

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

9701/32

Paper 3 Advanced Practical Skills 2

May/June 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.

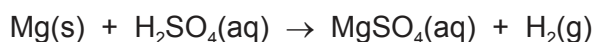
Session	
Laboratory	

For Examiner's Use	
1	
2	
3	
Total	

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

- 1 In **Questions 1** and **2** you will determine the relative atomic mass, A_r , of magnesium by two different methods.

In the first method you will collect and measure the volume of gas given off in the reaction between a known mass of magnesium and a known amount of dilute sulfuric acid. The acid will be in excess.



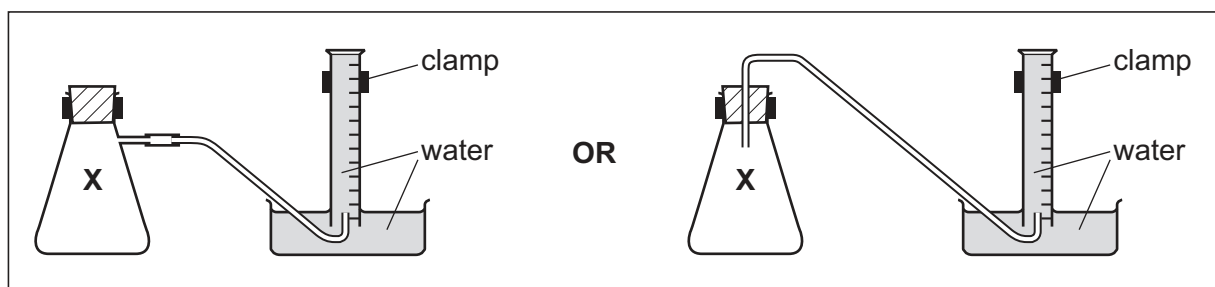
FB 1 is a strip of magnesium ribbon, Mg.

FB 2 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4 .

(a) Method

Read through the whole method before starting any practical work.

The diagrams below may help you in setting up your apparatus.



- Fill the tub with water to a depth of about 5 cm.
- Fill the 250 cm^3 measuring cylinder **completely** with water. Hold 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.
- Pipette 25.0 cm^3 of **FB 2** into the reaction flask labelled **X**.
- Check that the bung fits tightly in the neck of flask **X**, clamp flask **X**, and place the end of the delivery tube into the inverted 250 cm^3 measuring cylinder.
- Weigh the magnesium ribbon, **FB 1**, and record the mass in the space below.
- Remove the bung from the neck of the flask. Add the magnesium ribbon, **FB 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. Swirl the flask occasionally until no more gas is evolved. Replace the flask in the clamp.
- When no more gas is collected, measure and record the final volume of gas in the measuring cylinder in the space below.

KEEP THE CONTENTS OF THE CONICAL FLASK X FOR USE IN QUESTION 2.

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 gas collected in the measuring cylinder.
[Assume that 1 mole of gas occupies 24.0 dm^3 under these conditions.]

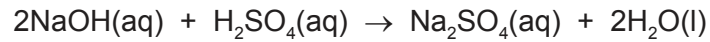
moles of gas = mol

- (ii) Use your answer to (i) and the mass of magnesium, **FB 1**, recorded in (a) to calculate the relative atomic mass, A_r , of magnesium.

A_r of magnesium =
[3]

[Total: 5]

- 2 You will determine the amount of sulfuric acid remaining in flask **X** after the reaction with magnesium in **Question 1**. You will do this by titration with sodium hydroxide of known concentration.



FB 3 is $0.150 \text{ mol dm}^{-3}$ sodium hydroxide, NaOH.
bromophenol blue indicator

(a) Method

- Transfer **all** the contents of flask **X** from **Question 1** into the 250 cm^3 volumetric flask.
- Rinse flask **X** with distilled water and add the washings to the volumetric flask. Add distilled water up to the mark. Stopper the volumetric flask and mix the contents thoroughly.
- Label this solution **FB 4**.
- Rinse the pipette and use it to transfer 25.0 cm^3 of **FB 4** into the conical flask.
- Add about 10 drops of bromophenol blue to the conical flask.
- Fill the burette with **FB 3**.
- Perform a rough titration and record your burette readings in the space below. The end point is reached when the solution becomes a permanent blue-violet colour.

The rough titre is cm^3 .

