Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER							CANDIDATE NUMBER					

8553479171

CHEMISTRY **9701/34**

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

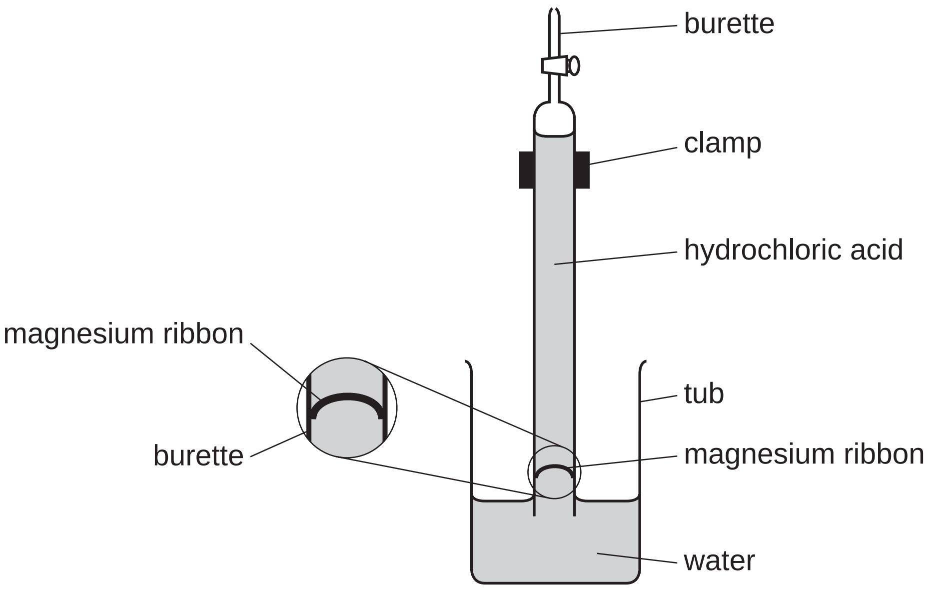
1 You will find the relative atomic mass, A_r, of magnesium by measuring the volume of hydrogen produced when a known mass of metal reacts with an excess of acid.

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

FB 1 is 1.00 mol dm^{-3} hydrochloric acid, HCl.
FB 2 is magnesium, Mg.

(a) Method
Read through the whole method before starting any practical work.

- Fill the tub with water to a depth of about 5 cm.
- Weigh the magnesium, **FB 2**, and note its mass below. If you are using a balance reading to 1 decimal place and the reading with the magnesium is zero, you should record this value.
- Fill the burette to about the 20 cm^3 mark with hydrochloric acid, **FB 1**.
- Add distilled water to reach the 0 cm^3 mark on the burette.
- Bend the magnesium strip into a U-shape.
- Place the magnesium in the burette so that it is above the liquid and friction holds it in position. Use a glass rod to push the magnesium about 2 cm into the burette.
- Hold a piece of paper towel over the open end of the burette, invert the burette and immediately place it in the tub of water. Remove the paper towel and clamp the burette as shown in the diagram.
- The liquid level should now be on the scale of the burette. If it is not, open the tap for a moment to allow the level to drop.



- Record the initial reading on the burette. Remember that the scale is now upside down.
- Leave the apparatus so that the acid from the burette diffuses around the magnesium and reacts.
- You should start **Question 2 or Question 3** while waiting for the reaction to complete.
- When all the magnesium has reacted, note and record the final reading on the burette.
- Calculate the volume of hydrogen produced.

Results

[3]

(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 hydrogen produced.
(Assume that 1 mole of gas occupies 24.0 dm^3 under these conditions.)

moles of H_2 = ... mol

(ii) Use your answer to **(i)** and the mass of magnesium used to calculate the A_r of magnesium.
(If you used a balance reading to 1 decimal place, you should assume that the mass of magnesium was 0.04 g correct to 2 decimal places.)

A_r of Mg = ...
[2]

(c) **(i)** Calculate the percentage error in the mass and volume readings in this experiment.

(ii) Suggest a change that could be made to reduce the greater error calculated in **(i)**.

....

....
[3]

(d) What would be the effect on the value of the A_r of magnesium calculated if the temperature of the room was much lower than that for your experiment? Explain your answer.

....

....

.... [2]

[Total: 10]

2 In **Question 1** you calculated the relative atomic mass, A_r, of magnesium by measuring the volume of hydrogen produced. The relative atomic mass can also be determined by investigating how much of the hydrochloric acid reacted with the magnesium.

The experiment described in **Question 1** was repeated, this time using 0.21 g of magnesium ribbon and 30.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid. All the solution left in the burette and tub was kept and water added to make the total volume 250 cm^3. This solution was labelled **FB 3**.

You will titrate **FB 3** using a known concentration of aqueous sodium carbonate to determine how much hydrochloric acid was left over after the reaction with magnesium.

