

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 2016**

**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 copy of the 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 You will find the relative atomic mass,  $A_r$ , of magnesium by measuring the volume of hydrogen produced when a known mass of metal reacts with an excess of acid.



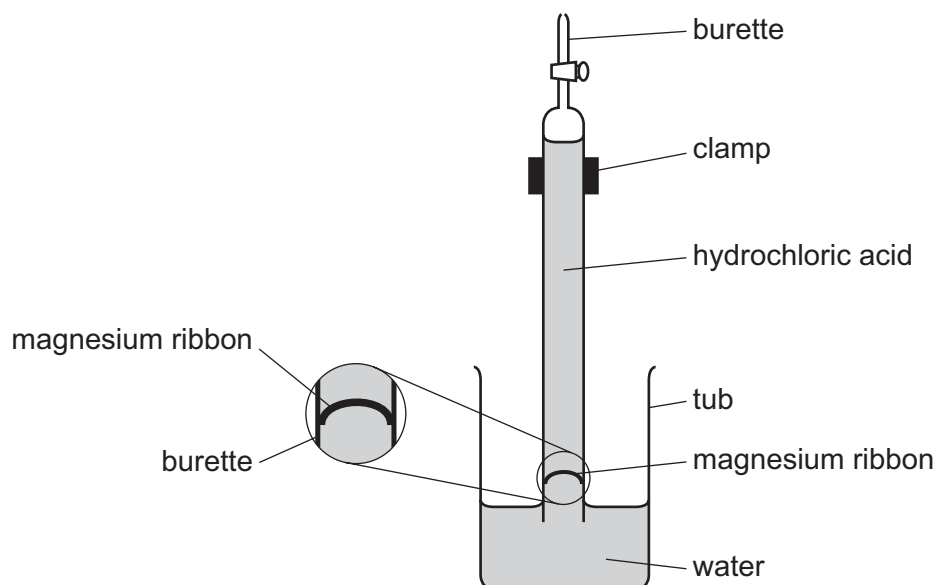
**FB 1** is  $1.00 \text{ mol dm}^{-3}$  hydrochloric acid,  $\text{HCl}$ .

**FB 2** is magnesium,  $\text{Mg}$ .

**(a) Method**

**Read through the whole method before starting any practical work.**

- Fill the tub with water to a depth of about 5 cm.
- Weigh the magnesium, **FB 2**, and note its mass below. If you are using a balance reading to 1 decimal place and the reading with the magnesium is zero, you should record this value.
- Fill the burette to about the  $20 \text{ cm}^3$  mark with hydrochloric acid, **FB 1**.
- Add distilled water to reach the  $0 \text{ cm}^3$  mark on the burette.
- Bend the magnesium strip into a U-shape.
- Place the magnesium in the burette so that it is above the liquid and friction holds it in position. Use a glass rod to push the magnesium about 2 cm into the burette.
- Hold a piece of paper towel over the open end of the burette, invert the burette and immediately place it in the tub of water. Remove the paper towel and clamp the burette as shown in the diagram.
- The liquid level should now be on the scale of the burette. If it is not, open the tap for a moment to allow the level to drop.



- Record the initial reading on the burette. Remember that the scale is now upside down.
- Leave the apparatus so that the acid from the burette diffuses around the magnesium and reacts.
- You should start **Question 2 or Question 3** while waiting for the reaction to complete.
- When all the magnesium has reacted, note and record the final reading on the burette.
- Calculate the volume of hydrogen produced.

**Results**

**(b) 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 hydrogen produced.  
(Assume that 1 mole of gas occupies 24.0 dm<sup>3</sup> under these conditions.)

moles of H<sub>2</sub> = ..... mol

- (ii) Use your answer to (i) and the mass of magnesium used to calculate the  $A_r$  of magnesium.  
(If you used a balance reading to 1 decimal place, you should assume that the mass of magnesium was 0.04 g correct to 2 decimal places.)

$A_r$  of Mg = .....  
[2]

- (c) (i) Calculate the percentage error in the mass and volume readings in this experiment.