- Carry out as many accurate titrations as you think 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^3 of **FB 4** required cm^3 of **FB 3**. [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, NaOH, in the volume of **FB 3** you calculated in **(b)**.

moles of NaOH = mol

- (ii) Use your answer to **(i)** to calculate the number of moles of sulfuric acid present in the 25.0 cm³ of **FB 4** pipetted in **(a)**.

moles of H₂SO₄ = mol

- (iii) Use your answer to **(ii)** to calculate the number of moles of sulfuric acid, H₂SO₄, remaining in flask **X** after the reaction in **1(a)**.

moles of H₂SO₄ remaining from **1(a)** = mol

- (iv) Use the relevant information on page 2 to calculate the number of moles of sulfuric acid, H₂SO₄, pipetted into reaction flask **X** in **1(a)**.

moles of H₂SO₄ pipetted into flask **X** = mol

- (v) Use your answers to (iii) and (iv) to calculate the number of moles of sulfuric acid which reacted with the magnesium in flask X.

moles of H_2SO_4 which reacted in flask X = mol

- (vi) Use your answer to (v) and the mass of magnesium used in 1(a) to calculate the relative atomic mass, A_r , of magnesium.

A_r of magnesium = [6]

- (d) (i) A student, who carried out the experiments in Questions 1 and 2 correctly, calculated the A_r of magnesium as shown in the table.

	Question 1	Question 2
A_r Mg	20.8	22.5

Use the A_r of magnesium given in the Periodic Table on page 12 to deduce which practical procedure is less accurate. Identify one source of inaccuracy and explain **one** change the student could make in order to improve the accuracy.

..... is less accurate

source of inaccuracy

.....

improvement

.....

- (ii) Use the A_r of magnesium given in the Periodic Table to calculate the percentage error in the student's value from Question 1.

.....

.....

.....

[3]

[Total: 17]

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) (i) **FB 5** is a solid element and **FB 6** is a solid compound containing one cation and one anion. Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>
Place a small spatula measure of FB 5 in a boiling tube, add a 1 cm depth of dilute hydrochloric acid and warm the contents of the tube gently.	
Place small spatula measures of FB 5 and FB 6 in a single boiling tube. Use a test-tube holder to hold the tube. Add a 2 cm depth of aqueous sodium hydroxide. CARE	
Place a spatula measure of FB 6 in a test-tube. Add a 3 cm depth of distilled water to form a solution for the following two tests.	X
To a 1 cm depth of aqueous FB 6 in a test-tube add a 1 cm depth of dilute hydrochloric acid.	
To a 1 cm depth of aqueous FB 6 in a test-tube add aqueous sodium hydroxide.	

- (ii) Suggest the identities of **FB 5** and **FB 6** from your observations. Refer to the relevant observations in your answers.

FB 5:

reason(s)

.....

FB 6: cation reason(s)

.....

anion reason(s)

.....

.....

[9]

(b) (i) **FB 7** and **FB 8** are solutions which contain different anions. These may be carbonate, halide, sulfate or sulfite. You are to devise tests to identify the two anions present. Record in a suitable table below:

- the reagent(s) you use for each test,
- the observations you make on carrying out the test,
- the conclusion you make from the result of the test.

(ii) The cation in either **FB 7** or **FB 8** is a transition metal ion. Carry out the following test to identify this cation and record your observations.

<i>test</i>	<i>observations</i>	
	FB 7	FB 8
To a 1 cm depth of solution in a test-tube add aqueous sodium hydroxide.		

FB contains the transition metal ion

[9]

[Total: 18]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on heating	–
barium, Ba ²⁺ (aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (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 ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (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 ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	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, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown 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, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	"pops" with a lighted splint
oxygen, O_2	relights a glowing splint

