Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 0 9 0 4 1 1 2 6 2 7 *

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.

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 **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, Na_2CO_3•**x**H_2O. 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, Na_2CO_3•**x**H_2O.
FB 2 is 0.800 mol dm^{-3} hydrochloric acid, HCl.
FB 4 is 0.100 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 cm^3 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 cm^3 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 .... cm^3.

- 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 cm^3 of **FB 3** required .... cm^3 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 5.55×10^{-3} 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.

$$Na_2CO_3{\bullet}\mathbf{y}H_2O(s) \rightarrow Na_2CO_3(s) + \mathbf{y}H_2O(g)$$

Solid **FB 5** is another sample of hydrated sodium carbonate, $Na_2CO_3{\bullet}\mathbf{y}H_2O$.

(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 = ... [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.

test	*observations*
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.	

test	*observations*
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]

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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

ion	*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 ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$)
iodide, $I^-(aq)$	gives 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
sulfate, $SO_4^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids)
sulfite, $SO_3^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ (soluble in excess dilute strong acids)

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 (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

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 –		114 Fl flerovium –		116 Lv livermorium –		

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 –