

CANDIDATE  
NAME

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CENTRE  
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.

<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 **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  $15.5 \text{ g dm}^{-3}$  of borax,  $\text{Na}_2\text{B}_x\text{O}_7 \cdot 10\text{H}_2\text{O}$ .

**FB 2** is  $2.00 \text{ mol dm}^{-3}$  hydrochloric acid,  $\text{HCl}$ .  
methyl orange indicator

**(a) Method**

**Dilution of FB 2**

- Pipette **10.0 cm<sup>3</sup>** of **FB 2** into the  $250 \text{ cm}^3$  volumetric flask.
- Make the solution up to  $250 \text{ cm}^3$  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 cm<sup>3</sup>** 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 .....  $\text{cm}^3$ .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FB 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 **FB 3** to be used in your calculations.  
Show clearly how you obtained this value.

$25.0 \text{ cm}^3$  of **FB 1** required .....  $\text{cm}^3$  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 dm<sup>3</sup> of **FB 1**.

moles of borax in 1.00 dm<sup>3</sup> **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, Na<sub>2</sub>B<sub>x</sub>O<sub>7</sub>·10H<sub>2</sub>O.  
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>		
	<b>FB 5</b>	<b>FB 6</b>	<b>FB 7</b>
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 <b>FB 5</b> .	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 <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 $\text{Al}$ foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil; $\text{NO}$ liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown $\text{NO}_2$ in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

## 3 Tests for gases

<i>gas</i>	<i>test and test result</i>
ammonia, $\text{NH}_3$	turns damp red litmus paper blue
carbon dioxide, $\text{CO}_2$	gives a white ppt. with limewater (ppt. dissolves with excess $\text{CO}_2$ )
chlorine, $\text{Cl}_2$	bleaches damp litmus paper
hydrogen, $\text{H}_2$	"pops" with a lighted splint
oxygen, $\text{O}_2$	relights a glowing splint

## The Periodic Table of Elements

		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 style="border: 1px solid black; padding: 2px;">10 Ne neon 20.2</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 style="border: 1px solid black; padding: 2px;">18 Ar argon 39.9</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 style="border: 1px solid black; padding: 2px;">31 Ga gallium 69.7</div> <div style="border: 1px solid black; padding: 2px;">32 Ge germanium 72.6</div> <div style="border: 1px solid black; padding: 2px;">33 As arsenic 74.9</div> <div style="border: 1px solid black; padding: 2px;">34 Se selenium 79.0</div> <div style="border: 1px solid black; padding: 2px;">35 Br bromine 79.9</div> <div style="border: 1px solid black; padding: 2px;">36 Kr krypton 83.8</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 style="border: 1px solid black; padding: 2px;">49 In indium 114.8</div> <div style="border: 1px solid black; padding: 2px;">50 Sn tin 118.7</div> <div style="border: 1px solid black; padding: 2px;">51 Sb antimony 121.8</div> <div style="border: 1px solid black; padding: 2px;">52 Te tellurium 127.6</div> <div style="border: 1px solid black; padding: 2px;">53 I iodine 126.9</div> <div style="border: 1px solid black; padding: 2px;">54 Xe xenon 131.3</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 style="border: 1px solid black; padding: 2px;">81 Tl thallium 204.4</div> <div style="border: 1px solid black; padding: 2px;">82 Pb lead 207.2</div> <div style="border: 1px solid black; padding: 2px;">83 Bi bismuth 209.0</div> <div style="border: 1px solid black; padding: 2px;">84 Po polonium —</div> <div style="border: 1px solid black; padding: 2px;">85 At astatine —</div> <div style="border: 1px solid black; padding: 2px;">86 Rn radon —</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 style="border: 1px solid black; padding: 2px;">113 Nh nihonium —</div> <div style="border: 1px solid black; padding: 2px;">114 Fl flerovium —</div> <div style="border: 1px solid black; padding: 2px;">115 Mc moscovium —</div> <div style="border: 1px solid black; padding: 2px;">116 Lv livermorium —</div> <div style="border: 1px solid black; padding: 2px;">117 Ts tennessine —</div> <div style="border: 1px solid black; padding: 2px;">118 Og oganesson —</div> </div>															

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 —

lanthanoids

actinoids