Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

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CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **February/March 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.

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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 Several ores of copper contain both copper(II) carbonate and copper(II) hydroxide. This combination is called basic copper(II) carbonate. You will determine the composition of an ore of copper by reacting it with an **excess** of acid and collecting the gas evolved.

$$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$$

FA 1 is a sample of basic copper(II) carbonate.
FA 2 is dilute sulfuric acid, H_2SO_4.

The formula of basic copper(II) carbonate, **FA 1**, can be written as $\mathbf{x}CuCO_3\bullet\mathbf{y}Cu(OH)_2$.
You will use your results to determine the ratio **x** : **y** in the formula.

(a) Method

- 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.
- Use the 50 cm^3 measuring cylinder to transfer 50 cm^3 of **FA 2** into the conical flask.
- Fit the bung tightly in the neck of the flask, clamp the flask and place the end of the delivery tube into the inverted 250 cm^3 measuring cylinder.
- Weigh the container with **FA 1** and record the mass.
- Remove the bung from the neck of the flask. Tip **FA 1** into 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 produced.
- Replace the flask in the clamp.
- Reweigh the container with any residual solid and record the mass.
- Calculate and record the mass of **FA 1** added to the flask.
- Measure and record the final volume of gas in the 250 cm^3 measuring cylinder.

Results

[2]

(b) Calculations

(i) Give your answers to **(ii)**, **(iii)**, **(iv)** and **(v)** to the appropriate number of significant figures. [1]

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

moles of CO_2 = ... mol

Hence deduce the number of moles of copper(II) carbonate in **FA 1**.

moles of $CuCO_3$ = ... mol
[1]

(iii) Calculate the mass of copper(II) carbonate in **FA 1**.

mass of $CuCO_3$ = ... g [1]

(iv) Use your answer to **(iii)** and the mass of **FA 1** added to the flask in **(a)** to calculate the mass of copper(II) hydroxide in **FA 1**.

mass of $Cu(OH)_2$ = ... g [1]

(v) Hence calculate the mole ratio of the **two** components of basic copper(II) carbonate, **FA 1**. This is the ratio **x** : **y**.

$CuCO_3$: $Cu(OH)_2$ = 1 : ....
x : **y**
[2]

(c) How would the value of **y** calculated in **(b)** change if the experiment was carried out at a much lower temperature?

Tick (✓) the correct box. Explain your answer.

y would decrease	
y would increase	
y would not change	

explanation ....

....

....
[1]

(d) Not all the carbon dioxide produced in the reaction is collected in the 250 cm^3 measuring cylinder. One reason for this is that some carbon dioxide is lost before the bung can be replaced in the flask.

Give **one** other reason why it is **not** possible to collect all of the carbon dioxide produced in **(a)**. Suggest an improvement to the method to address this.

reason ....

improvement ....

....
[1]

[Total: 10]

2 It is possible that ores containing basic copper(II) carbonate also contain water of crystallisation. The formula of these ores would be written as $\mathbf{x}CuCO_3 \bullet \mathbf{y}Cu(OH)_2 \bullet \mathbf{z}H_2O$.

In this experiment you will heat a sample of a different basic copper(II) carbonate which will thermally decompose as shown.

$$\mathbf{x}CuCO_3 \bullet \mathbf{y}Cu(OH)_2 \bullet \mathbf{z}H_2O(s) \rightarrow (\mathbf{x}+\mathbf{y})CuO(s) + \mathbf{x}CO_2(g) + (\mathbf{y}+\mathbf{z})H_2O(g)$$

You will use your results to determine whether this sample of a different basic copper(II) carbonate contains water of crystallisation.

FA 3 is a sample of a different basic copper(II) carbonate.

(a) Method

- Weigh the empty crucible with its lid and record the mass.
- Add all the **FA 3** to the crucible.
- Reweigh the crucible, lid and **FA 3**. Record the mass.
- Support the crucible in the pipeclay triangle on top of the tripod.
- Remove the lid.
- Heat the crucible gently for about 1 minute and then strongly for about 4 minutes.
- Replace the lid and allow the crucible to cool.
- You may wish to start **Question 3** while the crucible is cooling.
- When the crucible has cooled, reweigh the crucible, lid and contents. Record the mass.
- Calculate and record the mass of **FA 3** used, the mass of residue and the loss of mass.

