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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 6 4 2 8 7 2 2 2 8 5 *

CHEMISTRY **9701/31**

Paper 3 Advanced Practical Skills 1 **May/June 2016**

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 12 and 13.
A copy of the Periodic Table is printed on page 16.

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 **13** printed pages and **3** blank pages.

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1 In this experiment you will determine the identity of the Group 2 metal, **X**, in the carbonate, $\mathbf{X}CO_3$. To do this you will react a known mass of $\mathbf{X}CO_3$ with **excess** hydrochloric acid, HC*l*, and measure the mass of carbon dioxide that is given off.

FA 1 is $\mathbf{X}CO_3$.
FA 2 is hydrochloric acid, HC*l*.

(a) Method

- Weigh the stoppered tube containing **FA 1** and record its mass.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 2** into the 250 cm^3 beaker.
- Weigh the beaker containing the acid and record the mass.
- Carefully add all the sample of **FA 1** to the acid in the beaker.
- Stir the mixture until there is no further reaction.
- Reweigh the beaker and its contents and record the mass.

KEEP THE CONTENTS OF THE BEAKER FOR USE IN QUESTION 2.

- Reweigh the stoppered tube containing any residual **FA 1** and record its mass.
- Calculate the mass of **FA 1** added to the acid and record this value.
- Calculate the mass of carbon dioxide given off and record this value.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the number of moles of carbon dioxide given off when $\mathbf{X}CO_3$ reacted with the acid.
Use the data in the Periodic Table on page 16.

moles of CO_2 = ... mol

(ii) Write the equation for the reaction of **FA 1**, $\mathbf{X}CO_3$, with hydrochloric acid, HC*l*. Include state symbols.

....

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(iii) Use your answers to **(i)** and **(ii)** to calculate the number of moles of $\mathbf{X}CO_3$ that were added to the acid.

moles of $\mathbf{X}CO_3$ = ... mol

(iv) Use your answer to **(iii)** to calculate the relative atomic mass, A_r, of **X**.
Identify **X**.

I	
II	
III	
IV	
V	

A_r of **X** = ...

X is ....

[5]

(c) One of the sources of error in this experiment is that it is very difficult to reduce acid spraying out of the beaker when the metal carbonate is added to the acid.

(i) Explain what effect this acid spray would have on the value you calculated for the relative atomic mass, A_r, of **X**.

....

....

....

(ii) Why is a small amount of acid spray not likely to cause an error in the identification of **X**?

....

....

(iii) How could you minimise acid spraying out of the beaker?

....

....

.... [3]

[Total: 15]

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2 In this experiment you will determine the concentration of the hydrochloric acid, **FA 2**, used in **Question 1**. You will first dilute the reaction mixture that you prepared in **Question 1** and then titrate this diluted solution against sodium hydroxide, NaOH.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

FA 3 is 0.0400 mol dm^{-3} sodium hydroxide, NaOH.
methyl orange indicator

(a) Method

Dilution

- Transfer all the reaction mixture that you prepared in **1(a)** from the 250 cm^3 beaker to the 250 cm^3 volumetric flask.
- Rinse the beaker with a little distilled water and add these washings to the volumetric flask.
- Fill the volumetric flask to the line with distilled water. Stopper the flask and shake it to ensure thorough mixing.
- Label this solution **FA 4**.

Titration

- Fill the burette with **FA 4**.
- Use a pipette to transfer 25.0 cm^3 of **FA 3** into a conical flask.
- Add a few drops of methyl orange.
- 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 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 **FA 4** added in each accurate titration.

I	
II	
III	
IV	

[4]

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(b) From your accurate titration results, obtain a suitable value for the volume of **FA 4** 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 4**. [1]

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the number of moles of sodium hydroxide, NaOH, present in 25.0 cm^3 of **FA 3**.

moles of NaOH = ... mol

(ii) Calculate the number of moles of hydrochloric acid, HCl, present in 250 cm^3 of **FA 4**.

moles of HCl in 250 cm^3 of **FA 4** = ... mol

(iii) Use your answers to **1(b)(i)** and **1(b)(ii)** to calculate the number of moles of HCl that reacted with **FA 1** in the experiment you carried out in **Question 1**.

moles of HCl that reacted with **FA 1** = ... mol

(iv) Use your answers to **2(c)(ii)** and **2(c)(iii)** to calculate the concentration of **FA 2**.

concentration of **FA 2** = ... mol dm^{-3}
[5]

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(d) (i) One of the sources of error in determining the concentration of **FA 2** involves measuring volumes of solutions in both **Questions 1** and **2**.

State which volume of solution that you have measured has the greatest percentage error. How could you have reduced this error?

....

....

....

(ii) A student suggested that a greater mass of **X**CO_3 should be used so that the average titre calculated in **2(b)** would be a greater volume.

Explain whether you agree with the student that this would lead to a greater volume for the average titre.

....

....

....
[2]

[Total: 12]

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3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

FA 5 is a mixture of two different salts. Each of these salts contains one cation and one anion from those listed on pages 12 and 13. You will identify the cations and anions present.

(a) **(i)** Carry out the following test and record your observations.

test	*observations*
Place a small spatula measure of **FA 5** in a hard-glass test-tube and heat strongly. Test any gases that are given off.	

(ii) Identify one of the cations in **FA 5**.

One of the cations in **FA 5** is ....

[2]

(b) Place the remaining sample of **FA 5** in the 100 cm^3 beaker. Half fill the beaker with distilled water and stir until **FA 5** has fully dissolved. This may take some time. You will use this solution in the remaining tests.

(i) Select reagents to identify the other cation present in **FA 5**. Carry out tests using these reagents and record your results in the space below.
Identify the cation.

The other cation in **FA 5** is ....

(ii) Carry out the following tests and record your observations.
Identify one of the anions in **FA 5**.

test	*observations*
To a 1 cm depth of the solution of **FA 5** in a test-tube add aqueous barium chloride or aqueous barium nitrate, then	
add dilute hydrochloric acid.	

One of the anions in **FA 5** is ....

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(iii) The remaining ion is a halide.

Select a pair of reagents which can be used to identify the halide present. Carry out a test using these reagents and record your observations below. Suggest the identity of the halide anion present in **FA 5**. Explain why this test is not conclusive in this particular case.

The other anion in **FA 5** is ....

....

....

....

....
[8]

(c) Suggest the formulae of the two salts that could have been mixed to make **FA 5**.

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

(d) **FA 6** and **FA 7** are different organic liquids. Their possible identities are listed below.

- 2-methylpropan-2-ol
- propanal
- propanone

Half fill the 250 cm^3 beaker with water and heat to about 50 °C. You will use this as a hot water bath.

Turn off the Bunsen burner.

Carry out the following tests and record your observations.

test	*observations*
To a 1 cm depth of **FA 6** in a test-tube, add a few drops of acidified potassium manganate(VII). If no reaction is seen, warm the solution in the hot water bath.	
To a 1 cm depth of **FA 7** in a test-tube, add a few drops of acidified potassium manganate(VII). If no reaction is seen, warm the solution in the hot water bath.	

Suggest the identity of **FA 6** and **FA 7** with an explanation.

FA 6 ....

FA 7 ....
[2]

[Total: 13]

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Qualitative Analysis Notes

Key: [ppt. = precipitate]

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 giving dark green solution	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; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
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

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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 –

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