



Cambridge International AS & A Level

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CHEMISTRY

9701/33

Paper 3 Advanced Practical Skills 1

February/March 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.

Session	
Laboratory	

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.

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 In this experiment you will carry out a titration to identify the Group 1 metal, **M**, present in a metal hydrogencarbonate, **MHCO₃**.

FA 1 is 0.0550 mol dm⁻³ sulfuric acid, H₂SO₄.

FA 2 is the metal hydrogencarbonate, **MHCO₃**.
bromophenol blue indicator

(a) Method

Preparing a solution of FA 2

- Weigh the stoppered container of **FA 2**. Record the mass in the space below.
- Tip all the **FA 2** into the beaker.
- Reweigh the container with its stopper. Record the mass.
- Calculate and record the mass of **FA 2** used.
- Add approximately 100 cm³ of distilled water to **FA 2** in the beaker.
- Stir the mixture with a glass rod until all the **FA 2** has dissolved.
- Transfer this solution into the 250 cm³ volumetric flask.
- Wash the beaker with distilled water and transfer the washings to the volumetric flask.
- Rinse the glass rod with distilled water and transfer the washings to the volumetric flask.
- Make up the solution in the volumetric flask to the mark using distilled water.
- Shake the flask thoroughly.
- This solution of **MHCO₃** is **FA 3**. Label the flask **FA 3**.

Titration

- Fill the burette with **FA 1**.
- Pipette 25.0 cm³ of **FA 3** into a conical flask.
- Add a few drops of bromophenol blue indicator to the conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is cm³.

3

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FA 1** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

- (b)** From your accurate titration results, obtain a suitable value for the volume of **FA 1** to be used in your calculations.
Show clearly how you obtained this value.

25.0 cm³ of **FA 3** required cm³ of **FA 1**. [1]

(c) Calculations

- (i)** Give your answers to **(c)(ii)**, **(c)(iii)**, **(c)(iv)** and **(c)(v)** to the appropriate number of significant figures. [1]
- (ii)** Calculate the number of moles of sulfuric acid present in the volume of **FA 1** calculated in **(b)**.

moles of H₂SO₄ = mol [1]

- (iii)** Complete the equation for the reaction of sulfuric acid and **MHCO₃**.
State symbols are not required.



Use your answer to **(c)(ii)** to deduce the number of moles of **MHCO₃** used in each titration.

moles of **MHCO₃** = mol [1]

4

- (iv) Use your answer to (c)(iii) and your data on page 2 to calculate the relative formula mass, M_r , of MHCO_3 .

M_r of $\text{MHCO}_3 = \dots\dots\dots$ [1]

- (v) Calculate the relative atomic mass, A_r , of **M**.

A_r of **M** =

Suggest the identity of **M**.

M is
[1]

- (d) (i) A student used a pipette that was labelled $25.0 \pm 0.06 \text{ cm}^3$ to measure **FA 3**.

Show how you calculate the maximum percentage error in the volume of **FA 3**.

[1]

- (ii) The student suggested that it would have been more accurate to measure the volume of **FA 3** with a burette instead of the pipette.

State and explain whether you agree with the student.

.....
..... [1]

[Total: 16]

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- 2 In this experiment you will determine the relative formula mass of the same metal hydrogencarbonate, MHCO_3 , by thermal decomposition. Then you will compare the result obtained with your answer from 1(c)(iv).

FA 4 is another sample of the metal hydrogencarbonate, MHCO_3 .

(a) Method

- Weigh the empty crucible with its lid. Record the mass.
- Transfer all the **FA 4** from the container into the crucible.
- Weigh the crucible, lid and **FA 4**. Record the mass.
- Calculate and record the mass of **FA 4** used.
- Place the crucible and contents on a pipe-clay triangle.
- Heat the crucible gently, with the lid on, for approximately one minute.
- Heat strongly, with the lid off, for a further four minutes.
- Replace the lid and leave the crucible to cool for at least five minutes.

During each cooling period, you may wish to work on Question 3.

- When the crucible has cooled, weigh the crucible with its lid and contents. Record the mass.
- Heat strongly, with the lid off, for a further two minutes.
- Replace the lid and leave the crucible to cool for at least five minutes.
- When the crucible has cooled, reweigh the crucible with its lid and contents. Record the mass.
- Calculate and record the mass of residue obtained.
- This residue is **FA 5**.

Keep FA 5 for use in 2(b)(i).

Results

I	
II	
III	
IV	
V	

[5]

- (b) (i)** Pour a 1 cm depth of dilute hydrochloric acid into a test-tube. Add a spatula measure of residue **FA 5** to the acid.

Record **all** your observations and identify any gas formed.

.....

 [2]

- (ii) Use your observations in **(b)(i)** to identify the anion in **FA 5**. Assume all the MHCO_3 has decomposed.

Anion in **FA 5** is [1]

- (iii) Steam is produced when the metal hydrogencarbonate, **FA 4**, is thermally decomposed.

Use your answer in **(b)(ii)** to complete the equation for the thermal decomposition of MHCO_3 . Include state symbols.



- (iv) The number of moles of carbon dioxide given off during the thermal decomposition is given by the formula below.

$$\text{moles of CO}_2 = \frac{\text{mass lost during heating}}{(M_r \text{ of CO}_2 + M_r \text{ of H}_2\text{O})}$$

Calculate the number of moles of carbon dioxide given off.

moles $\text{CO}_2 = \text{..... mol}$ [1]

- (v) Calculate the relative formula mass, M_r , of MHCO_3 .

Show how you obtained your answer using your data from **Question 2**.

M_r of $\text{MHCO}_3 = \text{.....}$ [1]

- (vi) You have obtained two values for the M_r of MHCO_3 ; one in **1(c)(iv)** and another in **2(b)(v)**.

State which value is likely to be more accurate. Explain your answer in terms of the practical procedures used.

The M_r obtained in Question is more accurate.

reason

.....

..... [1]

[Total: 12]

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 6 contains one cation and one anion both of which are listed in the Qualitative analysis notes.

- (i)** Heat **FA 6** gently for one minute in the hard-glass test-tube in which it is supplied. Then heat strongly until no further change occurs.

Record **all** of your observations.

.....

.....

.....

.....

.....

..... [2]

- (ii)** Identify the ion that **must** be present in **FA 6**.

..... [1]

- (b) (i)** **FA 7** and **FA 8** are aqueous solutions. Each solution contains one cation and one anion both of which are listed in the Qualitative analysis notes. Use 1 cm depths of **FA 7** or **FA 8** in test-tubes for the following tests. Complete the table by recording your observations.

<i>test</i>	<i>observations</i>	
	FA 7	FA 8
Test 1 Add a few drops of aqueous acidified potassium manganate(VII), then ----- add a few drops of starch indicator.		
Test 2 Add a few drops of aqueous silver nitrate, then ----- add aqueous ammonia.		
Test 3 Add aqueous sodium hydroxide, then ----- pour the mixture into a boiling tube. Warm gently and carefully , then ----- add a piece of aluminium foil.		
Test 4 Add a few drops of dilute sulfuric acid.		

[6]

- (ii)** Deduce the chemical formulae of **FA 7** and **FA 8**.

FA 7 is and **FA 8** is [2]

- (iii)** Give the ionic equation for the reaction of **FA 8** with sulfuric acid. Include state symbols.

..... [1]

[Total: 12]

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