Results

I	
II	
III	
IV	
V	
VI	

[6]

(b) Calculations

(i) Assume the percentage by mass of copper(II) carbonate in **FA 3** is 60.0%.
Calculate the mass of copper(II) carbonate present in **FA 3**.

mass of $CuCO_3$ = ... g

Hence calculate the number of moles of copper(II) carbonate in **FA 3**.

moles of $CuCO_3$ = ... mol
[1]

(ii) Use your results from **(a)** to calculate the number of moles of copper(II) oxide formed on heating **FA 3**.

moles of CuO = ... mol [1]

(iii) Use your answers to **(i)** and **(ii)** and the equation on page 5 to calculate the number of moles of copper(II) hydroxide in **FA 3**.

moles of $Cu(OH)_2$ = ... mol [1]

(iv) Use your answer to **(i)** to calculate the mass of carbon dioxide produced by the **thermal decomposition** of the copper(II) carbonate in **FA 3**.

mass of CO_2 = ... g [1]

(v) Use your answer to **(iii)** to calculate the mass of water produced by the **thermal decomposition** of the copper(II) hydroxide in **FA 3**.

mass of H_2O = ... g [1]

(vi) Deduce whether water of crystallisation is present in basic copper(II) carbonate **FA 3**.

Justify your answer using your results from **(a)** and your answers to **(iv)** and **(v)**.

....
[1]

(c) (i) The lid was replaced before the crucible was cooled.

Explain how replacing the lid before the crucible was cooled may have increased the accuracy of your results.

....

.... [1]

(ii) Using the same apparatus, suggest an improvement to the method to increase the accuracy of your results.

....

.... [1]

(iii) A student carried out the method in **(a)** and obtained inaccurate results.
The student suggested that not all of the copper(II) carbonate in the sample of basic copper(II) carbonate **FA 3** had thermally decomposed.

Suggest a chemical test to determine whether the student was correct. Give the expected observations.

Do not carry out this test.

....

.... [1]

[Total: 15]

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 **FA 4** is a solid containing one cation and one anion.
FA 5 is a solution containing one cation and one anion.
Carry out the following tests and record your observations.

(a) **(i)** Warm (do **not** boil) a 5 cm depth of **FA 5** in a boiling tube. Stop warming the **FA 5**, add all of the **FA 4** and shake the boiling tube.

....

Filter the mixture into a second boiling tube. The filtrate will be used in the tests in **(ii)**.

....
[2]

(ii) Use a 1 cm depth of the filtrate from **(i)** in separate test-tubes for each of the following tests.

test	*observations*
Add aqueous ammonia.	
Add a 1 cm depth of aqueous potassium iodide, then	
add aqueous sodium thiosulfate. (Rinse the test-tube when you have completed this test.)	
Add a 1 cm depth of dilute nitric acid followed by a 1 cm depth of aqueous silver nitrate.	
Add a 1 cm depth of dilute hydrochloric or dilute nitric acid followed by a 1 cm depth of aqueous barium chloride or aqueous barium nitrate.	

[5]

(iii) **FA 6** is a dry sample of the residue obtained by filtration in **(i)**.

test	*observations*
Add a 1 cm depth of dilute nitric acid to all of the **FA 6** in its test-tube. Allow the mixture to stand for about 1 minute, then	
add aqueous sodium hydroxide.	

[2]

(b) **(i)** From your observations in **(a)**, suggest the identity of the cation and the anion present in the filtrate produced in **(a)(i)**.

cation present in the filtrate ....

anion present in the filtrate ....

[1]

(ii) Write an ionic equation for **one** reaction in **(a)(ii)** where a precipitate was formed. Include state symbols.

.... [1]

(iii) State the type of reaction that occurred in the first part of **(a)(iii)**.

.... [1]

(c) A student suggested that **FA 5** is an acid.

Apart from using an indicator, suggest and carry out a chemical test to determine whether the student was correct.

Record the name of the reagent you used, your observations and your conclusion.

[3]

[Total: 15]

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											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 –