- (ii) Suggest a change that could be made to reduce the greater error calculated in (i).

.....  
.....  
[3]

- (d) What would be the effect on the value of the  $A_r$  of magnesium calculated if the temperature of the room was much lower than that for your experiment? Explain your answer.

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

[Total: 10]

- 2 In **Question 1** you calculated the relative atomic mass,  $A_r$ , of magnesium by measuring the volume of hydrogen produced. The relative atomic mass can also be determined by investigating how much of the hydrochloric acid reacted with the magnesium.

The experiment described in **Question 1** was repeated, this time using 0.21 g of magnesium ribbon and 30.0 cm<sup>3</sup> of 1.00 mol dm<sup>-3</sup> hydrochloric acid. All the solution left in the burette and tub was kept and water added to make the total volume 250 cm<sup>3</sup>. This solution was labelled **FB 3**.

You will titrate **FB 3** using a known concentration of aqueous sodium carbonate to determine how much hydrochloric acid was left over after the reaction with magnesium.



**FB 3** is the solution of hydrochloric acid described above.

**FB 4** is aqueous sodium carbonate containing 2.64 g dm<sup>-3</sup> Na<sub>2</sub>CO<sub>3</sub>.  
bromophenol blue indicator

**(a) Method**

- Fill the burette with **FB 3**.
- Pipette 25.0 cm<sup>3</sup> of **FB 4** into a conical flask.
- Add about 10 drops of bromophenol blue indicator.
- 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 consider necessary to obtain consistent results.
- Record, in a suitable form below, all of your burette readings and the volume of **FB 3** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b) From your accurate titration results, obtain a suitable value for the volume of **FB 3** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm<sup>3</sup> of **FB 4** required ..... cm<sup>3</sup> of **FB 3**. [1]

**(c) Calculations**

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

- (i) Use the information on page 4 and the Periodic Table on page 12 to calculate the number of moles of sodium carbonate in the 25.0 cm<sup>3</sup> of **FB 4** used in each titration.

moles of Na<sub>2</sub>CO<sub>3</sub> = ..... mol

- (ii) Use your answer to (i) to calculate the number of moles of hydrochloric acid present in the volume of **FB 3** recorded in (b).



moles of HCl present = ..... mol

- (iii) Use your answer to (ii) to calculate the number of moles of hydrochloric acid present in 250 cm<sup>3</sup> of **FB 3**.

moles of HCl present in 250 cm<sup>3</sup> = ..... mol

- (iv) Use the information on page 4 to calculate the number of moles of hydrochloric acid added to the magnesium.

moles of HCl added = ..... mol

- (v) Calculate the number of moles of hydrochloric acid that reacted with the magnesium.

moles of HCl that reacted with the magnesium = ..... mol

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



$A_r$  of Mg = .....  
[5]

- (d) A solution of sodium hydroxide was prepared at the same concentration, in  $\text{mol dm}^{-3}$ , as **FB 4**. A student repeated the titration but replaced **FB 4** with this solution of sodium hydroxide.

- (i) Explain the effect that replacing **FB 4** with this solution of sodium hydroxide would have on the volume of acid, **FB 3**, needed for the titration.

.....  
.....

- (ii) If the sodium hydroxide had been stored for a long time it would not be suitable for use to find the concentration of the acid.

Suggest why storage for a long time would make the sodium hydroxide unsuitable.

.....  
.....

[2]

[Total: 15]

### 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.

**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) (i) Half fill the 250 cm<sup>3</sup> beaker with water. Heat the water to about 80 °C and then turn off the Bunsen burner. This is the hot water bath needed in the following tests.

To a 3–4 cm depth of aqueous silver nitrate in a test-tube, add a few drops of aqueous sodium hydroxide to give a grey / brown precipitate. Then add aqueous ammonia dropwise until the precipitate **just** disappears. This solution is Tollens' reagent and is needed in a following test.

