

CANDIDATE  
NAME

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CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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**CHEMISTRY**

**9701/35**

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 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.

<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 **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,  $\text{H}_2\text{SO}_4$ .

**FA 2** is aqueous sodium hydroxide, containing 4.20 g NaOH dissolved in  $1.00 \text{ dm}^3$  of water.  
thymolphthalein indicator

**(a) Method**

**Dilution of FA 1**

- Pipette **10.0 cm<sup>3</sup>** of **FA 1** into the  $250 \text{ cm}^3$  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<sup>3</sup>** 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 .....  $\text{cm}^3$ .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **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 cm<sup>3</sup> of **FA 3** required ..... cm<sup>3</sup> 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.

..... + ..... → ..... Na<sub>2</sub>SO<sub>4</sub>(aq) + .....

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

moles of H<sub>2</sub>SO<sub>4</sub> = ..... mol

- (iv) Calculate the concentration, in mol dm<sup>-3</sup>, of sulfuric acid in **FA 3**.

concentration of H<sub>2</sub>SO<sub>4</sub> in **FA 3** = ..... mol dm<sup>-3</sup>

- (v) Calculate the concentration, in mol dm<sup>-3</sup>, of sulfuric acid in **FA 1**.

concentration of H<sub>2</sub>SO<sub>4</sub> in **FA 1** = ..... mol dm<sup>-3</sup>  
[5]

[Total: 13]

- 2 In this experiment you will determine the enthalpy change,  $\Delta H$ , 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,  $\text{H}_2\text{SO}_4$ .

**FA 4** is magnesium carbonate,  $\text{MgCO}_3$ .

**FA 5** is magnesium oxide,  $\text{MgO}$ .

- (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 cm<sup>3</sup> beaker.
- Use a measuring cylinder to transfer 25 cm<sup>3</sup> 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 cm<sup>3</sup> 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 cm<sup>3</sup> 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<sup>-3</sup>. This is not the true value.)

moles of H<sub>2</sub>SO<sub>4</sub> = ..... mol

- (iv) Calculate the enthalpy change, in kJ mol<sup>-1</sup>, for the reaction below.



enthalpy change = ..... kJ mol<sup>-1</sup>  
(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 cm<sup>3</sup> of **FA 1** into the **100 cm<sup>3</sup>** 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 cm<sup>3</sup>** beaker.
- Use the measuring cylinder to transfer 25 cm<sup>3</sup> 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.

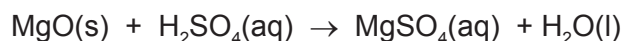
**Calculations**

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 cm<sup>3</sup> of solution by 1.0 °C.]

energy produced = ..... J

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



enthalpy change = ..... kJ mol<sup>-1</sup>  
(sign) (value)

[4]



### 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.

.....

.....

.....

.....

.....

.....

.....

.....



- (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 <b>FA 6</b> in a test-tube, add an equal volume of <b>FA 1</b> , aqueous sulfuric acid.	
To a 1 cm depth of the solution of <b>FA 6</b> in a test-tube, add aqueous ammonia.	
To a 1 cm depth of the solution of <b>FA 6</b> 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 <b>FA 7</b> in a test-tube, add aqueous sodium hydroxide.	
To a 1 cm depth of <b>FA 7</b> in a test-tube, add aqueous ammonia.	
To a 1 cm depth of <b>FA 7</b> 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 <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)	faint white ppt. is nearly always observed unless 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 giving dark green solution	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 <i>Al</i> foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and <i>Al</i> 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

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

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 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
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 —