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9701/31

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 12 and 13.
A copy of the Periodic Table is printed on page 16.

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 **13** printed pages and **3** blank pages.

- 1 In this experiment you will determine the identity of the Group 2 metal, **X**, in the carbonate, XCO_3 . To do this you will react a known mass of XCO_3 with **excess** hydrochloric acid, HCl , and measure the mass of carbon dioxide that is given off.

FA 1 is XCO_3 .

FA 2 is hydrochloric acid, HCl .

(a) Method

- Weigh the stoppered tube containing **FA 1** and record its mass.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 2** into the 250 cm^3 beaker.
- Weigh the beaker containing the acid and record the mass.
- Carefully add all the sample of **FA 1** to the acid in the beaker.
- Stir the mixture until there is no further reaction.
- Reweigh the beaker and its contents and record the mass.

KEEP THE CONTENTS OF THE BEAKER FOR USE IN QUESTION 2.

- Reweigh the stoppered tube containing any residual **FA 1** and record its mass.
- Calculate the mass of **FA 1** added to the acid and record this value.
- Calculate the mass of carbon dioxide given off and record this value.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(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 carbon dioxide given off when XCO_3 reacted with the acid.
Use the data in the Periodic Table on page 16.

moles of CO_2 = ... mol

- (ii) Write the equation for the reaction of **FA 1**, XCO_3 , with hydrochloric acid, HCl . Include state symbols.

.....

- (iii) Use your answers to (i) and (ii) to calculate the number of moles of XCO_3 that were added to the acid.

moles of XCO_3 = ... mol

- (iv) Use your answer to (iii) to calculate the relative atomic mass, A_r , of **X**.
Identify **X**.

I	
II	
III	
IV	
V	

A_r of **X** = ...

X is
[5]

- (c) One of the sources of error in this experiment is that it is very difficult to reduce acid spraying out of the beaker when the metal carbonate is added to the acid.

- (i) Explain what effect this acid spray would have on the value you calculated for the relative atomic mass, A_r , of **X**.

.....
.....
.....

- (ii) Why is a small amount of acid spray not likely to cause an error in the identification of **X**?

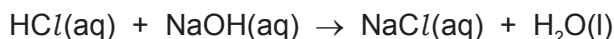
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- (iii) How could you minimise acid spraying out of the beaker?

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

[Total: 15]

- 2 In this experiment you will determine the concentration of the hydrochloric acid, **FA 2**, used in **Question 1**. You will first dilute the reaction mixture that you prepared in **Question 1** and then titrate this diluted solution against sodium hydroxide, NaOH.



FA 3 is 0.0400 mol dm⁻³ sodium hydroxide, NaOH.
methyl orange indicator

(a) Method

Dilution

- Transfer all the reaction mixture that you prepared in **1(a)** from the 250 cm³ beaker to the 250 cm³ volumetric flask.
- Rinse the beaker with a little distilled water and add these washings to the volumetric flask.
- Fill the volumetric flask to the line with distilled water. Stopper the flask and shake it to ensure thorough mixing.
- Label this solution **FA 4**.

Titration

- Fill the burette with **FA 4**.
- Use a pipette to transfer 25.0 cm³ of **FA 3** into a conical flask.
- Add a few drops of methyl orange.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is cm³.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain 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 **FA 4** added in each accurate titration.

I	
II	
III	
IV	

[4]

- (b) From your accurate titration results, obtain a suitable value for the volume of **FA 4** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm³ of **FA 3** required cm³ of **FA 4**. [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, present in 25.0 cm³ of **FA 3**.

moles of NaOH = ... mol

- (ii) Calculate the number of moles of hydrochloric acid, HCl, present in 250 cm³ of **FA 4**.

moles of HCl in 250 cm³ of **FA 4** = ... mol

- (iii) Use your answers to **1(b)(i)** and **1(b)(ii)** to calculate the number of moles of HCl that reacted with **FA 1** in the experiment you carried out in **Question 1**.

moles of HCl that reacted with **FA 1** = ... mol

- (iv) Use your answers to **2(c)(ii)** and **2(c)(iii)** to calculate the concentration of **FA 2**.

concentration of **FA 2** = ... mol dm⁻³
[5]

- (d) (i) One of the sources of error in determining the concentration of **FA 2** involves measuring volumes of solutions in both **Questions 1** and **2**.

State which volume of solution that you have measured has the greatest percentage error. How could you have reduced this error?

