



Cambridge International AS & A Level

CANDIDATE
NAME

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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.



Quantitative analysis

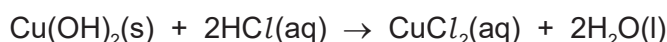
Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

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 $\text{CuCO}_3 \cdot x\text{Cu(OH)}_2$.

Both the carbonate and the hydroxide react with acids.



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, $\text{CuCO}_3 \cdot x\text{Cu(OH)}_2$.

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, $\text{CuCO}_3 \cdot x\text{Cu(OH)}_2$.

x =
[1]

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

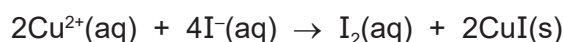
Show, by calculation, that this assumption is correct.

[2]

[Total: 10]

- 2 In **Question 1** you found the value of **x** in the formula of basic copper(II) carbonate, $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2$. You will now use another method to find the value of **x**.

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



The amount of iodine produced can be found by titration with aqueous thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$.



FA 3 contains $\text{Cu}^{2+}(\text{aq})$. It was made by reacting 10.40 g of $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2$ with excess dilute sulfuric acid and making the solution up to 1.00 dm^3 with distilled water.

FA 4 is $0.100 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

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 cm³ of **FA 3** required cm³ 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 S₂O₃²⁻ = 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 cm³ of **FA 3**.

amount of Cu²⁺ in 25.0 cm³ = mol

Hence deduce the amount, in mol, of copper(II) ions present in 1.00 dm³ of **FA 3**.

amount of Cu²⁺ in 1.00 dm³ = mol [1]

- (iv) Use your answer to (c)(iii) to calculate the mass of copper(II) ions in 1.00 dm³ of **FA 3**.

mass of Cu²⁺ in 1.00 dm³ = g [1]

- (v) The formula of basic copper(II) carbonate is $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2$.

Write an expression, including x , for the mass of Cu^{2+} ions in one mole of $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2$.

mass of Cu^{2+} ions in one mole of $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2 = \dots\dots\dots$ g [1]

- (vi) The formula of basic copper(II) carbonate is $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2$.

Write an expression, including x , for the mass of one mole of $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2$.

mass of one mole of $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2 = \dots\dots\dots$ g [1]

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

$$\frac{\text{mass of Cu}^{2+} \text{ present in sample of FA 3}}{\text{mass of CuCO}_3 \cdot x\text{Cu}(\text{OH})_2 \text{ used}} = \frac{\text{mass of Cu}^{2+} \text{ in one mole of CuCO}_3 \cdot x\text{Cu}(\text{OH})_2}{\text{mass of one mole of CuCO}_3 \cdot x\text{Cu}(\text{OH})_2}$$

Using this expression, show how you could determine the value of x in the formula of basic copper(II) carbonate, $\text{CuCO}_3 \cdot x\text{Cu}(\text{OH})_2$.

[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

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

Group																																				
1	2		Group																																	
3	Li lithium 6.9	4 Be beryllium 9.0	Key																																	
			atomic number atomic symbol name relative atomic mass																																	
11	Na sodium 23.0	12	Mg magnesium 24.3	3	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	10	11	12	13	14	15	16	17	18			
19	K potassium 39.1	20	Ca calcium 40.1	39	38	Sr strontium 87.6	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 oganeson	

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	euroium	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
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	209.0
85	At	astatine	210.0
86	Rn	radon	222.0
87	Fr	francium	223.0
88	Ra	radium	226.0
89	Ac	actinium	227.0
90	Th	thorium	232.0
91	Pa	protactinium	231.0
92	U	uranium	238.0
93	Np	neptunium	237.0
94	Pu	plutonium	244.1
95	Am	americium	243.1
96	Cm	curium	247.1
97	Bk	berkelium	247.1
98	Cf	californium	251.1
99	Es	einsteinium	252.1
100	Fm	fermium	257.1
101	Md	mendelevium	258.1
102	No	nobelium	259.1
103	Lr	lawrencium	262.1

lanthanoids

actinoids