Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER							CANDIDATE NUMBER				

0140273218

CHEMISTRY **9701/31**

Paper 3 Advanced Practical Skills 1 **May/June 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 14 and 15.
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 **14** printed pages and **2** blank pages.

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[Turn over

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 use a solution of sodium carbonate, Na_2CO_3, to determine the concentration of a solution of hydrochloric acid, HCl, by carrying out a titration.

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

FA 1 is a solution of sodium carbonate containing 1.30 g Na_2CO_3 in each 250 cm^3.
FA 2 is hydrochloric acid, HCl.
methyl orange indicator

(a) Method

- Fill a burette with **FA 2**.
- Use the pipette to transfer 25.0 cm^3 of **FA 1** into a conical flask.
- Add a few drops of methyl orange indicator.
- 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 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value for the volume of **FA 2** to be used in your calculations. Show clearly how you obtained this value.

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

(c) Calculations

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

(ii) Calculate the number of moles of sodium carbonate present in $25.0\,cm^3$ of **FA 1**.

moles of Na_2CO_3 = ... mol [1]

(iii) Calculate the number of moles of hydrochloric acid that reacted with the number of moles of sodium carbonate you calculated in **(ii)**.

moles of HCl = ... mol [1]

(iv) Use your answers to **(b)** and **(c)(iii)** to calculate the concentration of hydrochloric acid in **FA 2**.

concentration of HCl in **FA 2** = ... $mol\,dm^{-3}$ [1]

[Total: 12]

2 In this question you will determine the identity of the halogen in compound **W**. Compound **W** is the halogenoethanoic acid CH_2XCO_2H, where X is a halogen.

4 g of **W** were heated with 250 cm^3 of 0.400 mol dm^{-3} aqueous sodium hydroxide. Some of the sodium hydroxide reacted with compound **W**. The solution that remained after this reaction is **FA 3**.

By titrating **FA 3** with hydrochloric acid, you will determine how much of the sodium hydroxide remained after reaction with **W**. You will then calculate how much sodium hydroxide had reacted and use this to determine the identity of X in CH_2XCO_2H.

FA 3 is aqueous sodium hydroxide after reaction with **W**.
FA 4 is 0.100 mol dm^{-3} hydrochloric acid, HC*l*.
bromophenol blue indicator

(a) Method

- Fill the second burette with **FA 4**.
- Rinse the pipette with distilled water followed by a little **FA 3**.
- Use the pipette to transfer 25.0 cm^3 of **FA 3** into a conical flask.
- Add a few 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 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	

- 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**.
[3]

(b) Calculations

A halogenoethanoic acid reacts with aqueous sodium hydroxide in two reactions.

The alkali neutralises the carboxylic acid.

$$NaOH + CH_2XCO_2H \rightarrow CH_2XCO_2Na + H_2O$$

The halogenoalkyl group then undergoes a substitution reaction.

$$NaOH + CH_2XCO_2Na \rightarrow CH_2(OH)CO_2Na + NaX$$

(i) Calculate the number of moles of hydrochloric acid, **FA 4**, present in the volume calculated in **(a)**.

moles of HCl = ... mol

Hence deduce the number of moles of sodium hydroxide present in 25.0 cm^3 of **FA 3**.

moles of NaOH in 25.0 cm^3 **FA 3** = ... mol
[1]

(ii) Calculate the number of moles of sodium hydroxide added to the 4 g of **W**.

moles of NaOH added to 4 g **W** = ... mol

Calculate the number of moles of sodium hydroxide that **remain after** the reaction with compound **W**.

moles of NaOH remaining after reaction with **W** = ... mol
[1]

(iii) Calculate the number of moles of sodium hydroxide that reacted with **W**.

moles of NaOH that reacted with **W** = ... mol

Hence calculate the number of moles of **W** that reacted with this number of moles of sodium hydroxide.

moles of **W** that reacted = ... mol
[1]

(iv) Use your answer to **(iii)**, and the mass of **W** used to make **FA 3**, to calculate the M_r of **W**.

M_r of **W** = ... [1]

(v) **W** is a halogenoethanoic acid, CH_2XCO_2H. Use your answer to **(iv)** to determine the identity of X. Explain how you reached your conclusion.

....

....

....
[2]

(c) Apart from any inaccuracies in reading the volumes of solutions, suggest a significant source of error in this practical exercise.
Explain how you could minimise this error.

....

....

.... [1]

(d) State at what M_r value of **W**, closest to the one calculated in **(b)(iv)**, you would have concluded that X was a different halogen.

M_r value = ... [1]

[Total: 11]

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)** Half fill the 250 cm^3 beaker with water. Heat to approximately 70 °C, then turn off the Bunsen burner. This will be used as a water bath.

(i) **FA 5** is an aqueous solution of an organic compound. Carry out the following tests on **FA 5** and record your observations in the table.

test	*observations*
To a 1 cm depth of **FA 5** in a test-tube add a small spatula measure of sodium carbonate.	
To a 1 cm depth of **FA 5** in a test-tube add two drops of acidified potassium manganate(VII). Leave to stand in the water bath.	
To a 1 cm depth of **FA 5** in a test-tube add a few drops of aqueous silver nitrate.	
To a 1 cm depth of aqueous silver nitrate in a test-tube add a few drops of aqueous sodium hydroxide and then add aqueous ammonia slowly until the grey precipitate that forms **just** dissolves. This is Tollens' reagent. To this solution add a 1 cm depth of **FA 5** and leave to stand in the water bath. **Care: rinse the tube as soon as you have completed this test.**	

[4]

(ii) Suggest **two** functional groups that could be present in **FA 5**.

.... and ....
[2]

(b) **FA 6** is a mixture that contains two cations and two anions from the Qualitative Analysis Notes. Distilled water was added to **FA 6**, the mixture was stirred and then filtered. You are provided with the dried residue, **FA 7**, and the filtrate, **FA 8**, from this process.

(i) **Tests on the residue, FA 7**

Carry out the following tests and record your observations in the table.

test	*observations*
Place a spatula measure of **FA 7** in a boiling tube. Add dilute hydrochloric acid until no further reaction occurs, then	
transfer a 1 cm depth of the solution into a test-tube. To this add aqueous sodium hydroxide.	

[3]

(ii) **Tests on the filtrate, FA 8**

Carry out the following tests and record your observations in the table.

test	*observations*
To a 1 cm depth of **FA 8** in a boiling tube add a 1 cm depth of aqueous sodium hydroxide, then	
warm gently.	
To a 1 cm depth of **FA 8** in a boiling tube add a piece of aluminium foil and a 1 cm depth of aqueous sodium hydroxide. Warm gently.	

[3]

(iii) Conclusions about cations

State **one** cation that is **definitely** present in **FA 6**.

....

State **two** possible identities for the other cation present in **FA 6**.

.... or ....

Suggest how you could determine which of these two possible cations is present.
Do not carry out this test.

....

....

....
[3]

(iv) Conclusions about anions

State **one** anion that is **definitely** present in **FA 6**.

....

State **two** possible identities for the other anion present in **FA 6**.

.... or ....
[2]

[Total: 17]

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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	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 –