



Cambridge International AS & A Level

CANDIDATE
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CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

October/November 2021

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, use appropriate units and use an appropriate number of significant figures.
- Give details of the practical session and laboratory, where appropriate, in the boxes provided.

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.
- 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. Any blank pages are indicated.

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 You will investigate a compound of a Group 1 element to determine which element is present. Group 1 carbonates decompose to give carbon dioxide when heated to high temperatures.



FA 1 is the carbonate of the element, X_2CO_3 .

(a) Method

- Weigh a crucible with its lid and record the mass.
- Add 1.40–1.60 g of **FA 1** to the crucible.
- Weigh the crucible and its lid with **FA 1** and record the mass.
- Place the crucible on the pipe-clay triangle. Heat the crucible, with its lid on, gently for approximately 1 minute. Then heat strongly for another minute.
- Carefully remove the lid. Heat the crucible strongly for 4 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes.

While the crucible is cooling you may wish to begin work on Question 2.

- Reweigh the crucible and contents with its lid. Record the mass.
- Remove the lid. Heat the crucible and contents strongly for a further 2 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes. Reweigh the crucible and residue with its lid. Record the mass.
- Calculate and record the mass of **FA 1** added to the crucible. Calculate the mass of residue obtained.

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculations

- (i) Calculate the mass of carbon dioxide produced when the sample of X_2CO_3 was heated.

mass of CO_2 produced = g [1]

- (ii) Calculate the number of moles of X_2CO_3 needed to produce the mass of carbon dioxide calculated in (b)(i).

moles of X_2CO_3 needed = mol [1]

- (iii) Use your answer to (b)(ii) and the information on page 2 to calculate the relative formula mass, M_r , of X_2CO_3 .

M_r of X_2CO_3 = [1]

- (iv) Use your answer to (b)(iii) to calculate the relative atomic mass, A_r , of **X**. Hence identify **X**. Explain how you reached your conclusion.

X is

.....
 [2]

- (c) In this experiment you heated the sample of X_2CO_3 for approximately 8 minutes.

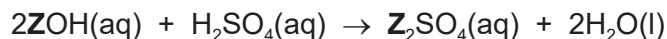
Explain, using evidence from your results in (a), whether your sample of X_2CO_3 had decomposed completely.

.....
 [1]

[Total: 11]

- 2 In this experiment you will titrate a solution of the hydroxide of a Group 1 element, **Z**, with sulfuric acid. The equation for the reaction is shown.

Z may or may not be the same as **X**.



FA 2 is 26.3 g dm^{-3} aqueous hydroxide of metal **Z**, **ZOH**.

FA 3 is $0.0500 \text{ mol dm}^{-3}$ sulfuric acid, H_2SO_4 .
bromophenol blue indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 2** into the 250 cm^3 volumetric flask.
- Add distilled water to the flask to make 250 cm^3 of solution. Shake the flask thoroughly to ensure complete mixing. Label this solution **FA 4**.
- Rinse the pipette with a little distilled water and then a little **FA 4**.
- Fill the burette with **FA 3**.
- Pipette 25.0 cm^3 of **FA 4** into a conical flask.
- Add a few drops of bromophenol blue indicator.
- 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 sure your recorded results show the accuracy of your practical work.
- Record in a suitable form in the space below all of your burette readings and the volume of **FA 3** 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 use in your calculations. Show clearly how you obtained this value.

25.0 cm^3 of **FA 4** required cm^3 of **FA 3**. [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 number of moles of sulfuric acid present in the volume of **FA 3** you calculated in **(b)**.

moles of H_2SO_4 = mol [1]

- (iii) Use your answer to **(c)(ii)** and the information on page 4 to calculate the concentration, in mol dm^{-3} , of **ZOH** present in **FA 4**.

concentration of **FA 4** = mol dm^{-3} [1]

- (iv) Calculate the concentration, in mol dm^{-3} , of **ZOH** in **FA 2**.

concentration of **FA 2** = mol dm^{-3} [1]

- (v) Use your answer to **(c)(iv)** and the information on page 4 to calculate the relative atomic mass, A_r , of **Z**. Hence identify **Z**.
Show your working.

Z is [2]

- (d) Using the value for the relative atomic mass of **Z** that you calculated in **(c)(v)**, calculate the percentage difference of your value from that shown in the Periodic Table.

(If you did not obtain a value for the A_r of **Z**, assume it is 32.0. Note, this is **not** the correct value.)

percentage difference = % [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** Half-fill the 250 cm³ beaker with water and place it on a tripod and gauze above a heatproof mat. Heat the water until boiling and then turn off the Bunsen burner. You will use this as a hot water-bath in **3(b)(i)**.

- (a) FA 5, FA 6 and FA 7** are solutions. Each solution contains one cation and one anion. Carbonate, CO₃²⁻, is **not** present in any of the solutions.

- (i)** Carry out the following tests and record your observations.
Use a 1 cm depth of solution in a test-tube for each test.

test	observations		
	FA 5	FA 6	FA 7
Test 1 Add an equal depth of dilute sulfuric acid.			
Test 2 Add an equal depth of aqueous sodium carbonate.			
Test 3 Add an equal depth of aqueous magnesium chloride.			

[5]

- (ii) Use your observations in (a)(i) to suggest a **possible** formula for each of the following:

The cation in **FA 5** is

The cation in **FA 6** is

The anion in **FA 7** is

[3]

- (iii) Apart from using an indicator, suggest a further test that would confirm the identity of the anion in **FA 7**.

Carry out this test and record the result.

.....

.....

..... [1]

- (iv) Did the result of your test in (a)(iii) confirm the identity of the anion in **FA 7**?
Explain your answer.

.....

.....

..... [1]

(b) **FA 8** is an aqueous solution.

(i) Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>
Test 1 To a 1 cm depth of FA 8 in a test-tube, add a few drops of acidified potassium manganate(VII). Place the tube in the hot water-bath.	
Test 2 To a 1 cm depth of FA 8 in a test-tube, add a 1 cm length of magnesium ribbon.	

[2]

(ii) For each observation, state what you can conclude about the chemical properties of **FA 8**.

Test 1

Test 2

[2]

[Total: 14]

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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	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

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

3 Tests for gases

<i>gas</i>	<i>test and test result</i>
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