**FB 5**, **FB 6** and **FB 7** are each known to be one of ethanol, propanal and propanone.

Carry out the following tests and complete the table.

test	observations		
	FB 5	FB 6	FB 7
To a 1 cm depth in a test-tube, add a few drops of acidified potassium manganate(VII) and place in the hot water bath.			
To a 0.5 cm depth in a test-tube, add a 1 cm depth of aqueous potassium iodide and a 1 cm depth of sodium chlorate(I). (This gives the same result as adding iodine and alkali.)			
To a few drops in a test-tube, add a 1 cm depth of Tollens' reagent and place in the hot water bath. Leave for several minutes.			

(ii) Use these observations to identify the unknown compounds.

**FB 5** is .....

**FB 6** is .....

**FB 7** is .....

(iii) Choose another reagent that would give a similar result for propanal and propanone but a different result for ethanol.

**Do not carry out this test.**

reagent .....

result for propanal and propanone .....

result for ethanol .....

(iv) Choose another reagent that would give a similar result for ethanol and propanone but a different result for propanal.

**Do not carry out this test.**

reagent .....

result for ethanol and propanone .....

result for propanal .....

[8]



(b) **FB 8** contains one cation and one anion from those listed on pages 10 and 11.  
You are provided with solid **FB 8** and an aqueous solution of **FB 8**.

(i) To a 1 cm depth of aqueous **FB 8** in a test-tube add a 1 cm depth of aqueous sodium hydroxide.

Keep the test-tube and contents for test (ii).

observation .....

(ii) Transfer the contents of the test-tube from test (i) into a boiling tube and heat gently and **carefully**.

Allow to cool and keep the boiling tube and contents for test (iii).

observation .....

(iii) Transfer a 1 cm depth of the mixture from test (ii) into a boiling tube and add a 2 cm depth of dilute hydrochloric acid. Heat gently and **carefully**.

observation .....

Allow to cool and keep the boiling tube and contents for test (iv).

(iv) To the boiling tube from test (iii) add a piece of aluminium foil. Leave the boiling tube to stand.

observation .....

.....

(v) Place a small spatula measure of solid **FB 8** in a hard-glass test-tube and heat it gently at first and then more strongly.

Identify **two** gases, other than water vapour, that are produced and give your evidence.

identity .....

evidence .....

identity .....

evidence .....

(vi) From your observations in (i) to (v), write the formula of **FB 8**.

.....

(vii) Write the **ionic** equation for the reaction that is occurring in test (i). Include state symbols.

.....

[7]

[Total: 15]

### Qualitative Analysis Notes

Key: [ppt. = precipitate]

#### 1 Reactions of aqueous cations

ion	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 heating	–
barium, Ba <sup>2+</sup> (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca <sup>2+</sup> (aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.
chromium(III), Cr <sup>3+</sup> (aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu <sup>2+</sup> (aq)	pale blue ppt. insoluble in excess	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

## 2 Reactions of anions

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

The Periodic Table of Elements

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lanthanoids

actinoids

57	La	lanthanum	138.9	58	Ce	cerium	140.1	59	Pr	praseodymium	140.9	60	Nd	neodymium	144.4	61	Pm	promethium	—	62	Sm	samarium	150.4	63	Eu	europlum	152.0	64	Gd	gadolinium	157.3	65	Tb	terbium	158.9	66	Dy	dysprosium	162.5	67	Ho	holmium	164.9	68	Er	erbium	167.3	69	Tm	thulium	168.9	70	Yb	ytterbium	173.1	71	Lu	lutetium	175.0
89	Ac	actinium	227.0	90	Th	thorium	232.0	91	Pa	protactinium	231.0	92	U	uranium	238.0	93	Np	neptunium	—	94	Pu	plutonium	—	95	Am	americium	—	96	Cm	curium	—	97	Bk	berkelium	—	98	Cf	californium	—	99	Es	einsteinium	—	100	Fm	fermium	—	101	Md	meitnerium	—	102	No	nobelium	—	103	Lr	lawrencium	—