The Periodic Table of Elements

		Group															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">1 H hydrogen 1.0</div> <div style="border: 1px solid black; padding: 5px;">2 He helium 4.0</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">3 Li lithium 6.9</div> <div style="border: 1px solid black; padding: 5px;">4 Be beryllium 9.0</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">5 B boron 10.8</div> <div style="border: 1px solid black; padding: 5px;">6 C carbon 12.0</div> <div style="border: 1px solid black; padding: 5px;">7 N nitrogen 14.0</div> <div style="border: 1px solid black; padding: 5px;">8 O oxygen 16.0</div> <div style="border: 1px solid black; padding: 5px;">9 F fluorine 19.0</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">11 Na sodium 23.0</div> <div style="border: 1px solid black; padding: 5px;">12 Mg magnesium 24.3</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">13 Al aluminium 27.0</div> <div style="border: 1px solid black; padding: 5px;">14 Si silicon 28.1</div> <div style="border: 1px solid black; padding: 5px;">15 P phosphorus 31.0</div> <div style="border: 1px solid black; padding: 5px;">16 S sulfur 32.1</div> <div style="border: 1px solid black; padding: 5px;">17 Cl chlorine 35.5</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">19 K potassium 39.1</div> <div style="border: 1px solid black; padding: 5px;">20 Ca calcium 40.1</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">21 Sc scandium 45.0</div> <div style="border: 1px solid black; padding: 5px;">22 Ti titanium 47.9</div> <div style="border: 1px solid black; padding: 5px;">23 V vanadium 50.9</div> <div style="border: 1px solid black; padding: 5px;">24 Cr chromium 52.0</div> <div style="border: 1px solid black; padding: 5px;">25 Mn manganese 54.9</div> <div style="border: 1px solid black; padding: 5px;">26 Fe iron 55.8</div> <div style="border: 1px solid black; padding: 5px;">27 Co cobalt 58.9</div> <div style="border: 1px solid black; padding: 5px;">28 Ni nickel 58.7</div> <div style="border: 1px solid black; padding: 5px;">29 Cu copper 63.5</div> <div style="border: 1px solid black; padding: 5px;">30 Zn zinc 65.4</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">37 Rb rubidium 85.5</div> <div style="border: 1px solid black; padding: 5px;">38 Sr strontium 87.6</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">39 Y yttrium 88.9</div> <div style="border: 1px solid black; padding: 5px;">40 Zr zirconium 91.2</div> <div style="border: 1px solid black; padding: 5px;">41 Nb niobium 92.9</div> <div style="border: 1px solid black; padding: 5px;">42 Mo molybdenum 95.9</div> <div style="border: 1px solid black; padding: 5px;">43 Tc technetium —</div> <div style="border: 1px solid black; padding: 5px;">44 Ru ruthenium 101.1</div> <div style="border: 1px solid black; padding: 5px;">45 Rh rhodium 102.9</div> <div style="border: 1px solid black; padding: 5px;">46 Pd palladium 106.4</div> <div style="border: 1px solid black; padding: 5px;">47 Ag silver 107.9</div> <div style="border: 1px solid black; padding: 5px;">48 Cd cadmium 112.4</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">55 Cs caesium 132.9</div> <div style="border: 1px solid black; padding: 5px;">56 Ba barium 137.3</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">57–71 lanthanoids</div> <div style="border: 1px solid black; padding: 5px;">72 Hf hafnium 178.5</div> <div style="border: 1px solid black; padding: 5px;">73 Ta tantalum 180.9</div> <div style="border: 1px solid black; padding: 5px;">74 W tungsten 183.8</div> <div style="border: 1px solid black; padding: 5px;">75 Re rhenium 186.2</div> <div style="border: 1px solid black; padding: 5px;">76 Os osmium 190.2</div> <div style="border: 1px solid black; padding: 5px;">77 Ir iridium 192.2</div> <div style="border: 1px solid black; padding: 5px;">78 Pt platinum 195.1</div> <div style="border: 1px solid black; padding: 5px;">79 Au gold 197.0</div> <div style="border: 1px solid black; padding: 5px;">80 Hg mercury 200.6</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">87 Fr francium —</div> <div style="border: 1px solid black; padding: 5px;">88 Ra radium —</div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;">89–103 actinoids</div> <div style="border: 1px solid black; padding: 5px;">104 Rf rutherfordium —</div> <div style="border: 1px solid black; padding: 5px;">105 Db dubnium —</div> <div style="border: 1px solid black; padding: 5px;">106 Sg seaborgium —</div> <div style="border: 1px solid black; padding: 5px;">107 Bh bohrium —</div> <div style="border: 1px solid black; padding: 5px;">108 Hs hassium —</div> <div style="border: 1px solid black; padding: 5px;">109 Mt meitnerium —</div> <div style="border: 1px solid black; padding: 5px;">110 Ds darmstadtium —</div> <div style="border: 1px solid black; padding: 5px;">111 Rg roentgenium —</div> <div style="border: 1px solid black; padding: 5px;">112 Cn copernicium —</div> </div>															

lanthanoids	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 europium 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
actinoids	89 Ac actinium —	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 mendelevium —	102 No nobelium —	103 Lr lawrencium —