Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

6185320962

CHEMISTRY **9701/31**

Paper 3 Advanced Practical Skills 1 **October/November 2019**

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

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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 determine the concentration of a sample of hydrochloric acid. You will do this by measuring the volume of hydrogen produced when an excess of magnesium reacts with the acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

FA 1 is magnesium powder, Mg.
FA 2 is hydrochloric acid, HCl.

(a) Method

- Weigh the container with **FA 1**. Record the mass.
- Fill the tub with water to a depth of approximately 5 cm.
- Fill the 250 cm^3 measuring cylinder completely with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so that the open end is just above the base of the tub.
- Use the 25 cm^3 measuring cylinder to place 25.0 cm^3 of **FA 2** into the reaction flask, labelled **X**.
- Check that the bung fits tightly in the neck of flask **X**, clamp flask **X**, and place the end of the delivery tube into the inverted 250 cm^3 measuring cylinder.
- Remove the bung from the neck of flask **X**. Tip all of **FA 1** into flask **X** and replace the bung **immediately**. Remove the flask from the clamp and swirl to mix the contents.
- Swirl the flask occasionally until no more gas is evolved. Replace the flask in the clamp.
- Measure and record the final volume of gas in the measuring cylinder.
- Weigh and record the mass of the container with any residual solid.
- Calculate and record the mass of **FA 1** used.

Keep FA 2 for use in Question 2.

[2]

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(b) Calculations

(i) Calculate the number of moles of hydrogen gas produced.
(Assume 1 mol of gas occupies 24.0 dm^3 at this temperature.)

moles of $H_2(g)$ = ... mol
[1]

(ii) Calculate the concentration of hydrochloric acid in **FA 2**.

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

(iii) In this experiment the magnesium powder was in excess.

Calculate the mass of magnesium powder needed for complete reaction with all the hydrochloric acid in 25.0 cm^3 of **FA 2**.

mass of Mg = ... g
[1]

(c) A student suggested two modifications to the method in **(a)** to give a more accurate value for the concentration.

For each suggestion, state whether you agree with the student and explain your answer.

Suggestion 1: Use magnesium ribbon rather than powdered magnesium; keep the rest of the experiment the same.

....

....

Suggestion 2: Use twice the mass of magnesium powder; keep the rest of the experiment the same.

....

....
[2]

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(d) Another student carried out the experiment in **(a)** but used less magnesium than that calculated in **(b)(iii)**.

State and explain the effect this would have on the calculated concentration of hydrochloric acid in **FA 2**.

....

....

.... [1]

[Total: 8]

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2 In this experiment you will determine the concentration of **FA 2** by titration using aqueous sodium hydroxide.

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

FA 2 is hydrochloric acid, HCl.
FA 3 is 0.100 mol dm^{-3} sodium hydroxide, NaOH.
methyl orange indicator

(a) Method

Dilution of FA 2

- Fill the burette with **FA 2**.
- Run between 40.00 and 45.00 cm^3 from the burette into the 250 cm^3 volumetric flask.
- Record the volume used.
- Make the solution up to the 250 cm^3 mark by adding distilled water.
- Shake the flask thoroughly to ensure mixing.
- Label this solution of hydrochloric acid **FA 4**.

volume of **FA 2** used = ... cm^3

Titration

- Rinse the burette with distilled water and then with a little **FA 4**.
- Fill the burette with **FA 4**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Add several drops of methyl orange indicator.
- Perform a rough titration and record your burette readings.

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 all of your burette readings and the volume of **FA 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

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(b) From your accurate titration results, obtain a 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

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

(ii) Calculate the number of moles of hydrochloric acid that reacted with 25.0 cm^3 of **FA 3**.

moles of HCl = ... mol [1]

(iii) Calculate the concentration of hydrochloric acid in **FA 4**.

concentration of HCl in **FA 4** = ... mol dm^{-3} [1]

(iv) Calculate the concentration of hydrochloric acid in **FA 2**.

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

(d) Calculate the maximum percentage error in the volume of **FA 2** you added to the volumetric flask.

maximum percentage error = ... % [1]

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(e) In **Question 1** and **Question 2** you have determined the concentration of **FA 2** by two different methods. Each method used has possible sources of error, for example in **Question 1** the largest source of error is escape of gas.

Apart from this error, state and explain a source of error for each method.

Question 1 ....

....

Question 2 ....

....
[2]

[Total: 16]

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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 5** is a salt that contains two different cations and a single anion from those listed in the Qualitative Analysis Notes.

(i) Place a small spatula measure of **FA 5** in a hard-glass test-tube and heat **gently**.
Do not inhale the fumes.
Record **all** your observations.

....

....

....

.... [2]

(ii) Pour a 4 cm depth of distilled water into a boiling tube. Add the remaining **FA 5** and stir carefully until the solid has dissolved. This solution is **FA 6**.
Carry out the following tests on **FA 6** and record your observations.

test	*observations*
To a 1 cm depth in a test-tube, add aqueous ammonia.	
To a 1 cm depth in a boiling tube, add aqueous sodium hydroxide, then	
warm the mixture.	

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test	*observations*
To a 1 cm depth in a test-tube, add aqueous barium nitrate or aqueous barium chloride, then	
add dilute hydrochloric acid or dilute nitric acid.	

[4]

(iii) Identify the three ions in **FA 5**.

FA 5 contains .... , ... and ....

[2]

(b) A student carried out Qualitative Analysis tests on a hydrated salt, **FA 7**, and concluded that it contained the ions K^+, Cr^{3+} and SO_4^{2-}.
The relative formula mass of **FA 7** is 499.3.

Determine the formula of **FA 7**.

The formula of **FA 7** is ....

[2]

Question 3 continues on page 10.

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(c) **FA 8** is a solution containing a single cation and a single anion, both of which are listed in the Qualitative Analysis Notes.

(i) Carry out the following tests and record your observations.

test	*observations*
To a 1 cm depth in a test-tube, add a few drops of aqueous acidified potassium manganate(VII), then	
add starch indicator.	
To a 1 cm depth in a test-tube, add aqueous sodium hydroxide.	

[2]

(ii) Identify the two ions in **FA 8**.

FA 8 contains .... and ....
[1]

(iii) Suggest an additional test you could carry out to confirm the presence of the anion in **FA 8**.

Carry out this test and record your result.

[2]

(iv) Give the ionic equation for the reaction you carried out using **FA 8** and sodium hydroxide. Include state symbols.

.... [1]

[Total: 16]

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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

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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

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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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