

# Cambridge International AS & A Level

CE NU CH Pa	CANDIDATE NAME		
	CENTRE NUMBER	CANDIDATE NUMBER	
	CHEMISTRY		9701/34
	Paper 3 Advand	ced Practical Skills 2	May/June 2024
NU CH Pa Yo Yo			2 hours
	You must answ	er on the question paper.	
	You will need:	The materials and apparatus listed in the confidential instructions	
	INSTRUCTION	S	

- 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 [ ].
- The Periodic Table is printed in the question paper. •
- Important values, constants and standards are printed in the • question paper.
- Notes for use in qualitative analysis are provided in the • question paper.

Session
Laboratory

For Examiner's Use							
1							
2							
3							
Total							

This document has 12 pages.

Ι

Π

III

IV

V

VI

VII

[7]



#### Quantitative analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

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Show the precision of the apparatus you used in the data you record.

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

1 In this experiment you will determine the relative formula mass,  $M_r$ , of a basic metal carbonate,  $MCO_3 \cdot M(OH)_2$ , by a titration method.

**FB 1** is the basic metal carbonate MCO<sub>3</sub>•M(OH)<sub>2</sub>.

**FB 2** is a solution containing hydrochloric acid, HC*l*, and MC*l*<sub>2</sub>, prepared using **FB 1** as follows.

- 22.50 g of **FB 1**,  $MCO_3 \cdot M(OH)_2$ , is weighed out. 100.0 cm<sup>3</sup> of 5.00 mol dm<sup>-3</sup> hydrochloric acid (a small excess) is added to **FB 1**.
- The mixture is left to allow FB 1 to react completely.

 $MCO_3 \cdot M(OH)_2(s) + 4HCl (aq) \rightarrow 2MCl_2(aq) + CO_2(g) + 3H_2O(l)$ 

- The resulting solution is made up to 1.00 dm<sup>3</sup> with distilled water.
- This solution is FB 2.

**FB 3** is potassium hydroxide, KOH, of concentration 5.05 g dm<sup>-3</sup>. FB 4 is thymolphthalein indicator.

#### (a) Method

- Fill the burette with FB 2. .
- Pipette 25.0 cm<sup>3</sup> of **FB 3** into a conical flask.
- Add a few drops of FB 4 to the conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is ..... cm<sup>3</sup>.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record, in a suitable form in the space below, all your burette readings and the volume of FB 2 added in each accurate titration.





(b) From your accurate titration results, calculate a suitable mean value to use in your calculations. Show clearly how you obtain the mean value.

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 $25.0 \text{ cm}^3$  of **FB 3** required ...... cm<sup>3</sup> of **FB 2**. [1]

## (c) Calculations

- (i) Give your answers to (c)(ii), (c)(iii) and (c)(iv) to an appropriate number of significant figures.
- (ii) Calculate the amount, in mol, of potassium hydroxide present in  $25.0 \text{ cm}^3$  of **FB 3**.

amount of KOH = .....mol [1]

(iii) Give the ionic equation for the reaction of hydrochloric acid with potassium hydroxide during the titration. Include state symbols.

.....

Hence calculate the concentration, in mol  $dm^{-3}$ , of hydrochloric acid in **FB 2**.

concentration of HCl = ..... mol dm<sup>-3</sup> [2]

(iv) Use the information about **FB 2** and your answer to (c)(iii) to calculate the relative formula mass,  $M_r$ , of MCO<sub>3</sub>•M(OH)<sub>2</sub>.

 $M_{\rm r} \text{ of } {\rm MCO}_3 {\rm \cdot M(OH)}_2 = \dots$  [2]

(d) A student suggested that the procedure used in (a) would be more accurate if the mass of FB 1 used to prepare solution FB 2 is doubled. No other change to the procedure is made.

Explain why the student is **not** correct.

[1] [Total: 15]





2 In this experiment you will determine the relative atomic mass, *A*<sub>r</sub>, of metal **M** by thermal decomposition of the same basic metal carbonate, **M**CO<sub>3</sub>•**M**(OH)<sub>2</sub>, **FB 1**.

