Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

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CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **October/November 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.
A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **12** printed pages.

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CAMBRIDGE International Examinations

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 determine the percentage by mass of an impure sample of sodium hydrogencarbonate, $NaHCO_3$.
You will do this by titration with hydrochloric acid, HC*l*. The impurity in the sample is **X**. **X** is a sodium compound which does not react with HC*l*.

FB 1 is a mixture containing sodium hydrogencarbonate and **X**.
You are supplied with approximately 6.5 g of **FB 1**. You will also use **FB 1** in **Question 2**.
FB 2 is 0.105 mol dm^{-3} hydrochloric acid, HC*l*.
methyl orange indicator

(a) Method

Preparing a solution of FB 1

- Weigh the 100 cm^3 beaker. Record the mass.
- Add between 2.8 g and 3.0 g of **FB 1** to the beaker.
- Reweigh the beaker with **FB 1**. Record the mass.
- Calculate and record the mass of **FB 1** used.
- Add approximately 50 cm^3 of distilled water to **FB 1** in the beaker.
- Stir the mixture with a glass rod until all the **FB 1** 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.
- Add distilled water to the volumetric flask up to the mark.
- Shake the flask thoroughly.
- This solution of impure sodium hydrogencarbonate is **FB 3**. Label the flask **FB 3**.

Titration of FB 3

- Fill the burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 3** into a conical flask.
- Add approximately 10 drops of methyl orange indicator.
- Carry out a rough titration.
- Record your burette readings and the rough titre 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 **FB 2** 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 **FB 2** to be used in your calculations.
Show clearly how you obtained this value.

25.0 cm^3 of **FB 3** required .... cm^3 of **FB 2**. [1]

(c) Calculations

(i) Give your answers to **(ii)**, **(iii)**, **(iv)** and **(v)** to the appropriate number of significant figures. [1]

(ii) Calculate the number of moles of hydrochloric acid, HCl, in the volume of **FB 2** calculated in **(b)**.

moles of HCl = ... mol [1]

(iii) Complete and balance the equation for the reaction of sodium hydrogencarbonate with hydrochloric acid. Include state symbols.

....$NaHCO_3$...... + ...HCl...... $\rightarrow$ ....$NaCl$...... + ...CO_2...... + ...

Deduce the number of moles of sodium hydrogencarbonate that reacted with the number of moles of HCl calculated in **(ii)**.

moles of $NaHCO_3$ = ... mol [1]

(iv) Use your answer to **(iii)** to calculate the number of moles of sodium hydrogencarbonate in the **FB 1** that you weighed out.

moles of $NaHCO_3$ in **FB 1** used = ... mol [1]

(v) Calculate the percentage by mass of $NaHCO_3$ in **FB 1**.

percentage by mass of $NaHCO_3$ in **FB 1** = ... % [1]

[Total: 14]

Question 2 starts on the next page.

2 You will determine the percentage by mass of $NaHCO_3$ in **FB 1** again, this time by thermal decomposition.

The equation for the thermal decomposition of sodium hydrogencarbonate is shown.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

FB 1 is a mixture containing sodium hydrogencarbonate and an impurity, **X**.

(a) Method

- Weigh a crucible with its lid and record the mass.
- Add between 2.8 g and 3.0 g of **FB 1** to the crucible. Weigh the crucible and lid with **FB 1** and record the mass.
- Place the crucible on the pipe-clay triangle. Heat the crucible and contents gently for approximately two minutes, with the lid off.
- Then heat strongly for approximately three minutes.
- Replace the lid and leave the crucible and residue to cool for at least five minutes.

While the crucible is cooling, you may wish to begin work on Question 3.

- Reweigh the crucible and contents with the lid on. Record the mass.
- Heat the crucible and contents strongly for a further two minutes, without the lid.
- Replace the lid and leave the crucible and residue to cool for at least five minutes.
- Reweigh the crucible and contents with the lid on. Record the mass.
- Calculate and record the starting mass of **FB 1** and the mass of residue obtained.

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Calculate the number of moles of carbon dioxide produced during the thermal decomposition of **FB 1** by using the formula below.

$$\text{moles of } CO_2 \text{ produced} = \frac{\text{mass lost during heating}}{M_rCO_2 + M_rH_2O}$$

moles of CO_2 produced = ... mol [1]

(ii) Use your answer to **(i)** and the equation on page 6 to calculate the mass of sodium hydrogencarbonate in the **FB 1** you used in this experiment.

mass of $NaHCO_3$ in **FB 1** = ... g [1]

(iii) For this experiment calculate the percentage by mass of $NaHCO_3$ in **FB 1**.

percentage by mass of $NaHCO_3$ in **FB 1** = ... % [1]

(c) (i) Explain why the crucible and contents were heated for a further two minutes after the first weighing of the crucible and residue.

....

....

.... [2]

(ii) What assumption did you make about the behaviour of **X** when you carried out the calculation?

....

.... [1]

(iii) A student suggested that it would have been more accurate to carry out the thermal decomposition with the lid on the crucible throughout the experiment.

State and explain whether or not you agree with this suggestion.

....

.... [1]

(iv) Suggest which of the two procedures, titration or thermal decomposition, gives a more accurate value for the percentage by mass of $NaHCO_3$ in **FB 1**.
Explain your choice.

....

....

.... [1]

[Total: 13]

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 4** has the same composition as the residue obtained in **Question 2**.
It contains two sodium compounds, one of which is **X**.
Both anions present in **FB 4** are listed in the Qualitative Analysis Notes.

(i) To a small spatula measure of **FB 4** in a test-tube, add dilute nitric acid slowly.
Record your observations. Keep the solution produced for use in **(ii)**.

....

....

.... [2]

(ii) To a 1 cm depth of the solution obtained in **(i)** in a test-tube, add a few drops of aqueous silver nitrate, followed by aqueous ammonia.
Record your observations.

....

....

.... [1]

(iii) Give the equation for one reaction taking place in **(i)**. State symbols are **not** required.

.... [1]

(b) Dissolve the remaining **FB 4** in a 5 cm depth of distilled water in a boiling tube. This solution is **FB 5**.

(i) Carry out the following tests and record your observations.
Use a 1 cm depth of **FB 5** in a test-tube for each test.

test	*observations*
Add several drops of aqueous copper(II) sulfate, then	
add dilute sulfuric acid.	
Add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
add dilute nitric acid.	
Add a few drops of methyl orange indicator.	
Add several drops of aqueous silver nitrate, then	
add dilute nitric acid.	

[6]

(ii) To a 1 cm depth of **FB 5** in a boiling tube, add an equal volume of aqueous sodium hydroxide and warm carefully, then add a small piece of aluminium foil to the mixture.
Record your observations.

[1]

(iii) Using your observations in **(a)** and **(b)**, name **X**.

.... [1]

(iv) What can you deduce about **FB 4** from the observation when methyl orange indicator was added to **FB 5**?

.... [1]

[Total: 13]

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	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 –