

Cambridge  
International  
AS & A Level

**Cambridge International Examinations**  
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE  
NAME

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CENTRE  
NUMBER

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**CHEMISTRY**

**9701/34**

Paper 3 Advanced Practical Skills 2

**October/November 2015**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.  
Give details of the practical session and laboratory where appropriate, in the boxes provided.  
Write in dark blue or black pen.  
You may use an HB pencil for any diagrams or graphs.  
Do not use staples, paper clips, glue or correction fluid.  
**DO NOT WRITE IN ANY BARCODES.**

Answer **all** questions.  
Electronic calculators may be used.  
You may lose marks if you do not show your working or if you do not use appropriate units.  
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.  
A Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.  
The number of marks is given in brackets [ ] at the end of each question or part question.

|                   |  |
|-------------------|--|
| <b>Session</b>    |  |
|                   |  |
| <b>Laboratory</b> |  |
|                   |  |

|                           |  |
|---------------------------|--|
| <b>For Examiner's Use</b> |  |
| <b>1</b>                  |  |
| <b>2</b>                  |  |
| <b>3</b>                  |  |
| <b>Total</b>              |  |

This document consists of **12** printed pages.

- 1 In this experiment you will determine the relative atomic mass,  $A_r$ , of magnesium by a titration method.

**FB 1** is  $2.00 \text{ mol dm}^{-3}$  hydrochloric acid, HCl.

**FB 3** is  $0.120 \text{ mol dm}^{-3}$  sodium hydroxide, NaOH.

magnesium ribbon

bromophenol blue indicator

**(a) Method**

**Reaction of magnesium with FB 1**

- Pipette  $25.0 \text{ cm}^3$  of **FB 1** into the  $250 \text{ cm}^3$  beaker.
- Weigh the strip of magnesium ribbon and record its mass.

mass of magnesium = ..... g

- Coil the strip of magnesium ribbon loosely and then add it to the **FB 1** in the beaker.
- Stir the mixture occasionally and wait until the reaction has finished.

**Dilution of the excess acid**

- Transfer all the solution from the beaker into the volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution before using it for your titrations.
- Label this solution of hydrochloric acid **FB 2**.

**Titration**

- Fill the burette with **FB 2**.
- Rinse the pipette out thoroughly. Then pipette  $25.0 \text{ cm}^3$  of **FB 3** into a conical flask.
- Add several drops of bromophenol blue indicator.
- Perform a rough titration, by running the solution from the burette into the conical flask until the mixture just becomes yellow.
- 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 below all of your burette readings and the volume of **FB 2** added in each accurate titration.

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

[7]

- (b) From your accurate titration results, obtain a suitable value for the volume of **FB 2** to be used in your calculations.  
Show clearly how you have obtained this value.

25.0 cm<sup>3</sup> of **FB 3** required ..... cm<sup>3</sup> of **FB 2**. [1]

**(c) Calculations**

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

- (i) Calculate the number of moles of sodium hydroxide present in 25.0 cm<sup>3</sup> of solution **FB 3**.

moles of NaOH = ..... mol

- (ii) Give the equation for the reaction of hydrochloric acid, HCl, with sodium hydroxide, NaOH. State symbols are **not** required.

.....

Deduce the number of moles of hydrochloric acid in the volume of **FB 2** you calculated in (b).

moles of HCl = ..... mol

- (iii) Calculate the number of moles of hydrochloric acid in 250 cm<sup>3</sup> of **FB 2**.

moles of HCl in 250 cm<sup>3</sup> of **FB 2** = ..... mol

- (iv) Calculate the number of moles of hydrochloric acid in 25.0 cm<sup>3</sup> of **FB 1**.

moles of HCl in 25.0 cm<sup>3</sup> of **FB 1** = ..... mol

- (v) In (a), you reacted  $25.0\text{ cm}^3$  of **FB 1** with your weighed piece of magnesium. After the reaction, the unreacted hydrochloric acid was used to prepare  $250\text{ cm}^3$  of **FB 2**.

