Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

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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.

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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, **M**HCO_3.

FA 1 is 0.0550 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 2 is the metal hydrogencarbonate, **M**HCO_3.
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 cm^3 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 cm^3 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 **M**HCO_3 is **FA 3**. Label the flask **FA 3**.

Titration

- Fill the burette with **FA 1**.
- Pipette 25.0 cm^3 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 .... cm^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 cm^3 of **FA 3** required .... cm^3 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 H_2SO_4 = ... mol [1]

(iii) Complete the equation for the reaction of sulfuric acid and **M**HCO_3.
State symbols are not required.

.....**M**HCO_3 + ...H_2SO_4 $\rightarrow$ .....**M**$_2SO_4$ + ... + ...

Use your answer to **(c)(ii)** to deduce the number of moles of **M**HCO_3 used in each titration.

moles of **M**HCO_3 = ... mol [1]

(iv) Use your answer to **(c)(iii)** and your data on page 2 to calculate the relative formula mass, M_r, of **M**HCO_3.

M_r of **M**HCO_3 = ... [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 ± 0.06 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, **M**HCO_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, **M**HCO_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 **M**HCO_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 **M**HCO_3. Include state symbols.

.....**M**HCO_3(s) $\rightarrow$ .....CO_2(g) + ... + ... [1]

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

$$\text{moles of } CO_2 = \frac{\text{mass lost during heating}}{(M_r \text{ of } CO_2 + M_r \text{ of } H_2O)}$$

Calculate the number of moles of carbon dioxide given off.

moles CO_2 = ... mol [1]

(v) Calculate the relative formula mass, M_r, of **M**HCO_3.

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

M_r of **M**HCO_3 = ... [1]

(vi) You have obtained two values for the M_r of **M**HCO_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.

test	*observations*	
	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

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 –