.....

.....

.....

- (ii) A student suggested that a greater mass of XCO_3 should be used so that the average titre calculated in **2(b)** would be a greater volume.

Explain whether you agree with the student that this would lead to a greater volume for the average titre.

.....

.....

.....

[2]

[Total: 12]

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.

FA 5 is a mixture of two different salts. Each of these salts contains one cation and one anion from those listed on pages 12 and 13. You will identify the cations and anions present.

(a) (i) Carry out the following test and record your observations.

<i>test</i>	<i>observations</i>
Place a small spatula measure of FA 5 in a hard-glass test-tube and heat strongly. Test any gases that are given off.	

(ii) Identify one of the cations in **FA 5**.

One of the cations in **FA 5** is

[2]

- (b) Place the remaining sample of **FA 5** in the 100 cm³ beaker. Half fill the beaker with distilled water and stir until **FA 5** has fully dissolved. This may take some time. You will use this solution in the remaining tests.
- (i) Select reagents to identify the other cation present in **FA 5**. Carry out tests using these reagents and record your results in the space below.
Identify the cation.

The other cation in **FA 5** is

- (ii) Carry out the following tests and record your observations.
Identify one of the anions in **FA 5**.

<i>test</i>	<i>observations</i>
To a 1 cm depth of the solution of FA 5 in a test-tube add aqueous barium chloride or aqueous barium nitrate, then	
add dilute hydrochloric acid.	

One of the anions in **FA 5** is

- (iii) The remaining ion is a halide.

Select a pair of reagents which can be used to identify the halide present. Carry out a test using these reagents and record your observations below. Suggest the identity of the halide anion present in **FA 5**. Explain why this test is not conclusive in this particular case.

The other anion in **FA 5** is

.....

.....

.....

.....

[8]

- (c) Suggest the formulae of the two salts that could have been mixed to make **FA 5**.

..... and

[1]

(d) **FA 6** and **FA 7** are different organic liquids. Their possible identities are listed below.

- 2-methylpropan-2-ol
- propanal
- propanone

Half fill the 250 cm³ beaker with water and heat to about 50 °C. You will use this as a hot water bath.

Turn off the Bunsen burner.

Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>
To a 1 cm depth of FA 6 in a test-tube, add a few drops of acidified potassium manganate(VII). If no reaction is seen, warm the solution in the hot water bath.	
To a 1 cm depth of FA 7 in a test-tube, add a few drops of acidified potassium manganate(VII). If no reaction is seen, warm the solution in the hot water bath.	

Suggest the identity of **FA 6** and **FA 7** with an explanation.

FA 6

FA 7

[2]

[Total: 13]

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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Li lithium 6.9	Be beryllium 9.0	Na sodium 23.0	Mg magnesium 24.3	K potassium 39.1	Ca calcium 40.1	Sc scandium 45.0	Ti titanium 47.9	V vanadium 50.9	Cr chromium 52.0	Mn manganese 54.9	Fe iron 55.8	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3	Rn radon —	Fr francium —	Ra radium —	Ac actinoids —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium 237.0	Pu plutonium 244.0	Am americium 243.0	Cm curium 247.0	Bk berkelium 247.0	Cf californium 251.0	Es einsteinium 252.0	Fm fermium 257.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8	Sr strontium 87.6	Rb rubidium 85.5	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3	Rn radon —	Fr francium —	Ra radium —	Ac actinoids —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium 237.0	Pu plutonium 244.0	Am americium 243.0	Cm curium 247.0	Bk berkelium 247.0	Cf californium 251.0	Es einsteinium 252.0	Fm fermium 257.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8	Sr strontium 87.6	Rb rubidium 85.5	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3	Rn radon —	Fr francium —	Ra radium —	Ac actinoids —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium 237.0	Pu plutonium 244.0	Am americium 243.0	Cm curium 247.0	Bk berkelium 247.0	Cf californium 251.0	Es einsteinium 252.0	Fm fermium 257.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8	Sr strontium 87.6	Rb rubidium 85.5	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3	Rn radon —	Fr francium —	Ra radium —	Ac actinoids —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium 237.0	Pu plutonium 244.0	Am americium 243.0	Cm curium 247.0	Bk berkelium 247.0	Cf californium 251.0	Es einsteinium 252.0	Fm fermium 257.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8	Sr strontium 87.6	Rb rubidium 85.5	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3	Rn radon —	Fr francium —	Ra radium —	Ac actinoids —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium 237.0	Pu plutonium 244.0	Am americium 243.0	Cm curium 247.0	Bk berkelium 247.0	Cf californium 251.0	Es einsteinium 252.0	Fm fermium 257.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8	Sr strontium 87.6	Rb rubidium 85.5	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3	Rn radon —	Fr francium —	Ra radium —	Ac actinoids —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium 237.0	Pu plutonium 244.0	Am americium 243.0	Cm curium 247.0	Bk berkelium 247.0	Cf californium 251.0	Es einsteinium 252.0	Fm fermium 257.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

