



# Cambridge International AS & A Level

CANDIDATE  
NAMECENTRE  
NUMBER

|  |  |  |  |  |
|--|--|--|--|--|
|  |  |  |  |  |
|--|--|--|--|--|

CANDIDATE  
NUMBER

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|

## CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

May/June 2025

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

### 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 [ ].
- 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.

**Quantitative analysis**

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

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

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

- 1 Group 1 metal carbonates react with dilute acids to form a salt, water and carbon dioxide. The identity of the metal, **M**, can be determined by measuring the volume of carbon dioxide produced when excess acid is added to a known mass of the carbonate,  $\text{M}_2\text{CO}_3$ .

**FA 1** is the metal carbonate,  $\text{M}_2\text{CO}_3$ .

**FA 2** is  $0.250 \text{ mol dm}^{-3}$  sulfuric acid,  $\text{H}_2\text{SO}_4$ .

**(a) Method**

- Weigh the container with **FA 1**. Record the mass in the space for results.
- Fill the tub with water to a depth of approximately 5 cm.
- Fill the  $250 \text{ cm}^3$  measuring cylinder completely with water. Holding a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so the open end is in the water just above the base of the tub.
- Use the  $50 \text{ cm}^3$  measuring cylinder to transfer  $50.0 \text{ cm}^3$  of **FA 2** into the flask labelled **X**. Check that the bung fits tightly into the neck of flask **X**, clamp flask **X** and place the delivery tube into the inverted  $250 \text{ cm}^3$  measuring cylinder.
- Remove the bung from the neck of the flask. Add all of the **FA 1** into the acid in the flask and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents.
- Replace the flask in the clamp and leave until the fizzing stops. Swirl the flask occasionally.
- Weigh the container with any residual **FA 1**. Record the mass.
- Calculate and record the mass of **FA 1** that is added to the acid.
- When no more gas is collected, record the final volume of gas.

You may wish to start Question 2 or Question 3 while the gas is being collected.

**Results**

|     |  |
|-----|--|
| I   |  |
| II  |  |
| III |  |

[3]



**(b) Calculations**

- (i) Calculate the amount, in mol, of carbon dioxide collected in the measuring cylinder (at room conditions).

amount of  $\text{CO}_2$  = ..... mol [1]

- (ii) Write an equation for the reaction between sulfuric acid and the metal carbonate,  $\text{M}_2\text{CO}_3$ . Include state symbols.

..... [1]

- (iii) Use your answers to **(b)(i)** and **(b)(ii)** to deduce the amount, in mol, of the metal carbonate in the mass of **FA 1** you used in your experiment.

amount of  $\text{M}_2\text{CO}_3$  = ..... mol

Hence, calculate the relative formula mass,  $M_r$ , of the metal carbonate.

$M_r$  of  $\text{M}_2\text{CO}_3$  = ..... [1]

- (iv) Use your answer to **(b)(iii)** to calculate the relative atomic mass,  $A_r$ , of metal **M**. Hence, identify metal **M** in **FA 1**.

$A_r$  of **M** = .....

**M** is ..... [2]

- (c) A student carries out a similar experiment on a powdered Group 2 carbonate. The student determines the relative atomic mass,  $A_r$ , to be 49.3 and concludes that the metal in the carbonate is calcium. Calculate the percentage error in the student's result. Show your working.

percentage error in  $A_r$  of Ca = ..... % [1]

- (d) Suggest why the method you used in **(a)** would be unsuitable for use with small lumps of calcium carbonate.

..... [1]

[Total: 10]

**[Turn over]**





4

- 2 The identity of a Group 1 metal in a metal carbonate may also be determined by titration with acid.  $Z_2CO_3$  is a Group 1 metal carbonate. The metal may or may not be the same as that in **FA 1**. You will determine which metal is present in  $Z_2CO_3$ .

**FA 3** is  $7.26 \text{ g dm}^{-3}$   $Z_2CO_3$ .

**FA 4** is  $0.0500 \text{ mol dm}^{-3}$  sulfuric acid,  $H_2SO_4$ .

**FA 5** is bromophenol blue indicator.

**(a) Method**

- Fill the burette with **FA 4**.
- Pipette  $25.0 \text{ cm}^3$  of **FA 3** into a conical flask.
- Add a few drops of **FA 5** to the same conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is .....  $\text{cm}^3$ .