Use your answers to (iii) and (iv) to calculate the number of moles of hydrochloric acid that reacted with the magnesium ribbon.

moles of  $\text{HCl}$  reacting with  $\text{Mg}$  = ..... mol

- (vi) Complete the equation below, for the reaction of magnesium with hydrochloric acid. State symbols **are** required.



Use your answer to (v) to calculate the number of moles of magnesium used.

moles of  $\text{Mg}$  = ..... mol

- (vii) Use your answer to (vi) to calculate the relative atomic mass,  $A_r$ , of magnesium.

$A_r$  of  $\text{Mg}$  = .....  
[6]

- (d) (i) State **one** observation that proves that the hydrochloric acid in **FB 1** was in excess for the reaction with the magnesium ribbon.

.....  
.....

- (ii) A student carried out exactly the same experiment but used  $1.00\text{ g}$  of magnesium ribbon. State and explain why the student's experiment could not be used to determine the value for the  $A_r$  of magnesium. Include a calculation in your answer.

.....  
.....

[3]

[Total: 17]

- 2 In this experiment you will determine the relative atomic mass of magnesium by thermal decomposition of hydrated magnesium sulfate.



**FB 4** is hydrated magnesium sulfate,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ .

**(a) Method**

Record all your weighings in the space below.

- Weigh the crucible with its lid.
- Transfer all **FB 4** into the crucible.
- Weigh the crucible, lid and **FB 4**.
- Place the crucible on the pipe-clay triangle.
- Heat the crucible gently with the lid **on**, for about one minute.
- Then heat the crucible strongly, without the lid, for a further four minutes.
- Leave the crucible and its contents to cool with the lid on, for several minutes.
- **While the crucible is cooling, begin work on Question 3.**
- When the crucible has cooled, weigh it, with the lid and contents.
- Calculate and record the mass of anhydrous magnesium sulfate produced and the mass of water lost.

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

[3]

**(b) Calculations**

- (i) Calculate the number of moles of water lost during heating.  
(Use the data in the Periodic Table on page 12.)

moles of  $\text{H}_2\text{O}$  = ..... mol

- (ii) Use the **equation above** and **your answer to (i)** to calculate the number of moles of anhydrous magnesium sulfate produced.

moles of  $\text{MgSO}_4$  = ..... mol

- (iii) Use your weighings and your answer to (ii) to calculate the relative formula mass,  $M_r$ , of anhydrous magnesium sulfate.

$M_r$  of  $\text{MgSO}_4$  = .....

- (iv) From your answer to (iii), calculate the relative atomic mass,  $A_r$ , of magnesium.

$A_r$  of Mg = .....  
[4]

- (c) (i) How could the experiment be improved to ensure that the magnesium sulfate had been completely dehydrated?

.....  
.....

- (ii) Why is the lid put on the crucible during cooling?

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

[Total: 9]

### 3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

You should indicate clearly at what stage in a test a change occurs.

Marks are **not** given for chemical equations.

**No additional tests for ions present should be attempted.**

**If any solution is warmed, a boiling tube MUST be used.**

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

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

(a) **FB 5** is a solution containing one cation and one anion.

Carry out test-tube tests to find out whether the cation in **FB 5** is magnesium and whether the anion is sulfate.

- State what reagents you used.
- Record the observations you made in a table.
- State your conclusions about which ions are present.

[4]





| <i>test</i>  | <i>observations</i> |
|--|---------------------|
| To a 1 cm depth of the solution of <b>FB 6</b> in a boiling tube, add aqueous sodium hydroxide until in excess, then |                     |
| heat the mixture gently and carefully, and test any gas produced, then   |                     |
| add a small piece of aluminium foil while the mixture is still warm. Test any gas produced.                          |                     |

(iii) Deduce the formula of the salt in **FB 6**.

Formula is .....

