Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

0162956062

CHEMISTRY **9701/31**

Paper 3 Advanced Practical Skills 1 **May/June 2019**

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.

Cambridge Assessment International Education

Quantitative Analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

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

1 Metal carbonates react with acid to produce carbon dioxide. You will determine the identity of a Group 2 metal **M** in a carbonate of formula **M**CO_3 by reacting the carbonate with excess dilute hydrochloric acid and measuring the volume of carbon dioxide produced.

$$MCO_3(s) + 2HCl(aq) \rightarrow MCl_2(aq) + CO_2(g) + H_2O(l)$$

FA 1 is 50 cm^3 of 4.00 $mol\,dm^{-3}$ hydrochloric acid, HC*l*.
FA 2 is the metal carbonate, **M**CO_3.

(a) Method

- Fill the tub with water to a depth of approximately 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.
- Add all the **FA 1** into the flask labelled **X**.
- Check that the bung fits tightly into 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 container with **FA 2** and record the mass.
- Remove the bung from the neck of the flask. Tip the **FA 2**, from the container, into the acid in the flask and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents.
- Replace the flask in the clamp. Leave for several minutes, swirling the flask occasionally.

You may wish to start Question 2 while the gas is being evolved.

- When no more gas is collected, measure and record the final volume of gas in the measuring cylinder.
- Weigh the container, with any residual **FA 2**, and record the mass.
- Calculate and record the mass of **FA 2** added to flask **X**.

Results

[3]

(b) Calculations

(i) Calculate the number of moles of carbon dioxide collected in the measuring cylinder. [Assume that 1 mol of gas occupies 24.0 dm^3 under these conditions.]

moles of CO_2 = ... mol [1]

(ii) Use your answer to **(b)(i)** and the information on page 2 to calculate the relative atomic mass, A_r, of **M**.

A_r of **M** = ... [3]

(iii) Use your answer to **(b)(ii)** to identify **M**.

M is .... [1]

(c) (i) A student suggested that, using the same apparatus, the accuracy of the experiment would be increased if approximately 2 g of **M**CO_3 were used to react with the excess hydrochloric acid.

State and explain whether the student was correct.

....

....

.... [1]

(ii) Another student suggested that the experiment would be more accurate if the carbon dioxide was collected in a gas syringe rather than over water.

State and explain whether the student was correct.

....

....

.... [1]

[Total: 10]

2 In **Question 1** you measured the volume of carbon dioxide produced by a metal carbonate, **M**CO_3, in order to identify **M**. In **Question 2** you will identify another Group 2 metal, **Q**, by using a gravimetric method.

When Group 2 carbonates are heated they decompose.

$$\mathbf{Q}CO_3(s) \rightarrow \mathbf{Q}O(s) + CO_2(g)$$

FA 3 is the metal carbonate, **Q**CO_3.

(a) Method

- Weigh the crucible with its lid and record the mass.
- Add between 1.30 g and 1.50 g of **FA 3** into the crucible. Record the mass of crucible, lid and **FA 3**.
- Place the crucible on the pipe-clay triangle on the tripod. Put the lid on the crucible and heat gently for approximately 1 minute.
- Use tongs to remove the lid and heat the crucible strongly for approximately 5 minutes. Replace the lid and then leave to cool.
- While the crucible is cooling, begin work on **Question 3**.
- When cool, reweigh the crucible with its lid and contents. Record the mass.
- Calculate and record the mass of **FA 3** placed in the crucible.
- Calculate and record the mass of residue left after heating.

Keep the crucible and its contents for use in Question 3(b).

Results

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the number of moles of carbon dioxide produced during heating of **FA 3**.

moles CO_2 = ... mol [1]

(ii) Use the mass of **FA 3** in **(a)** and your answer to **(b)(i)** to calculate the relative atomic mass, A_r, of **Q** and hence identify **Q**. You should assume complete decomposition of **Q**CO_3.

A_r of **Q** is ....

Q is ....

