Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER							CANDIDATE NUMBER					

6297166006

CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2022**

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION
- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document has **12** pages.

IB22 06_9701_35/5RP

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 the precision of the apparatus you used in the data you record.

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

1 Basic copper(II) carbonate contains both copper(II) carbonate, $CuCO_3$, and copper(II) hydroxide, $Cu(OH)_2$. The ratio of these two components can be different in samples from different sources. This means that the formula of basic copper(II) carbonate can be written as $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$.

Both the carbonate and the hydroxide react with acids.

$$CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + CO_2(g) + H_2O(l)$$

$$Cu(OH)_2(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + 2H_2O(l)$$

You will determine the value of **x** in a sample of basic copper(II) carbonate by reacting it with excess acid and measuring the mass of carbon dioxide given off.

FA 1 is basic copper(II) carbonate, $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$.
FA 2 is 2.0 mol dm^{-3} hydrochloric acid, HCl.

(a) Method

- Use the 25 cm^3 measuring cylinder to transfer 25.0 cm^3 of **FA 2** into a conical flask.
- Weigh the flask with the acid. Record the mass.
- Weigh the container with **FA 1**. Record the mass.
- Carefully tip all of **FA 1** into the acid in the conical flask. Swirl the contents of the flask and leave the flask to stand.
- Weigh the container with any residual **FA 1**. Record the mass.
- Calculate and record the mass of **FA 1** added to the flask.
- Calculate and record the theoretical initial mass of flask + acid + **FA 1**.
- Swirl the flask occasionally. Weigh the flask and contents after approximately 5 minutes. Record the mass.

During this step you may wish to continue with Question 2 or Question 3.

- Calculate and record the mass of carbon dioxide given off during the experiment.

Results

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the amount, in mol, of carbon dioxide given off in the reaction.

amount of CO_2 = ... mol [1]

(ii) Calculate the amount, in mol, of copper(II) carbonate in the sample of **FA 1** that you added to the flask.

amount of $CuCO_3$ = ... mol

Hence calculate the mass of copper(II) carbonate in the sample of **FA 1** that you added to the flask.

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

(iii) Calculate the mass of copper(II) hydroxide in the sample of **FA 1** that you added to the flask.

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

(iv) Calculate the amount, in mol, of copper(II) hydroxide in the sample of **FA 1** that you added to the flask.

amount of $Cu(OH)_2$ = ... mol

Hence calculate the value of **x** in the formula of basic copper(II) carbonate, $CuCO_3 \bullet \mathbf{x}Cu(OH)_2$.

x = ...
[1]

(c) In this determination you assume that hydrochloric acid is in excess.

Show, by calculation, that this assumption is correct.

[2]

[Total: 10]

2 In **Question 1** you found the value of **x** in the formula of basic copper(II) carbonate, $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$. You will now use another method to find the value of **x**.

Copper(II) ions oxidise iodide ions to produce iodine.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow I_2(aq) + 2CuI(s)$$

The amount of iodine produced can be found by titration with aqueous thiosulfate ions, $S_2O_3^{2-}$.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^{-}(aq)$$

FA 3 contains Cu^{2+}(aq). It was made by reacting 10.40 g of $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$ with excess dilute sulfuric acid and making the solution up to 1.00 dm^3 with distilled water.
FA 4 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 5 is aqueous potassium iodide, KI.
FA 6 is starch indicator.

(a) Method

- Fill the burette with **FA 4**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Rinse the 25 cm^3 measuring cylinder with approximately 5 cm^3 of **FA 5**. Discard the solution used for rinsing.
- Use the 25 cm^3 measuring cylinder to add 15 cm^3 of **FA 5**, an excess of KI, to the conical flask. The solution will turn brown because iodine is formed.
- Add **FA 4** from the burette until the mixture changes to pale brown.
- Add approximately 10 drops of **FA 6**. The mixture will turn blue-black.
- Continue adding **FA 4** from the burette until the blue-black colour disappears to leave an off-white solid. This is the end-point of the titration.
- Carry out a rough titration and record your burette readings in the space below.

The rough titre is .... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record in a suitable form below, all your burette readings and the volume of **FA 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, calculate a suitable mean value to be used in your calculations. Show clearly how you have obtained the mean value.