- 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 **FA 4** added in each accurate titration.

**Results**

|     |  |
|-----|--|
| I   |  |
| II  |  |
| III |  |
| IV  |  |
| V   |  |
| VI  |  |
| VII |  |

[7]

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

$25.0 \text{ cm}^3$  of **FA 3** required .....  $\text{cm}^3$  of **FA 4**. [1]



**(c) Calculations**

- (i) Calculate the amount, in mol, of sulfuric acid present in the volume of **FA 4** in **(b)**.

amount of  $\text{H}_2\text{SO}_4$  = ..... mol [1]

- (ii) Use your answer to **(c)(i)** to calculate the amount, in mol, of  $\text{Z}_2\text{CO}_3$  in  $1.0\text{ dm}^3$  of **FA 3**.

amount of  $\text{Z}_2\text{CO}_3$  = ..... mol [1]

- (iii) Use your answer to **(c)(ii)** to determine the identity of metal **Z**.

Metal **Z** is ..... [2]

- (d)**  $\text{Z}_2\text{CO}_3$  also exists as the hydrated salt.

State whether your titre will increase or decrease if 7.26 g of hydrated  $\text{Z}_2\text{CO}_3$  is dissolved to prepare  $1\text{ dm}^3$  of **FA 3**. Explain your answer.

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

- (e)** A titration is a more accurate method of determining the relative atomic mass of the metal in a metal carbonate than gas collection.

Give **two** reasons why titration is a more accurate method.

1 .....  
 .....  
 2 .....  
 ..... [2]

[Total: 15]



### 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
- 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 any 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 Half-fill the 250 cm<sup>3</sup> beaker with water and place it on a tripod and gauze. Heat the water until boiling then switch off your Bunsen burner. This is your hot water bath for use in (b).
- (a) **FA 6** and **FA 7** are aqueous solutions that each contain one cation and one anion. All the ions are listed in the Qualitative analysis notes. None of the ions contains nitrogen.
- (i) Carry out the following tests using a 1 cm depth of **FA 6** or **FA 7** in a test-tube for each test. Record your observations in Table 3.1.

Table 3.1

| test                                                   | observations |      |
|--------------------------------------------------------|--------------|------|
|                                                        | FA 6         | FA 7 |
| <b>Test 1</b><br>Add aqueous sodium hydroxide.         |              |      |
| <b>Test 2</b><br>Add aqueous ammonia, then             |              |      |
| let the mixture stand for 5 minutes.                   |              |      |
| <b>Test 3</b><br>Add hydrogen peroxide, mix well, then |              |      |
| add aqueous sodium hydroxide.                          |              |      |

[4]



- (ii) Carry out tests to identify the anions in **FA 6** and **FA 7**.

Record your tests and observations in a suitable form in the space below.

[4]

- (iii) Use your observations from **(a)(i)** and **(a)(ii)** to deduce the formulae of **FA 6** and **FA 7**.

**FA 6** is .....

**FA 7** is .....

[2]



Ensure your water bath is hot and the Bunsen burner is turned off before you start **(b)**.

- (b) FA 8** is an organic liquid containing **one** functional group and **only** the elements C, H and O. You will carry out two tests to investigate **FA 8**.

For each test you will record your observations and then conclude one of the following:

- at least two types of compound that **FA 8** could be
- or
- one type of compound that **FA 8 cannot** be.

- (i)** To a 1 cm depth of **FA 8** in a test-tube, add a few drops of acidified aqueous potassium manganate(VII), then place the test-tube in the hot water bath.

observation .....

.....

conclusion .....

[2]

- (ii)** To a 1 cm depth of **FA 8** in a test-tube, add a small spatula measure of sodium carbonate.

observation .....

.....

conclusion .....

[2]

- (iii)** Suggest a further test you could carry out to identify one of the types of compound that you have concluded could be **FA 8**.

State the reagent you would use. State what a positive result would indicate about the identity of **FA 8**.

Do **not** carry out your test.

reagent .....

conclusion from a positive result .....

.....

