



Cambridge International AS & A Level

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CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

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 **16** 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 Solid **FB 1** is hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$. You will determine the value of **x** in a sample of **FB 1**.

The experiment involves three steps:

- Step 1** React a known mass of sodium carbonate, **FB 1**, with an excess of acid.
Step 2 Dilute the products of **Step 1** to a known volume.
Step 3 Carry out a titration to find out how much acid remained after the reaction in **Step 1**.

You will use the results of these three steps to find **x**.

FB 1 is hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

FB 2 is $0.800 \text{ mol dm}^{-3}$ hydrochloric acid, HCl .

FB 4 is $0.100 \text{ mol dm}^{-3}$ sodium hydroxide, NaOH .
bromophenol blue indicator

(a) Method

Step 1

- Label a burette **FB 2** and fill this burette with **FB 2**.
- Run 50.00 cm^3 of **FB 2** into the 250 cm^3 beaker.
- Weigh the container with **FB 1**. Record the mass.
- Slowly, and in small portions, add **FB 1** to the acid.
- Stir the mixture until the fizzing has stopped. Leave the stirring rod in the beaker.
- Reweigh the container with any residue. Record the mass.
- Calculate and record the mass of **FB 1** added to the acid.

Step 2

- Stir the mixture from **Step 1** and ensure that all the solid has dissolved. Transfer this solution to the graduated flask.
- Rinse the beaker and stirring rod twice with distilled water, then add the washings into the graduated flask.
- Make the solution up to 250 cm³ with distilled water. Thoroughly mix the contents of the flask. This solution is **FB 3**.

Step 3

- Label the other burette **FB 4**. Fill this burette with **FB 4**.
- Pipette 25.0 cm³ of **FB 3** into a conical flask.
- Add several drops of bromophenol blue indicator.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is cm³.

- Carry out as many titrations as you think are necessary to obtain consistent results.
- Make certain 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 **FB 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

- (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 cm³ of **FB 3** required cm³ of **FB 4**. [1]

Calculations

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

- (ii) Calculate the number of moles of hydrochloric acid in the **FB 2** used in **Step 1**.

moles of HCl in **FB 2** used in **Step 1** = mol [1]

- (iii) Use your answer to (b) to calculate the number of moles of sodium hydroxide, **FB 4**, required to react with 25.0 cm^3 of **FB 3** in **Step 3**.

moles of NaOH required = mol

Use this answer to deduce the number of moles of hydrochloric acid in 250 cm^3 of **FB 3**. This is the number of moles remaining after the reaction in **Step 1**.

moles of HCl in 250 cm^3 of **FB 3** = mol [1]

- (iv) Use your answers to (c)(ii) and (c)(iii) to calculate the number of moles of hydrochloric acid that reacted with sodium carbonate in **FB 1**.

moles of HCl that reacted with **FB 1** = mol [1]

- (v) Write an equation for the reaction of sodium carbonate with hydrochloric acid in **Step 1**. Include state symbols.

..... [1]

- (vi) Use the equation and your answer to (c)(iv) to determine the moles of sodium carbonate present in **FB 1**.

moles of Na_2CO_3 = mol [1]

- (vii) Use your answer to (c)(vi) and your mass of **FB 1** to calculate the formula mass of hydrated sodium carbonate.
Hence find the value for **x**.

(If you were unable to calculate the number of moles of Na_2CO_3 in (c)(vi) assume that it is $5.55 \times 10^{-3} \text{ mol}$. This is **not** the correct value.)

x = [2]

- (d) State the maximum error in a single balance reading.

maximum error in a balance reading = g

Calculate the maximum percentage error in the mass of **FB 1** you used.
Show your working.

maximum percentage error = %
[1]

- (e) A student decided to use a larger mass of **FB 1** when carrying out the same method.

What effect would this have on the titre volume in **Step 3**?
Explain your answer.

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

[Total: 19]

- 2 In this question you will determine the value of **y** in another sample of hydrated sodium carbonate by thermal decomposition.

The equation for the reaction which occurs is given below.



Solid **FB 5** is another sample of hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot y\text{H}_2\text{O}$.

(a) Method

- Weigh the empty crucible with its lid. Record the mass.
- Transfer all the **FB 5** from its container into the crucible.
- Weigh the crucible, lid and **FB 5**. Record the mass.
- Calculate and record the mass of **FB 5** used.
- Place the crucible and contents on a pipe-clay triangle.
- Heat the crucible gently, with the lid on, for approximately 1 minute.
- Heat strongly, with the lid on, for a further 1 minute.
- Heat strongly, with the lid off, for a further 4 minutes.
- Allow the crucible to cool, with the lid on, for at least 5 minutes.

During the cooling period you may wish to start work on Question 3.

- When the crucible is cool, weigh the crucible with its lid and contents.
- Calculate and record the mass of the residue obtained and the mass lost during heating.

I	
II	
III	

[3]

(b) Use your results to calculate a value for y .

$y = \dots\dots\dots$ [2]

(c) Suggest **one** improvement to the method used in **Question 2** which would lead to a more accurate value for y .

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

[Total: 6]

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) FB 6, FB 7 and FB 8** each contain one cation and one anion. All the cations and anions are different. All the cations and two of the anions are listed in the Qualitative Analysis Notes. **FB 7** 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 hydrogen peroxide in a test-tube, add a small spatula measure of FB 6 .	
Test 2 To a 2 cm depth of aqueous potassium manganate(VII) in a test-tube, add the same depth of aqueous sodium hydroxide. Then add a small spatula measure of FB 6 . Stir for about 30 seconds. Filter the mixture and collect the filtrate, then add dilute sulfuric acid to the filtrate.	

<i>test</i>	<i>observations</i>
Test 3 To a 1 cm depth of FB 7 in a test-tube, add an equal volume of hydrogen peroxide. Shake the tube, then add aqueous sodium hydroxide.	
Test 4 To a 1 cm depth of FB 7 in a test-tube, add a few drops of aqueous barium chloride or aqueous barium nitrate, then add dilute hydrochloric acid.	
Test 5 Place a small spatula measure of FB 8 into a hard-glass test-tube. Heat the contents.	
Test 6 Dissolve a small spatula measure of FB 8 in a 2 cm depth of distilled water in a test-tube. To the solution add a few drops of aqueous silver nitrate, then add aqueous ammonia.	

[7]

- (ii) From your test results, identify the anions in **FB 6**, **FB 7** and **FB 8**. If the tests do not allow you to positively identify an anion, write 'unknown'.

	FB 6	FB 7	FB 8
formula of anion			

[2]

- (b) Aqueous sodium hydroxide may be used to help identify cations. You will use this reagent to carry out tests on **FB 7** and **FB 8**.

Record your method, observations and conclusions in the space below.

You are reminded that if any solution is warmed, a boiling tube **must** be used.

I	
II	
III	
IV	

[4]

- (c) (i) From your observations, suggest a conclusion that could be made about the chemical behaviour of **FB 7** in **Test 3** of (a)(i).
Explain your answer.

.....

..... [1]

- (ii) Write an ionic equation for any precipitation reaction you observed in (a)(i).
Include state symbols.

..... [1]

[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	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

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	europlum	152.0	64	Gd	gadolinium	157.3	65	Tb	terbium	158.9	66	Dy	dyprosium	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
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	—

actinoids