[10]

[Total: 14]

### Qualitative Analysis Notes

Key: [ppt. = precipitate]

#### 1 Reactions of aqueous cations

| ion  | reaction with  |  |
|--|--|--|
|  | NaOH(aq)   | NH <sub>3</sub> (aq)   |
| aluminium,<br>Al <sup>3+</sup> (aq)            | white ppt.<br>soluble in excess  | white ppt.<br>insoluble in excess  |
| ammonium,<br>NH <sub>4</sub> <sup>+</sup> (aq) | no ppt.<br>ammonia produced on heating   | –  |
| barium,<br>Ba <sup>2+</sup> (aq)               | no ppt. (if reagents are pure)   | no ppt.  |
| calcium,<br>Ca <sup>2+</sup> (aq)              | white ppt. with high [Ca <sup>2+</sup> (aq)]                                       | no ppt.  |
| chromium(III),<br>Cr <sup>3+</sup> (aq)        | grey-green ppt. soluble in excess<br>giving dark green solution                    | grey-green ppt.<br>insoluble in excess   |
| copper(II),<br>Cu <sup>2+</sup> (aq)           | pale blue ppt.<br>insoluble in excess  | blue ppt. soluble in excess<br>giving dark blue solution                           |
| iron(II),<br>Fe <sup>2+</sup> (aq)             | green ppt. turning brown on contact<br>with air<br>insoluble in excess             | green ppt. turning brown on contact<br>with air<br>insoluble in excess             |
| iron(III),<br>Fe <sup>3+</sup> (aq)            | red-brown ppt.<br>insoluble in excess  | red-brown ppt.<br>insoluble in excess  |
| magnesium,<br>Mg <sup>2+</sup> (aq)            | white ppt.<br>insoluble in excess  | white ppt.<br>insoluble in excess  |
| manganese(II),<br>Mn <sup>2+</sup> (aq)        | off-white ppt. rapidly turning brown<br>on contact with air<br>insoluble in excess | off-white ppt. rapidly turning brown<br>on contact with air<br>insoluble in excess |
| zinc,<br>Zn <sup>2+</sup> (aq)                 | white ppt.<br>soluble in excess  | white ppt.<br>soluble in excess  |

## 2 Reactions of anions

| <i>ion</i>                                | <i>reaction</i>   |
|---|---|
| carbonate,<br>$\text{CO}_3^{2-}$          | $\text{CO}_2$ liberated by dilute acids   |
| chloride,<br>$\text{Cl}^-(\text{aq})$     | gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$ )   |
| bromide,<br>$\text{Br}^-(\text{aq})$      | gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$ )   |
| iodide,<br>$\text{I}^-(\text{aq})$        | gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$ )  |
| nitrate,<br>$\text{NO}_3^-(\text{aq})$    | $\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil   |
| nitrite,<br>$\text{NO}_2^-(\text{aq})$    | $\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil;<br>$\text{NO}$ liberated by dilute acids<br>(colourless $\text{NO} \rightarrow$ (pale) brown $\text{NO}_2$ in air) |
| sulfate,<br>$\text{SO}_4^{2-}(\text{aq})$ | gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)   |
| sulfite,<br>$\text{SO}_3^{2-}(\text{aq})$ | $\text{SO}_2$ liberated with dilute acids;<br>gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)   |

## 3 Tests for gases

| <i>gas</i>                    | <i>test and test result</i>  |
|-------------------------------|--|
| ammonia, $\text{NH}_3$        | turns damp red litmus paper blue   |
| carbon dioxide, $\text{CO}_2$ | gives a white ppt. with limewater<br>(ppt. dissolves with excess $\text{CO}_2$ ) |
| chlorine, $\text{Cl}_2$       | bleaches damp litmus paper   |
| hydrogen, $\text{H}_2$        | "pops" with a lighted splint   |
| oxygen, $\text{O}_2$          | relights a glowing splint  |
| sulfur dioxide, $\text{SO}_2$ | turns acidified aqueous potassium manganate(VII) from purple to colourless       |