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
72	Hf	hafnium	178.5
73	Ta	tantalum	180.9
74	W	tungsten	183.8
75	Re	rhenium	186.2
76	Os	osmium	190.2
77	Ir	iridium	192.2
78	Pt	platinum	195.1
79	Au	gold	197.0
80	Hg	mercury	200.6
81	Tl	thallium	204.4
82	Pb	lead	207.2
83	Bi	bismuth	209.0
84	Po	polonium	—
85	At	astatine	—
86	Rn	radon	—
87	Fr	francium	—
88	Ra	radium	—
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	—

lanthanoids

actinoids

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9701/32

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.



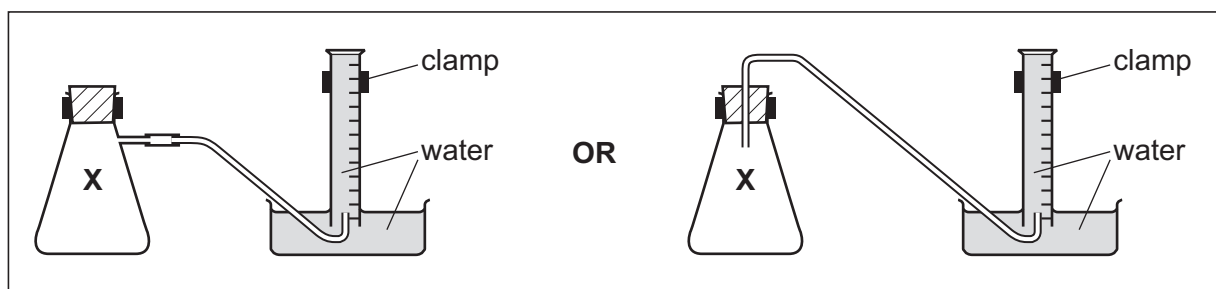
FB 1 is a strip of magnesium ribbon, Mg.

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.]

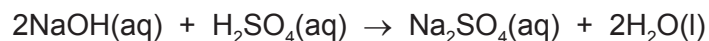
moles of gas = ... mol

- (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.	
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													13	14	15	16	17	18

CANDIDATE
NAMECENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

9701/33

Paper 3 Advanced Practical Skills 1

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.

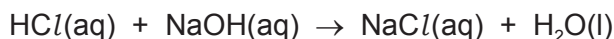
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

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

- 1 You will determine the concentration of a solution of hydrochloric acid by diluting it and then titrating the diluted solution against an alkali.



FA 1 was made by dissolving 1.06 g of sodium hydroxide, NaOH, in distilled water to make 250 cm³ of solution.

FA 2 is hydrochloric acid, HCl.
bromophenol blue indicator

(a) Method

- Pipette 25.0 cm³ of **FA 2** into the 250 cm³ volumetric flask. **Keep remaining FA 2 for use in Question 2.**
- Add distilled water to make 250 cm³ of solution and shake the flask thoroughly. Label this solution **FA 3**.
- Fill the burette with **FA 3**.
- Use the second pipette to transfer 25.0 cm³ of **FA 1** into a conical flask.
- Add about 10 drops of bromophenol blue.
- Perform a rough titration and record your burette readings in the space below. The end point is reached when the solution becomes a permanent yellow colour.