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#### (a) Method

- Weigh the empty crucible with its lid. Record the mass in the results section.
- Transfer all of the **FB 1** from the container into the crucible.
- Weigh the crucible, lid and **FB 1**. Record the mass.
- Calculate the mass of **FB 1** used. Record this mass in the space for other results.
- Place the crucible and contents on a pipe-clay triangle.
- Heat the crucible gently, with the lid on, for approximately 1 minute.
- Heat strongly, with the lid off, for a further 5 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.

#### During the cooling period, you may wish to begin work on Question 3.

- When the crucible is cool, weigh the crucible with its lid and contents. Record the mass.
- Place the crucible and contents on the pipe-clay triangle. Remove the lid.
- Heat strongly for a further 2 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.
- When the crucible is cool, reweigh the crucible with its lid and contents. Record the mass.
- Calculate the mass of residue obtained. Record this mass in the space for other results.

#### Results

mass of empty crucible and lid	=
mass of crucible, lid and <b>FB 1</b> (before heating)	=
mass of crucible, lid and <b>FB 1</b> (after first heating)	=
mass of crucible, lid and <b>FB 1</b> (after second heating)	=

### Other results

### (b) Calculations

(i) When FB 1 undergoes thermal decomposition, the products are the metal oxide, MO, carbon dioxide and water vapour.
 Give the equation for the thermal decomposition of FB 1. Include state symbols.

## ......[1]





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(ii) The amount, in mol, of carbon dioxide produced is given by the following formula.

amount of 
$$CO_2 = \frac{\text{mass loss during heating}}{(M_r \text{ of } CO_2 + M_r \text{ of } H_2O)}$$

Calculate the amount, in mol, of carbon dioxide produced in (a).

amount of CO<sub>2</sub> = .....mol [1]

- (iii) Calculate the relative formula mass,  $M_r$ , of the basic metal carbonate.
  - $M_{\rm r} \text{ of } {\rm MCO}_3 \cdot {\rm M(OH)}_2 = \dots$ [1]
- (iv) Use your answer to (b)(iii) to calculate the relative atomic mass, A<sub>r</sub>, of metal M. Show your working.

*A*<sub>r</sub> of **M** = ..... [1]

(c) (i) Explain why the headings for the third and fourth readings in the results section in (a) are **not** suitable.

.....

.....[1]

(ii) State whether or not your experiment would be more accurate if the crucible and its contents were heated for a third time. Explain your answer by referring to your results in (a).

......[1]

(iii) A student carries out the experiments in **Questions 1** and **2**. The student expects the value of the  $M_r$  of  $MCO_3 \cdot M(OH)_2$  obtained by thermal decomposition in **Question 2** to be more accurate than the value of the  $M_r$  obtained by titration in **Question 1**.

State **one** reason why the student expects the experiment in **Question 2** to be more accurate.

......[1]

[Total: 11]

DO NOT WRITE IN THIS MARGIN



#### Qualitative analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:

- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added

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• the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write 'no change'.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests should be attempted.

- 3 (a) **FB 5** is a compound containing one cation and one anion, both of which are listed in the Qualitative analysis notes.
  - (i) Heat a small spatula measure of FB 5 in a hard-glass test-tube until no further change occurs. Record your observations.

 (ii) Describe another test to positively identify the cation in FB 5. Carry out your test and record your observations. test
 observations



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Question 3 continues on page 8.



\* 0019655525108 \*

(b) You will devise chemical tests to distinguish between the two possible identities given for each of compounds FB 6, FB 7, FB 8 and FB 9.

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In each case you should:

- use a 1 cm depth of the solution of the unknown compound in a test-tube
- use a boiling tube if you need to warm a mixture
- use a spatula measure of the unknown solid
- record details of your test(s) and your observations
- state your conclusion about the identity of the compound.
- (i) **FB 6** is either aqueous chromium(III) sulfate or aqueous iron(II) sulfate.

(ii) FB 7 is either dilute hydrobromic acid or dilute nitric acid.
 If you select a test that gives a negative result, then you must carry out a further test that gives a positive result.

**FB 7** is ...... [2]

(iii) **FB 8** is either magnesium carbonate or zinc carbonate.







(iv) FB 9 is either aqueous methanol or aqueous ethanol.
 Note: FB 9 is flammable and should not be heated with a flame.
 (When carrying out your test you may need to leave the reaction mixture to stand.)