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

FB 3 is the solution of hydrochloric acid described above.
FB 4 is aqueous sodium carbonate containing 2.64 g dm^{-3} Na_2CO_3.
bromophenol blue indicator

(a) Method

- Fill the burette with **FB 3**.
- Pipette 25.0 cm^3 of **FB 4** into a conical flask.
- Add about 10 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 consider necessary to obtain consistent results.
- Record, in a suitable form below, all of your burette readings and the volume of **FB 3** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value for the volume of **FB 3** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm^3 of **FB 4** required .... cm^3 of **FB 3**. [1]

(c) Calculations

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

(i) Use the information on page 4 and the Periodic Table on page 12 to calculate the number of moles of sodium carbonate in the 25.0 cm^3 of **FB 4** used in each titration.

moles of Na_2CO_3 = ... mol

(ii) Use your answer to **(i)** to calculate the number of moles of hydrochloric acid present in the volume of **FB 3** recorded in **(b)**.

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

moles of HCl present = ... mol

(iii) Use your answer to **(ii)** to calculate the number of moles of hydrochloric acid present in 250 cm^3 of **FB 3**.

moles of HCl present in 250 cm^3 = ... mol

(iv) Use the information on page 4 to calculate the number of moles of hydrochloric acid added to the magnesium.

moles of HCl added = ... mol

(v) Calculate the number of moles of hydrochloric acid that reacted with the magnesium.

moles of HCl that reacted with the magnesium = ... mol

(vi) Use your answer to **(v)** and the mass of magnesium used to calculate the relative atomic mass, A_r, of magnesium.

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

A_r of Mg = ...
[5]

(d) A solution of sodium hydroxide was prepared at the same concentration, in mol dm^{-3}, as **FB 4**. A student repeated the titration but replaced **FB 4** with this solution of sodium hydroxide.

(i) Explain the effect that replacing **FB 4** with this solution of sodium hydroxide would have on the volume of acid, **FB 3**, needed for the titration.

....

....

(ii) If the sodium hydroxide had been stored for a long time it would not be suitable for use to find the concentration of the acid.

Suggest why storage for a long time would make the sodium hydroxide unsuitable.

....

....
[2]

[Total: 15]

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.
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.

(a) **(i)** Half fill the 250 cm^3 beaker with water. Heat the water to about 80 °C and then turn off the Bunsen burner. This is the hot water bath needed in the following tests.

To a 3–4 cm depth of aqueous silver nitrate in a test-tube, add a few drops of aqueous sodium hydroxide to give a grey / brown precipitate. Then add aqueous ammonia dropwise until the precipitate **just** disappears. This solution is Tollens' reagent and is needed in a following test.

FB 5, **FB 6** and **FB 7** are each known to be one of ethanol, propanal and propanone.

Carry out the following tests and complete the table.

test	*observations*		
	FB 5	**FB 6**	**FB 7**
To a 1 cm depth in a test-tube, add a few drops of acidified potassium manganate(VII) and place in the hot water bath.			
To a 0.5 cm depth in a test-tube, add a 1 cm depth of aqueous potassium iodide and a 1 cm depth of sodium chlorate(I). (This gives the same result as adding iodine and alkali.)			
To a few drops in a test-tube, add a 1 cm depth of Tollens' reagent and place in the hot water bath. Leave for several minutes.			

(ii) Use these observations to identify the unknown compounds.

FB 5 is ....

FB 6 is ....

FB 7 is ....

(iii) Choose another reagent that would give a similar result for propanal and propanone but a different result for ethanol.

Do not carry out this test.

reagent ....

result for propanal and propanone ....

result for ethanol ....

(iv) Choose another reagent that would give a similar result for ethanol and propanone but a different result for propanal.

Do not carry out this test.

reagent ....

result for ethanol and propanone ....

result for propanal ....

[8]

(b) **FB 8** contains one cation and one anion from those listed on pages 10 and 11.
You are provided with solid **FB 8** and an aqueous solution of **FB 8**.

(i) To a 1 cm depth of aqueous **FB 8** in a test-tube add a 1 cm depth of aqueous sodium hydroxide.

Keep the test-tube and contents for test **(ii)**.

observation ....

(ii) Transfer the contents of the test-tube from test **(i)** into a boiling tube and heat gently and **carefully**.

Allow to cool and keep the boiling tube and contents for test **(iii)**.

observation ....

(iii) Transfer a 1 cm depth of the mixture from test **(ii)** into a boiling tube and add a 2 cm depth of dilute hydrochloric acid. Heat gently and **carefully**.

observation ....

Allow to cool and keep the boiling tube and contents for test **(iv)**.

(iv) To the boiling tube from test **(iii)** add a piece of aluminium foil. Leave the boiling tube to stand.

observation ....

....

(v) Place a small spatula measure of solid **FB 8** in a hard-glass test-tube and heat it gently at first and then more strongly.

Identify **two** gases, other than water vapour, that are produced and give your evidence.

identity ....

evidence ....

identity ....

evidence ....

(vi) From your observations in **(i)** to **(v)**, write the formula of **FB 8**.

....

(vii) Write the **ionic** equation for the reaction that is occurring in test **(i)**. Include state symbols.

....

[7]

[Total: 15]

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, $Ba^{2+}(aq)$	no ppt. (if 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; 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

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 –