The rough titre is cm³.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain 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 **FA 3** 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 **FA 3** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm³ of **FA 1** required cm³ of **FA 3**. [1]

(c) Calculations

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

- (i) Calculate the concentration, in mol dm^{-3} , of sodium hydroxide in **FA 1**.
Use the data in the Periodic Table on page 12.

concentration of NaOH in **FA 1** = ... mol dm^{-3}

- (ii) Calculate the number of moles of sodium hydroxide present in 25.0 cm^3 of **FA 1**.

moles of NaOH = ... mol

- (iii) Deduce the number of moles of hydrochloric acid present in the volume of **FA 3** you have calculated in (b).

moles of HCl = ... mol

- (iv) Calculate the concentration, in mol dm^{-3} , of hydrochloric acid in **FA 2**.

concentration of HCl in **FA 2** = ... mol dm^{-3}
[5]

[Total: 13]

- 2 Metal carbonates react with dilute acids to produce carbon dioxide. You will identify the metal, **M**, in a metal carbonate, M_2CO_3 , by measuring the volume of carbon dioxide produced during the reaction of M_2CO_3 with excess hydrochloric acid.



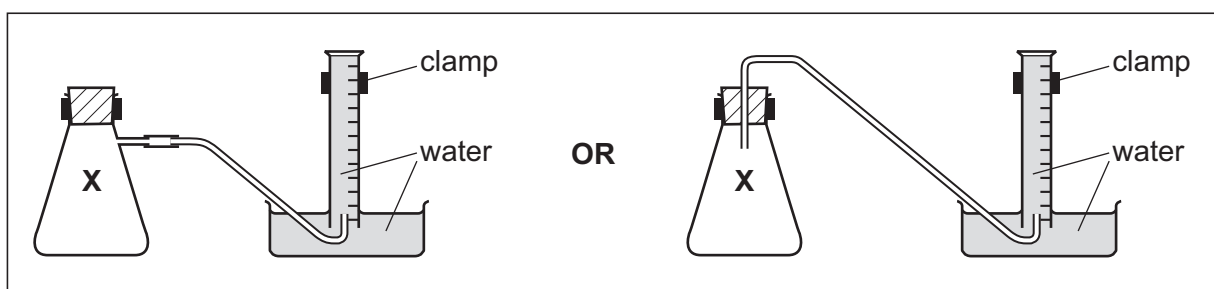
FA 2 is hydrochloric acid, HCl , as used in **Question 1**.

FA 4 is M_2CO_3 .

(a) Method

Read **all** instructions before starting your 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 cm³ 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.
- Use the 50 cm³ measuring cylinder to place 50 cm³ of **FA 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 cm³ measuring cylinder.
- Weigh the container with **FA 4** and record the mass in the space below.
- Remove the bung from the neck of the flask. Tip all the **FA 4** 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.
- Reweigh the container and record the mass, and the mass of **FA 4** used, in the space below.
- When no more gas is collected, measure and record the final volume of gas in the measuring cylinder in the space below.

(b) Calculations

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

- (i) Use the volume of gas you collected to calculate the number of moles of gas produced.
[Assume that 1 mole of gas occupies 24.0 dm^3 under these conditions.]

moles of gas = ... mol

- (ii) Use your answer to (i) to deduce the number of moles of M_2CO_3 used in the reaction.

moles of M_2CO_3 = ... mol

- (iii) Use your answer to (ii) and the mass of **FA 4** used to calculate the relative formula mass, M_r , of M_2CO_3 .

M_r of M_2CO_3 = ...

- (iv) Use your answer to (iii) and the Periodic Table on page 12 to identify metal **M**. Explain your answer.

M is

.....

.....

[4]

- (c) (i) A 250 cm^3 measuring cylinder can be read to $\pm 1\text{ cm}^3$.

Calculate the maximum percentage error in your reading of the volume of gas.

maximum percentage error = ... %

- (ii) It is likely that the volume of carbon dioxide that you collected was less than the theoretical volume.

Give **two** reasons why this volume is likely to be less than the theoretical volume.

In each case, suggest and explain a modification to the practical procedure that could help to reduce the difference in volume.

reason

.....

modification

.....

.....

reason

.....

modification

.....

.....

[5]

[Total: 11]

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) **FA 5, FA 6, FA 7** and **FA 8** are aqueous solutions of organic compounds. All of **FA 5, FA 6, FA 7** and **FA 8** contain carbon, hydrogen and oxygen only.

Half fill the 250 cm³ beaker with water and heat it to about 80 °C. Turn off the Bunsen burner. This will be used as a water bath.

To a 2 cm depth of aqueous silver nitrate in a boiling tube add 2 drops of aqueous sodium hydroxide and then add ammonia dropwise until the brown solid just disappears. This solution is Tollens' reagent and is needed in a test in (i).