[1]

[Total: 15]



## 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.<br>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<br>insoluble in excess             | green ppt. turning brown on contact with air<br>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<br>insoluble in excess | off-white ppt. rapidly turning brown on contact with air<br>insoluble in excess |
| zinc, Zn <sup>2+</sup> (aq)                 | white ppt. soluble in excess                                                    | white ppt. soluble in excess                                                    |

## 2 Reactions of anions

| anion                                                         | reaction                                                                                                                                     |
|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| carbonate, CO <sub>3</sub> <sup>2-</sup>                      | CO <sub>2</sub> liberated by dilute acids                                                                                                    |
| chloride, Cl <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 <sup>+</sup> (aq) (insoluble in NH <sub>3</sub> (aq))                                                         |
| nitrate, NO <sub>3</sub> <sup>-</sup> (aq)                    | NH <sub>3</sub> liberated on heating with OH <sup>-</sup> (aq) and Al foil                                                                   |
| nitrite, NO <sub>2</sub> <sup>-</sup> (aq)                    | NH <sub>3</sub> liberated on heating with OH <sup>-</sup> (aq) and Al foil;<br>decolourises acidified aqueous KMnO <sub>4</sub>              |
| sulfate, SO <sub>4</sub> <sup>2-</sup> (aq)                   | gives white ppt. with Ba <sup>2+</sup> (aq) (insoluble in excess dilute strong acids);<br>gives white ppt. with high [Ca <sup>2+</sup> (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);<br>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>                                                                                  |



### 3 Tests for gases

| gas                           | test and test result              |
|-------------------------------|-----------------------------------|
| ammonia, $\text{NH}_3$        | turns damp red litmus paper blue  |
| carbon dioxide, $\text{CO}_2$ | gives a white ppt. with limewater |
| hydrogen, $\text{H}_2$        | 'pops' with a lighted splint      |
| oxygen, $\text{O}_2$          | relights a glowing splint         |

### 4 Tests for elements

| element              | test and test result                                   |
|----------------------|--------------------------------------------------------|
| iodine, $\text{I}_2$ | gives blue-black colour on addition of starch solution |

### Important values, constants and standards

|                                 |                                                                                                                                           |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| molar gas constant              | $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$                                                                                              |
| Faraday constant                | $F = 9.65 \times 10^4 \text{ C mol}^{-1}$                                                                                                 |
| Avogadro constant               | $L = 6.02 \times 10^{23} \text{ mol}^{-1}$                                                                                                |
| electronic charge               | $e = -1.60 \times 10^{-19} \text{ C}$                                                                                                     |
| molar volume of gas             | $V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K)<br>$V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions |
| ionic product of water          | $K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))                                                             |
| specific heat capacity of water | $c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ ( $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ )                                                   |