**The Periodic Table of the Elements**

|                                     |                                      | Group                                |                                     |                                      |                                       |                                      |                                     |                                     |                                   |                                   |                                   |                                    |                                      |                                    |                                     |                                    |                                    |  |  |  |  |
|-------------------------------------|--------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|---------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|--------------------------------------|------------------------------------|-------------------------------------|------------------------------------|------------------------------------|--|--|--|--|
| I                                   | II                                   | III                                  | IV                                  | V                                    | VI                                    | VII                                  | 0                                   |                                     |                                   |                                   |                                   |                                    |                                      |                                    |                                     |                                    |                                    |  |  |  |  |
| 6.9<br><b>Li</b><br>Lithium<br>3    | 9.0<br><b>Be</b><br>Beryllium<br>4   | 1.0<br><b>H</b><br>Hydrogen<br>1     | 10.8<br><b>B</b><br>Boron<br>5      | 12.0<br><b>C</b><br>Carbon<br>6      | 14.0<br><b>N</b><br>Nitrogen<br>7     | 16.0<br><b>O</b><br>Oxygen<br>8      | 19.0<br><b>F</b><br>Fluorine<br>9   | 20.2<br><b>Ne</b><br>Neon<br>10     |                                   |                                   |                                   |                                    |                                      |                                    |                                     |                                    |                                    |  |  |  |  |
| 23.0<br><b>Na</b><br>Sodium<br>11   | 24.3<br><b>Mg</b><br>Magnesium<br>12 | 27.0<br><b>Al</b><br>Aluminium<br>13 | 28.1<br><b>Si</b><br>Silicon<br>14  | 31.0<br><b>P</b><br>Phosphorus<br>15 | 32.1<br><b>S</b><br>Sulfur<br>16      | 35.5<br><b>Cl</b><br>Chlorine<br>17  | 39.9<br><b>Ar</b><br>Argon<br>18    |                                     |                                   |                                   |                                   |                                    |                                      |                                    |                                     |                                    |                                    |  |  |  |  |
| 39.1<br><b>K</b><br>Potassium<br>19 | 40.1<br><b>Ca</b><br>Calcium<br>20   | 47.9<br><b>Ti</b><br>Titanium<br>22  | 48.9<br><b>Sc</b><br>Scandium<br>21 | 50.9<br><b>V</b><br>Vanadium<br>23   | 52.0<br><b>Cr</b><br>Chromium<br>24   | 54.9<br><b>Mn</b><br>Manganese<br>25 | 55.8<br><b>Fe</b><br>Iron<br>26     | 58.7<br><b>Ni</b><br>Nickel<br>28   | 59.7<br><b>Co</b><br>Cobalt<br>27 | 63.5<br><b>Cu</b><br>Copper<br>29 | 65.4<br><b>Zn</b><br>Zinc<br>30   | 69.7<br><b>Ga</b><br>Gallium<br>31 | 72.6<br><b>Ge</b><br>Germanium<br>32 | 74.9<br><b>As</b><br>Arsenic<br>33 | 79.0<br><b>Se</b><br>Selenium<br>34 | 79.9<br><b>Br</b><br>Bromine<br>35 | 83.8<br><b>Kr</b><br>Krypton<br>36 |  |  |  |  |
| 85.5<br><b>Rb</b><br>Rubidium<br>37 | 87.6<br><b>Sr</b><br>Strontium<br>38 | 91.2<br><b>Zr</b><br>Zirconium<br>40 | 88.9<br><b>Y</b><br>Yttrium<br>39   | 92.9<br><b>Nb</b><br>Niobium<br>41   | 95.9<br><b>Mo</b><br>Molybdenum<br>42 | 101<br><b>Tc</b><br>Technetium<br>43 | 101<br><b>Ru</b><br>Ruthenium<br>44 | 106<br><b>Pd</b><br>Palladium<br>46 | 103<br><b>Rh</b><br>Rhodium<br>45 | 108<br><b>Ag</b><br>Silver<br>47  | 112<br><b>Cd</b><br>Cadmium<br>48 | 115<br><b>In</b><br>Indium<br>49   | 119<br><b>Sn</b><br>Tin<br>50        | 122<br><b>Sb</b><br>Antimony<br>51 | 128<br><b>Te</b><br>Tellurium<br>52 | 127<br><b>I</b><br>Iodine<br>53    | 131<br><b>Xe</b><br>Xenon<br>54    |  |  |  |  |
| 133<br><b>Cs</b><br>Caesium<br>55   | 137<br><b>Ba</b><br>Barium<br>56     | 178<br><b>Hf</b><br>Hafnium<br>72    | 139<br><b>La</b><br>Lanthanum<br>57 | 181<br><b>Ta</b><br>Tantalum<br>73   | 184<br><b>W</b><br>Tungsten<br>74     | 186<br><b>Re</b><br>Rhenium<br>75    | 190<br><b>Os</b><br>Osmium<br>76    | 195<br><b>Pt</b><br>Platinum<br>78  | 192<br><b>Ir</b><br>Iridium<br>77 | 197<br><b>Au</b><br>Gold<br>79    | 201<br><b>Hg</b><br>Mercury<br>80 | 204<br><b>Tl</b><br>Thallium<br>81 | 207<br><b>Pb</b><br>Lead<br>82       | 209<br><b>Bi</b><br>Bismuth<br>83  | 210<br><b>Po</b><br>Polonium<br>84  | 210<br><b>At</b><br>Astatine<br>85 | 222<br><b>Rn</b><br>Radon<br>86    |  |  |  |  |
| 87<br><b>Fr</b><br>Francium         | 88<br><b>Ra</b><br>Radium            | 104<br><b>Rf</b><br>Rutherfordium    | 89<br><b>Ac</b><br>Actinium         | 105<br><b>Db</b><br>Dubnium          | 106<br><b>Sg</b><br>Seaborgium        | 107<br><b>Bh</b><br>Bohrium          | 108<br><b>Hs</b><br>Hassium         | 110<br><b>Uun</b><br>Ununium        | 109<br><b>Mt</b><br>Meitnerium    | 111<br><b>Uuu</b><br>Unununium    | 112<br><b>Uub</b><br>Unubium      | 114<br><b>Uuq</b><br>Ununquadium   | 116<br><b>Uuh</b><br>Ununhexium      | 118<br><b>Uuo</b><br>Ununoctium    |                                     |                                    |                                    |  |  |  |  |