- (i) Carry out the following tests on **FA 5**, **FA 6**, **FA 7** and **FA 8** and record your observations in the table.

test	observations			
	FA 5	FA 6	FA 7	FA 8
To a 1 cm depth in a test-tube, add a small spatula measure of sodium carbonate.				
To a few drops in a test-tube, add a 1 cm depth of Tollens' reagent. Place the tube in the water bath and leave to stand. When you have completed this test rinse all tubes used.				
To a 1 cm depth in a test-tube, add a few drops of acidified potassium manganate(VII). Place the tube in the water bath and leave to stand.				

- (ii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 6**?

.....

- (iii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 8**?

.....

- (iv) What **type** of reaction is occurring in the potassium manganate(VII) test?

.....

- (v) Using your observations from the table, what functional group is present in **FA 7**?

.....

- (vi) Suggest a test that would confirm the presence of the functional group in a pure sample of **FA 7**. Include the result you would expect the test to give.

Do not carry out this test.

.....

.....

.....

[9]

- (b) **FA 9** and **FA 10** are solids that each contain one anion from those listed in the Qualitative Analysis Notes on page 11.

- (i) Carry out the following tests on **FA 9** and **FA 10** and record your observations in the table.

<i>test</i>	<i>observations</i>	
	FA 9	FA 10
To a spatula measure of solid in a boiling tube, add a 1 cm depth of aqueous sodium hydroxide. Warm, then,		
add a small piece of aluminium foil.		
Place a spatula measure of solid in a hard-glass test-tube. Heat gently at first and then more strongly.		

- (ii) Using your observations from the table, which **two** anions could be present in **FA 9** and **FA 10**?

anion or

- (iii) Suggest a test that would allow you to decide which of the anions is present. State what observations you would expect.

.....

.....

- (iv) Carry out this test on **FA 9** and **FA 10** to decide which anion is present in each.

observation for **FA 9** anion in **FA 9** is

observation for **FA 10** anion in **FA 10** is

[7]

[Total: 16]

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													13	14	15	16	17	18

lanthanoids	57	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	lanthanum	cerium	praseodymium	neodymium	promethium	samarium	euroium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium	
	138.9	140.1	140.9	144.4	—	150.4	152.0	157.3	158.9	162.5	164.9	167.3	168.9	173.1	175.0	
actinoids	89	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
	actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendeleevium	nobelium	lawrencium	
	—	232.0	231.0	238.0	—	—	—	—	—	—	—	—	—	—	—	—

CANDIDATE
NAMECENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

9701/34

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	
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Total	

This document consists of **11** printed pages and **1** blank page.

- 1 Borax is an alkali which has many uses. In this experiment you will determine **x** in the chemical formula of borax, $\text{Na}_2\text{B}_x\text{O}_7 \cdot 10\text{H}_2\text{O}$, by titration with hydrochloric acid.

FB 1 is a solution containing 15.5 g dm^{-3} of borax, $\text{Na}_2\text{B}_x\text{O}_7 \cdot 10\text{H}_2\text{O}$.

FB 2 is 2.00 mol dm^{-3} hydrochloric acid, HCl .

methyl orange indicator

(a) Method

Dilution of FB 2

- Pipette **10.0 cm³** of **FB 2** into the 250 cm^3 volumetric flask.
- Make the solution up to 250 cm^3 using distilled water.
- Shake the solution in the volumetric flask thoroughly.
- This diluted solution of hydrochloric acid is **FB 3**. Label the volumetric flask **FB 3**.

Titration

- Fill the burette with **FB 3**.
- Pipette **25.0 cm³** of **FB 1** into a conical flask.
- Add several drops of methyl orange.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is 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 3** added in each accurate titration.

I	
II	
III	
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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 1** 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 hydrochloric acid present in the volume of **FB 3** calculated in (b).

moles of HCl = ... mol

- (ii) 1 mole of borax is neutralised by 2 moles of hydrochloric acid.
Calculate the number of moles of borax that react with the hydrochloric acid in (i).

moles of borax = ... mol

- (iii) Use your answer to (ii) to calculate the number of moles of borax in 1.00 dm³ of **FB 1**.

moles of borax in 1.00 dm³ **FB 1** = ... mol

- (iv) Use your answer to (iii) and the information on page 2 to calculate the relative formula mass, M_r , of borax.

M_r of borax = ...

- (v) Calculate x in the formula of borax, Na₂B _{x} O₇·10H₂O.
Use data from the Periodic Table on page 12.

x = ...
[5]

[Total: 13]

- 2 Some metal carbonates cannot be obtained in a pure state. For example magnesium carbonate exists in a 'basic' form, in which magnesium hydroxide is also present.