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[Total: 14]





Qualitative analysis notes

#### 1 Reactions of cations

cation	reaction with								
	NaOH(aq)	NH <sub>3</sub> (aq)							
aluminium, Al <sup>3+</sup> (aq)	white ppt. soluble in excess	white ppt. insoluble in excess							
ammonium, NH <sub>4</sub> <sup>+</sup> (aq)	no ppt. ammonia produced on warming	_							
barium, Ba <sup>2+</sup> (aq)	faint white ppt. is observed unless [Ba <sup>2+</sup> (aq)] is very low	no ppt.							
calcium, Ca <sup>2+</sup> (aq)	white ppt. unless [Ca <sup>2+</sup> (aq)] is very low	no ppt.							
chromium(III), Cr <sup>3+</sup> (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess							
copper(II), Cu <sup>2+</sup> (aq)	pale blue ppt. insoluble in excess	pale blue ppt. soluble in excess giving dark blue solution							
iron(II), Fe <sup>2+</sup> (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess							
iron(III), Fe <sup>3+</sup> (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess							
magnesium, Mg <sup>2+</sup> (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess							
manganese(II), Mn <sup>2+</sup> (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess							
zinc, Zn <sup>2+</sup> (aq)	white ppt. soluble in excess	white ppt. soluble in excess							

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### 2 Reactions of anions

anion	reaction
carbonate, CO32-	CO <sub>2</sub> liberated by dilute acids
chloride, C <i>l</i> <sup>-</sup> (aq)	gives white ppt. with Ag <sup>+</sup> (aq) (soluble in NH <sub>3</sub> (aq))
bromide, Br <sup>_</sup> (aq)	gives cream/off-white ppt. with Ag <sup>+</sup> (aq) (partially soluble in NH <sub>3</sub> (aq))
iodide, I <sup>_</sup> (aq)	gives pale yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$ )
nitrate, NO <sub>3</sub> <sup>-</sup> (aq)	$NH_3$ liberated on heating with OH <sup>-</sup> (aq) and Al foil
nitrite, NO <sub>2</sub> <sup>-</sup> (aq)	$\rm NH_3$ liberated on heating with OH <sup>-</sup> (aq) and Al foil; decolourises acidified aqueous $\rm KMnO_4$
sulfate, SO <sub>4</sub> <sup>2–</sup> (aq)	gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids); gives white ppt. with high $[Ca^{2+}(aq)]$
sulfite, SO <sub>3</sub> <sup>2–</sup> (aq)	gives white ppt. with Ba <sup>2+</sup> (aq) (soluble in excess dilute strong acids); decolourises acidified aqueous KMnO <sub>4</sub>
thiosulfate, S <sub>2</sub> O <sub>3</sub> <sup>2–</sup> (aq)	gives off-white/pale yellow ppt. slowly with H <sup>+</sup>
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gas	test and test result
ammonia, NH <sub>3</sub>	turns damp red litmus paper blue
carbon dioxide, CO <sub>2</sub>	gives a white ppt. with limewater
hydrogen, H <sub>2</sub>	'pops' with a lighted splint
oxygen, O <sub>2</sub>	relights a glowing splint

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### 4 Tests for elements

element	test and test result
iodine, I <sub>2</sub>	gives blue-black colour on addition of starch solution

#### Important values, constants and standards

molar gas constant	$R = 8.31 \mathrm{J}\mathrm{K}^{-1}\mathrm{mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \mathrm{C  mol^{-1}}$
Avogadro constant	$L = 6.022 \times 10^{23} \mathrm{mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \mathrm{C}$
molar volume of gas	$V_{\rm m}$ = 22.4 dm <sup>3</sup> mol <sup>-1</sup> at s.t.p. (101 kPa and 273 K) $V_{\rm m}$ = 24.0 dm <sup>3</sup> mol <sup>-1</sup> at room conditions
ionic product of water	$K_{\rm w} = 1.00 \times 10^{-14} {\rm mol}^2 {\rm dm}^{-6} ({\rm at}298{\rm K}(25{\rm °C}))$
specific heat capacity of water	$c = 4.18 \mathrm{kJ  kg^{-1}  K^{-1}} (4.18 \mathrm{J  g^{-1}  K^{-1}})$



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The Periodic Table of Elements



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