25.0 cm^3 of **FA 3** required .... cm^3 of **FA 4**. [1]

(c) Calculations

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

(ii) Calculate the amount, in mol, of thiosulfate ions present in the volume of **FA 4** you have calculated in **(b)**.

amount of $S_2O_3^{2-}$ = ... mol [1]

(iii) Use your answer to **(c)(ii)**, and the equations for the reactions involved, to calculate the amount, in mol, of copper(II) ions present in 25.0 cm^3 of **FA 3**.

amount of Cu^{2+} in 25.0 cm^3 = ... mol

Hence deduce the amount, in mol, of copper(II) ions present in 1.00 dm^3 of **FA 3**.

amount of Cu^{2+} in 1.00 dm^3 = ... mol [1]

(iv) Use your answer to **(c)(iii)** to calculate the mass of copper(II) ions in 1.00 dm^3 of **FA 3**.

mass of Cu^{2+} in 1.00 dm^3 = ... g [1]

(v) The formula of basic copper(II) carbonate is $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$.

Write an expression, including **x**, for the mass of Cu^{2+} ions in one mole of $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$.

mass of Cu^{2+} ions in one mole of $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$ = ... g [1]

(vi) The formula of basic copper(II) carbonate is $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$.

Write an expression, including **x**, for the mass of one mole of $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$.

mass of one mole of $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$ = ... g [1]

(vii) The expression below links the masses of copper(II) ions in **FA 3** and in one mole.

$$\frac{\text{mass of } Cu^{2+} \text{ present in sample of } \mathbf{FA\ 3}}{\text{mass of } CuCO_3 \cdot \mathbf{x}Cu(OH)_2 \text{ used}} = \frac{\text{mass of } Cu^{2+} \text{ in one mole of } CuCO_3 \cdot \mathbf{x}Cu(OH)_2}{\text{mass of one mole of } CuCO_3 \cdot \mathbf{x}Cu(OH)_2}$$

Using this expression, show how you could determine the value of **x** in the formula of basic copper(II) carbonate, $CuCO_3 \cdot \mathbf{x}Cu(OH)_2$.

[3]

[Total: 17]

Qualitative analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:

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

You should record clearly at what stage in a test an observation is made.

Where no change is observed you should write 'no change'.

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

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

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

No additional tests should be attempted.

3 **(a)** **FA 7** is a sample of basic copper(II) carbonate.

Place a small spatula measure of **FA 7** into a hard-glass test-tube and heat the tube, gently at first and then more strongly.
Record **all** your observations.

....

....

....

.... [2]

(b) **FA 8** is an aqueous solution containing Cu^{2+} ions.

(i) Carry out the following tests using a 1 cm depth of **FA 8** in a test-tube for each test. Record your observations.

Table 3.1

test	*observations*
Test 1 Add a 1 cm depth of aqueous EDTA.	
Test 2 Add concentrated hydrochloric acid (**CARE, corrosive**) dropwise until no further change is seen.	
Test 3 Add a small spatula measure of metal **M**. Leave the test-tube to stand.	

[2]

(ii) Suggest a possible ionic equation for the reaction between **M** and **FA 8** in **Test 3**. Include state symbols.

.... [1]

(c) Carry out tests to identify **M**. Use only a small spatula measure of **M**. Do **not** use concentrated hydrochloric acid in your tests.

(i) Record the tests you carry out and the observations you make, in a table, in the space below.

[3]

(ii) From your observations in **(c)(i)**, identify **M**.

M is .... [1]

(d) **FA 9** and **FA 10** are sodium compounds that contain either a halide or a carbonate.

Carry out tests to confirm the identity of **FA 9** and **FA 10**.

Record the tests you carry out, the observations you make and your conclusions in a table in the space below.

[4]

[Total: 13]

Qualitative analysis notes

1 Reactions of cations

cation	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 warming	–
barium, Ba^{2+}(aq)	faint white ppt. is observed unless $[Ba^{2+}(aq)]$ is very low	no ppt.
calcium, Ca^{2+}(aq)	white ppt. unless $[Ca^{2+}(aq)]$ is very low	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	pale 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

anion	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 / off-white ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives pale 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; decolourises acidified aqueous $KMnO_4$
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids); gives white ppt. with high $[Ca^{2+}(aq)]$
sulfite, SO_3^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids); decolourises acidified aqueous $KMnO_4$
thiosulfate, $S_2O_3^{2-}$(aq)	gives off-white / pale yellow ppt. slowly with H^+

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
hydrogen, H_2	‘pops’ with a lighted splint
oxygen, O_2	relights a glowing splint

4 Tests for elements

element	test and test result
iodine, I_2	gives blue-black colour on addition of starch solution

Important values, constants and standards

molar gas constant	$R = 8.31\,J\,K^{-1}\,mol^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,C\,mol^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23}\,mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,C$
molar volume of gas	$V_m = 22.4\,dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,dm^3\,mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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 –