One possible chemical formula of basic magnesium carbonate is $\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 2\text{H}_2\text{O}$.

When basic magnesium carbonate is heated, if the possible formula were correct, it would decompose as shown below.



In this experiment, you will decompose basic magnesium carbonate by heating it, and you will use your results to determine whether this possible formula is correct.

FB 4 is basic magnesium carbonate.

(a) Method

Read through the method before starting any practical work and prepare a table for your results in the space below.

- Weigh a crucible with its lid and record the mass.
- Add 1.1-1.3 g of **FB 4** to the crucible. Weigh the crucible and lid with **FB 4** and record the mass.
- Place the crucible on the pipe-clay triangle and remove the lid.
- Heat the crucible and contents **gently** for about one minute.
- Then heat the crucible and contents strongly for about four minutes.
- Replace the lid and allow the crucible to cool for at least five minutes.
- **While the crucible is cooling, you may wish to begin work on Question 3.**
- Re-weigh the crucible and contents with lid. Record the mass.
- Calculate, and record, the mass of **FB 4** used and the mass of residue obtained.

I	
II	
III	
IV	
V	

[5]

(b) Calculations

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

- (i) Use your results to calculate the number of moles of magnesium oxide, MgO, obtained as residue.

moles of MgO obtained = ... mol

- (ii) Use your answer to (i), with the equation on page 4 and the mass of **FB 4** you used, to calculate the relative formula mass, M_r , of basic magnesium carbonate.

M_r of basic magnesium carbonate (from experiment) = ...

- (iii) Use data from the Periodic Table to calculate the relative formula mass, M_r , of basic magnesium carbonate from its possible formula, $\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 2\text{H}_2\text{O}$.

M_r of basic magnesium carbonate (from formula) = ...

- (iv) If the relative formula mass of basic magnesium carbonate obtained from your experiment is within 2.5% of the answer in (iii), this is good evidence that the possible formula, $\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 2\text{H}_2\text{O}$, is correct.
Does your experiment support the possible formula? Give a reason for your answer.

.....
.....

[5]

(c) Evaluation

- (i) State **one** way in which the accuracy of the experimental procedure could have been improved using the same mass of **FB 4**.
Explain your answer.

.....

.....

.....

.....

.....

- (ii) A student carried out the experiment twice using different masses of **FB 4**. He used the mean mass of **FB 4** and the mean mass of magnesium oxide obtained to calculate the relative formula mass of basic magnesium carbonate.

Instead of doing this, he could have calculated the relative formula mass of basic magnesium carbonate from his two experiments separately.

Suggest **one** advantage of carrying out separate calculations for each experiment.

.....

.....

.....

.....

- (iii) State the error when making **one** reading on your balance.

error = ... g

Calculate the maximum percentage error in the mass of **FB 4** used.

percentage error = ... %
[4]

[Total: 14]

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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) **FB 5, FB 6 and FB 7** are solutions, each of which contain one cation and one anion. The **anions** present are all listed on page 11.

Use a 1 cm depth of these solutions in a test-tube for each of the following tests.

Complete the table below.

<i>test</i>	<i>observations</i>		
	FB 5	FB 6	FB 7
Add a 2 cm strip of magnesium ribbon.			
Add aqueous sodium hydroxide.			
Add an equal depth of aqueous potassium iodide.			
Add a few drops of FB 5 .	X		

[5]

- (b) (i) From the observation made when potassium iodide was added to **FB 6**, suggest the identity of the cation in **FB 6**. Explain your conclusion.

cation in **FB 6**

explanation

.....

- (ii) **FB 5** gives no precipitate when aqueous ammonia is added.
Suggest the identities of **both** ions in **FB 5**.

cation in **FB 5**

anion in **FB 5**

- (iii) Identify **FB 7**.

.....

- (iv) Give the ionic equation for the reaction between magnesium and **FB 7**.

.....

[4]

- (c) **FB 8** is a solid. Carry out the following tests on **FB 8**.
Record your observations in each test.

- (i) Heat a small spatula measure of **FB 8** gently in a hard-glass test-tube.

observations

.....

.....

.....

- (ii) To a 1 cm depth of hydrochloric acid in a test-tube, add a small spatula measure of **FB 8**.

observations

.....

.....

.....

