Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

1069608282

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	
2	
3	
Total	

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

CAMBRIDGE International Examinations

[Turn over

1 Borax is an alkali which has many uses. In this experiment you will determine **x** in the chemical formula of borax, $Na_2B_xO_7.10H_2O$, by titration with hydrochloric acid.

FB 1 is a solution containing 15.5 g dm^{-3} of borax, $Na_2B_xO_7.10H_2O$.
FB 2 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.
methyl orange indicator

(a) Method

Dilution of FB 2

- Pipette **10.0 cm³** of **FB 2** into the 250 cm³ volumetric flask.
- Make the solution up to 250 cm³ 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 .... cm³.

- 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 cm³ of **FB 1** required .... cm³ 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 HC*l* = ... 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^3 of **FB 1**.

moles of borax in 1.00 dm^3 **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, $Na_2B_{\mathbf{x}}O_7.10H_2O$.
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 $MgCO_3.Mg(OH)_2.2H_2O$.

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

$$MgCO_3.Mg(OH)_2.2H_2O(s) \rightarrow 2MgO(s) + CO_2(g) + 3H_2O(g)$$

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, $MgCO_3.Mg(OH)_2.2H_2O$.

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, $MgCO_3.Mg(OH)_2.2H_2O$, 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.

test	*observations*		
	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**.			

[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

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$)
bromide, $Br^-(aq)$	gives cream ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$)
iodide, $I^-(aq)$	gives yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$)
nitrate, $NO_3^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil
nitrite, $NO_2^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, $SO_4^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids)
sulfite, $SO_3^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ (soluble in excess dilute strong acids)

3 Tests for gases

gas	*test and test result*
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

Key

atomic number
atomic symbol
name
relative atomic mass

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	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 –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

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