The Periodic Table of Elements

| Group |                        |                                                                |                         |                      |                        |     |                         |     |                         |     |                          |     |                         |     |                          |                      |                        |     |                          |     |                       |     |                        |     |                         |     |                         |     |                         |     |                          |     |                       |     |                       |  |  |
|-------|------------------------|----------------------------------------------------------------|-------------------------|----------------------|------------------------|-----|-------------------------|-----|-------------------------|-----|--------------------------|-----|-------------------------|-----|--------------------------|----------------------|------------------------|-----|--------------------------|-----|-----------------------|-----|------------------------|-----|-------------------------|-----|-------------------------|-----|-------------------------|-----|--------------------------|-----|-----------------------|-----|-----------------------|--|--|
| 1     | 2                      | 1                                                              |                         |                      |                        |     |                         |     |                         |     |                          |     |                         |     |                          | 13                   | 14                     | 15  | 16                       | 17  | 18                    |     |                        |     |                         |     |                         |     |                         |     |                          |     |                       |     |                       |  |  |
|       |                        | Key                                                            |                         |                      |                        |     |                         |     |                         |     |                          |     |                         |     |                          |                      |                        |     |                          |     |                       |     |                        |     |                         |     |                         |     |                         |     |                          |     |                       |     |                       |  |  |
|       |                        | atomic number<br>atomic symbol<br>name<br>relative atomic mass |                         |                      |                        |     |                         |     |                         |     |                          |     |                         |     |                          | H<br>hydrogen<br>1.0 |                        |     |                          |     |                       |     |                        |     |                         |     |                         |     |                         |     |                          |     |                       |     |                       |  |  |
| 3     | Li<br>lithium<br>6.9   | 4                                                              | Be<br>beryllium<br>9.0  |                      |                        |     |                         |     |                         |     |                          |     |                         |     |                          |                      |                        | 5   | 6                        | 7   | 8                     | 9   | 10                     | 11  | 12                      |     |                         |     |                         |     |                          |     |                       |     |                       |  |  |
| 11    | Na<br>sodium<br>23.0   | 12                                                             | Mg<br>magnesium<br>24.3 |                      |                        |     |                         |     |                         |     |                          |     |                         |     |                          |                      |                        | 13  | 14                       | 15  | 16                    | 17  | 18                     |     |                         |     |                         |     |                         |     |                          |     |                       |     |                       |  |  |
| 19    | K<br>potassium<br>39.1 | 20                                                             | Ca<br>calcium<br>40.1   | 21                   | Sc<br>scandium<br>45.0 | 22  | Ti<br>titanium<br>47.9  | 23  | V<br>vanadium<br>50.9   | 24  | Cr<br>chromium<br>52.0   | 25  | Mn<br>manganese<br>54.9 | 26  | Fe<br>iron<br>55.8       | 27                   | Co<br>cobalt<br>58.9   | 28  | Ni<br>nickel<br>58.7     | 29  | Cu<br>copper<br>63.5  | 30  | Zn<br>zinc<br>65.4     | 31  | Ga<br>gallium<br>69.7   | 32  | Ge<br>germanium<br>72.6 | 33  | As<br>arsenic<br>74.9   | 34  | Se<br>selenium<br>79.0   | 35  | Br<br>bromine<br>79.9 | 36  | Kr<br>krypton<br>83.8 |  |  |
| 37    | Rb<br>rubidium<br>85.5 | 38                                                             | Sr<br>strontium<br>87.6 | 39                   | Y<br>yttrium<br>88.9   | 40  | Zr<br>zirconium<br>91.2 | 41  | Nb<br>niobium<br>92.9   | 42  | Mo<br>molybdenum<br>95.9 | 43  | Tc<br>technetium        | 44  | Ru<br>ruthenium<br>101.1 | 45                   | Rh<br>rhodium<br>102.9 | 46  | Pd<br>palladium<br>106.4 | 47  | Ag<br>silver<br>107.9 | 48  | Cd<br>cadmium<br>112.4 | 49  | In<br>indium<br>114.8   | 50  | Sn<br>tin<br>118.7      | 51  | Sb<br>antimony<br>121.8 | 52  | Te<br>tellurium<br>127.6 | 53  | I<br>iodine<br>126.9  | 54  | Xe<br>xenon<br>131.3  |  |  |
| 55    | Cs<br>caesium<br>132.9 | 56                                                             | Ba<br>barium<br>137.3   | 57–71<br>lanthanoids |                        | 72  | Hf<br>hafnium<br>178.5  | 73  | Ta<br>tantalum<br>180.9 | 74  | W<br>tungsten<br>183.8   | 75  | Re<br>rhenium<br>186.2  | 76  | Os<br>osmium<br>190.2    | 77                   | Ir<br>iridium<br>192.2 | 78  | Pt<br>platinum<br>195.1  | 79  | Au<br>gold<br>197.0   | 80  | Hg<br>mercury<br>200.6 | 81  | Tl<br>thallium<br>204.4 | 82  | Pb<br>lead<br>207.2     | 83  | Bi<br>bismuth<br>209.0  | 84  | Po<br>polonium           | 85  | At<br>astatine        | 86  | Rn<br>radon           |  |  |
| 87    | Fr<br>francium         | 88                                                             | Ra<br>radium            | 89–103<br>actinoids  |                        | 104 | Rf<br>rutherfordium     | 105 | Db<br>dubnium           | 106 | Sg<br>seaborgium         | 107 | Bh<br>bohrium           | 108 | Hs<br>hassium            | 109                  | Mt<br>meitnerium       | 110 | Ds<br>darmstadtium       | 111 | Rg<br>roentgenium     | 112 | Cn<br>copernicium      | 113 | Nh<br>nihonium          | 114 | Fl<br>flerovium         | 115 | Mc<br>moscovium         | 116 | Lv<br>livermorium        | 117 | Ts<br>tennessine      | 118 | Og<br>ognesson        |  |  |