- (iii) What conclusions, if any, can you make about the identities of the ions in **FB 8**?

cation in **FB 8**

anion in **FB 8**

[4]

[Total: 13]

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													13	14	15	16	17	18
</																			

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9701/35

May/June 2016

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

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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 14 and 15.
A copy of the Periodic Table is printed on page 16.

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 **13** printed pages and **3** blank pages.

- 1 In this experiment you will determine the concentration of a solution of sulfuric acid by titration.

FA 1 is sulfuric acid, H_2SO_4 .

FA 2 is aqueous sodium hydroxide, containing 4.20 g NaOH dissolved in 1.00 dm^3 of water.
thymolphthalein indicator

(a) Method

Dilution of FA 1

- Pipette **10.0 cm^3** of **FA 1** into the 250 cm^3 volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the flask thoroughly.
- This diluted solution of sulfuric acid is **FA 3**. Label the flask **FA 3**.

Titration

- Fill the burette with **FA 2**.
- Pipette **25.0 cm^3** of **FA 3** into a conical flask.
- Add a few drops of thymolphthalein indicator.
- Perform a rough titration and record your burette readings in the space below. The end point is reached when the solution turns a permanent pale blue colour.

The rough titre is 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 **FA 2** added in each accurate titration.

Keep solution FA 1 for use in Questions 2 and 3.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

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

25.0 cm³ of **FA 3** required cm³ of **FA 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 the volume of **FA 2** calculated in (b).
Use the data in the Periodic Table on page 16.

moles of NaOH = ... mol

- (ii) Complete the equation for the reaction of sulfuric acid with sodium hydroxide. State symbols are required.

..... + ... → Na₂SO₄(aq) + ...

- (iii) Use your answers to (i) and (ii) to calculate the number of moles of sulfuric acid used in each titration.

moles of H₂SO₄ = ... mol

- (iv) Calculate the concentration, in mol dm⁻³, of sulfuric acid in **FA 3**.

concentration of H₂SO₄ in **FA 3** = ... mol dm⁻³

- (v) Calculate the concentration, in mol dm⁻³, of sulfuric acid in **FA 1**.

concentration of H₂SO₄ in **FA 1** = ... mol dm⁻³
[5]

[Total: 13]

- 2 In this experiment you will determine the enthalpy change, ΔH , for the decomposition of magnesium carbonate to magnesium oxide.



In order to do this, you will determine the enthalpy changes for the reactions of magnesium carbonate and magnesium oxide with sulfuric acid. Excess of the two magnesium compounds will be used in each experiment.

Then you will use Hess' Law to calculate the enthalpy change for the reaction above.

FA 1 is sulfuric acid, H_2SO_4 .

FA 4 is magnesium carbonate, MgCO_3 .

FA 5 is magnesium oxide, MgO .

- (a) Determination of the enthalpy change for the reaction of magnesium carbonate, **FA 4**, with sulfuric acid, **FA 1**

(i) **Method**

- Support the plastic cup inside the 250 cm³ beaker.
- Use a measuring cylinder to transfer 25 cm³ of **FA 1** into the plastic cup.
- Measure and record the initial temperature of the **FA 1** in the space below.
- Add all the **FA 4** from the container to the **FA 1** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature of the contents of the cup.
- Rinse out the plastic cup and shake to dry for use in (b).
- Calculate and record the temperature rise.

Calculations

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

- (ii) Calculate the energy produced during this reaction.
[Assume that 4.2 J are needed to raise the temperature of 1.0 cm³ of solution by 1.0 °C.]

energy produced = ... J

- (iii) Use your answer to **1(c)(v)** to calculate the number of moles of sulfuric acid in 25 cm³ of **FA 1**.

(If you were unable to calculate the concentration of sulfuric acid in **FA 1**, assume that it is 1.27 mol dm⁻³. This is not the true value.)

moles of H₂SO₄ = ... mol

- (iv) Calculate the enthalpy change, in kJ mol⁻¹, for the reaction below.



enthalpy change = ... kJ mol⁻¹
(sign) (value)

[6]

(b) Determination of the enthalpy change for the reaction of magnesium oxide, **FA 5**, with sulfuric acid, **FA 1**

(i) **Method**

- Use the measuring cylinder to transfer approximately 40 cm³ of **FA 1** into the 100 cm³ beaker.
- Place the beaker on a tripod and gauze.
- Heat **FA 1** in the beaker until the temperature is between 40 °C and 50 °C.
- Support the plastic cup in the 250 cm³ beaker.
- Use the measuring cylinder to transfer 25 cm³ of hot **FA 1** into the plastic cup. **CARE.**
- Measure and record, in the space below, the initial temperature of **FA 1** in the plastic cup.
- Immediately, add all the **FA 5** from the container to the **FA 1** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Calculate and record the temperature rise.