[4]

(c) Explain why the lid was placed on the crucible when the residue was left to cool.

....

.... [1]

(d) In order to decompose Group 2 carbonates, the solid must be heated strongly. In this experiment **Q**CO_3 was heated for a few minutes.

(i) Suggest an improvement to the method used that would ensure that decomposition was complete.

....

.... [1]

(ii) Suggest a chemical test to determine whether the decomposition of **Q**CO_3 was complete. State the expected observation if the decomposition was incomplete.

Do not carry out this test.

....

.... [1]

(e) **(i)** In your calculation in **(b)** you used the mass of **Q**CO_3 and assumed that it was all decomposed during the heating.

Explain what effect incomplete decomposition would have on the calculated value of the A_r of **Q**.

....

....

.... [1]

(ii) A student suggested that you could use the mass of the residue, **Q**O, rather than the mass of **Q**CO_3 in a calculation to identify **Q**.

Explain why this method of calculating the A_r of **Q** is valid.

....

.... [1]

[Total: 14]

Qualitative Analysis

Where reagents are selected for use in a test, the **name** or **correct formula** of the element or compound must be given.

At each stage of any test you are to record details of the following:

- colour changes seen;
- the formation of any precipitate and its solubility in an excess of the reagent added;
- the formation of any gas and its identification by a suitable test.

You should indicate clearly at what stage in a test a change occurs.

If any solution is warmed, a **boiling tube** must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests for ions present should be attempted.

3 **(a)** **FA 4** and **FA 5** are aqueous solutions each containing one anion and one cation.

(i) Carry out the following tests and record your observations. For each test use a 1 cm depth of **FA 4** or **FA 5** in a test-tube.

test	*observations*	
	FA 4	**FA 5**
Add a 1 cm depth of dilute hydrochloric acid. Leave to stand.		
Add a 1 cm depth of aqueous copper(II) sulfate. Leave to stand.		
Add a few drops of aqueous silver nitrate, then		
add aqueous ammonia.		
Add a 1 cm depth of aqueous chlorine, then		
add a 1 cm depth of **FA 5**.		

[5]

(ii) From your observations in **(a)(i)** identify one of the ions present in either **FA 4** or **FA 5**.

Ion present in .... is .... [1]

(iii) Apart from the reaction with **FA 5** suggest a test that could be used to identify the coloured product formed in the reaction between aqueous chlorine and **FA 4**. You should include the reagent used and the expected observation.

Do not carry out this test.

reagent ....

expected observation ....
[1]

(b) (i) Place the cooled crucible and residue from **Question 2** onto a heatproof mat and add approximately 5 cm^3 of water.

Test the solution with litmus papers.
Record your observations.

....

.... [1]

(ii) Using **Q**O as the formula of the residue, write the equation for the reaction with water that occurs in **(b)(i)**. Include state symbols.

.... [1]

(c) In **Questions 1** and **2** you identified the Group 2 metals present in **M**CO_3 and **Q**CO_3.

You will now plan and carry out tests to confirm, or not confirm, the identities of **M** and **Q**. Both **M** and **Q** are listed in the Qualitative Analysis Notes.

(i) Group 2 carbonates are insoluble in water. In order to test for the cations present (**M**$^{2+}$ and **Q**$^{2+}$) they must be in solution.

Name a reagent you could use to prepare solutions of the cations from solid samples of **M**CO_3 and **Q**CO_3.

.... [1]

(ii) You are provided with the following solutions.
FA 6 contains **M**$^{2+}$(aq).
FA 7 contains **Q**$^{2+}$(aq).

Choose reagents that could be used to confirm the identity of **M** and **Q**.
Carry out the tests. Record the tests, observations and conclusions.

[5]

(iii) Do your conclusions confirm your identification of **M** and **Q** in **Questions 1** and **2**?
Explain your answer.

....

....

.... [1]

[Total: 16]

Qualitative Analysis Notes

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	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
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	3	4	5	6	7	8	9	10	11	12	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											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 –