Q**.

Your plan should describe the use of common laboratory apparatus, dilute hydrochloric acid and **Q**. No other chemicals should be used.

Your plan should include:

- the apparatus needed
- the preparation of magnesium chloride solution
- the method to obtain pure magnesium chloride crystals
- the method to obtain pure barium sulfate solid
- how to test that the barium sulfate is pure.

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

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