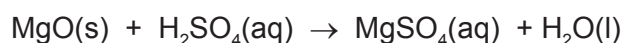
Calculations

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

- (ii) Calculate the energy produced during this reaction.
[Assume that 4.2 J are needed to raise the temperature of 1.0 cm³ of solution by 1.0 °C.]

energy produced = ... J

- (iii) Use your answer to (a)(iii) to calculate the enthalpy change, in kJ mol⁻¹, for the reaction below.



enthalpy change = ... kJ mol⁻¹
(sign) (value)

[4]

- (c) Use your values for the enthalpy changes calculated in (a)(iv) and (b)(iii) to calculate the enthalpy change for the reaction below.

Show clearly how you obtained your answer by drawing a Hess' Law energy cycle.

(If you were unable to calculate the enthalpy changes, assume that the value of the enthalpy change in **(a)(iv)** is $-58.7 \text{ kJ mol}^{-1}$ and the value in **(b)(iii)** is $-140.3 \text{ kJ mol}^{-1}$. Note: these are not the correct values.)



enthalpy change = ... kJ mol⁻¹
(sign) (value)

[2]

- (d) (i)** Calculate the maximum percentage error in the temperature **rise** in **(b)(i)**.

percentage error = ... %

- (ii) The magnesium oxide, **FA 5**, was weighed with a balance measuring to one decimal place. A student suggested that the accuracy of the experiment in **(b)(i)** would be improved by weighing **FA 5** using a balance measuring to two decimal places. State and explain whether or not the student is correct.

.....

.....

.....

[2]

[Total: 14]

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) **FA 6** is a salt containing one cation and one anion from those listed on pages 14 and 15. Transfer a **small** spatula measure of **FA 6** into a hard-glass test-tube. Heat gently at first, then heat strongly until no further change occurs.

Record **all** your observations below.

.....

.....

.....

.....

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.....

.....

- (ii) Dissolve the remainder of **FA 6** in an approximate depth of 5 cm of distilled water in a boiling tube for use in the following tests. Record your observations in the table below.

<i>test</i>	<i>observations</i>
To a 1 cm depth of the solution of FA 6 in a test-tube, add an equal volume of FA 1 , aqueous sulfuric acid.	
To a 1 cm depth of the solution of FA 6 in a test-tube, add aqueous ammonia.	
To a 1 cm depth of the solution of FA 6 in a boiling tube, add aqueous sodium hydroxide, then	
heat the mixture, gently and carefully, then	
place the boiling tube in a rack and add aluminium foil.	

- (iii) Give the chemical formula of **FA 6**.

.....

Give the ionic equation for the reaction of **FA 6** with cold sodium hydroxide. Include state symbols.

.....

[8]

- (b) (i) **FA 7** is a solution containing one cation and one anion from the list on pages 14 and 15.

Carry out the following tests and record your observations in the table below.

<i>test</i>	<i>observations</i>
To a 1 cm depth of FA 7 in a test-tube, add aqueous sodium hydroxide.	
To a 1 cm depth of FA 7 in a test-tube, add aqueous ammonia.	
To a 1 cm depth of FA 7 in a test-tube, add a few drops of acidified potassium manganate(VII), followed by a few drops of aqueous starch.	

- (ii) Identify **FA 7**.

FA 7 is

- (iii) Carry out **one** further test of your choice to confirm the identity of the **anion** in **FA 7**.

reagent(s) used

observation(s)

..... [5]

[Total: 13]

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	Key												13	14	15	16	17	18						
		atomic number atomic symbol name relative atomic mass												1 H hydrogen 1.0											
3	4																								
Li lithium 6.9	Be beryllium 9.0																								
11	12																								
Na sodium 23.0	Mg magnesium 24.3																								
19	20																								
K potassium 39.1	Ca calcium 40.1																								
37	38																								
Rb rubidium 85.5	Sr strontium 87.6																								
55	56																								
Cs caesium 132.9	Ba barium 137.3																								
87	88																								
Fr francium —	Ra radium —																								