\* 58-71 Lanthanides  
 † 90-103 Actinides

Key

|   |          |   |
|---|----------|---|
| a | <b>X</b> | b |
|---|----------|---|

a = relative atomic mass  
 † = atomic symbol  
 b = proton (atomic) number

|                                      |                                       |  |                                       |                                       |  |   |
|--------------------------------------|---------------------------------------|--|---------------------------------------|---------------------------------------|--|---|
| 163<br><b>Dy</b><br>Dysprosium<br>66 | 159<br><b>Tb</b><br>Terbium<br>65     | 165<br><b>Ho</b><br>Holmium<br>67      | 167<br><b>Er</b><br>Erbium<br>68      | 169<br><b>Tm</b><br>Thulium<br>69     | 173<br><b>Yb</b><br>Ytterbium<br>70    | 175<br><b>Lu</b><br>Lutetium<br>71      |
| 152<br><b>Eu</b><br>Europium<br>63   | 150<br><b>Sm</b><br>Samarium<br>62    | 157<br><b>Gd</b><br>Gadolinium<br>64   | 155<br><b>Pm</b><br>Promethium<br>61  | 151<br><b>Pu</b><br>Plutonium<br>94   | 147<br><b>Np</b><br>Neptunium<br>93    | 143<br><b>U</b><br>Uranium<br>92        |
| 137<br><b>Am</b><br>Americium<br>95  | 135<br><b>Cm</b><br>Curium<br>96      | 138<br><b>Bk</b><br>Berkelium<br>97    | 136<br><b>Cf</b><br>Californium<br>98 | 134<br><b>Es</b><br>Einsteinium<br>99 | 132<br><b>Fm</b><br>Fermium<br>100     | 130<br><b>Md</b><br>Mendelevium<br>101  |
| 118<br><b>No</b><br>Nobelium<br>102  | 116<br><b>Lr</b><br>Lawrencium<br>103 | 114<br><b>Uue</b><br>Ununhexium<br>116 | 112<br><b>Uub</b><br>Unubium<br>112   | 110<br><b>Uun</b><br>Ununium<br>110   | 108<br><b>Uuo</b><br>Ununoctium<br>118 | 106<br><b>Uuq</b><br>Ununquadium<br>114 |