Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER							CANDIDATE NUMBER				

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CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2023**

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document has **12** pages.

DC (LK/CB) 310969/3

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 the precision of the apparatus you used in the data you record.

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

1 Magnesium is a reactive metal which corrodes when left in air. Magnesium reacts with acid to release hydrogen.

You will determine the percentage purity of a sample of magnesium by reacting it with excess hydrochloric acid and measuring the volume of hydrogen formed.

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

FA 1 is hydrochloric acid, HC*l*.
FA 2 is magnesium, Mg.

(a) Method

- Weigh the container with **FA 2**. 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. Holding 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 the open end is in the water just above the base of the tub.
- Use the 50 cm^3 measuring cylinder to transfer 50.0 cm^3 of **FA 1** into the flask labelled **X**. Check that the bung fits tightly into 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 the flask. Add all the **FA 2** to the acid and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents.
- Replace the flask in the clamp. Leave for several minutes, swirling the flask occasionally.
- Weigh the empty container. Record the mass.
- Calculate and record the mass of **FA 2** that is added to the acid.

Start Question 2 or Question 3 while the gas is being collected.

- When the reaction stops producing gas, record the final volume of gas collected.

I	
II	
III	

volume of gas = ... cm^3 [3]

(b) Calculations

(i) Calculate the amount, in mol, of hydrogen collected in the measuring cylinder at room conditions.

amount of H_2 = ... mol [1]

(ii) Use your answer to **(b)(i)** to deduce the amount, in mol, of magnesium that reacted in your experiment.

amount of Mg = ... mol

Hence calculate the percentage purity of the magnesium.

purity of Mg = ... %
[2]

(c) A student carries out this practical procedure but uses magnesium powder rather than magnesium ribbon. State the effect this would have on the percentage purity the student calculates. Explain your answer.

....

....

.... [2]

(d) Another student investigates the reaction of a metal carbonate with hydrochloric acid by measuring the change in mass during the reaction. The reaction is carried out in a beaker on the pan of a balance.

(i) Explain why the mass displayed on the balance decreases during the reaction.

....

.... [1]

(ii) Explain why using a balance to monitor the reaction between magnesium and hydrochloric acid is **not** accurate.

....

....

.... [2]

(iii) Give the ionic equation for a solid carbonate, CO_3^{2-}(s), reacting with hydrochloric acid. Include state symbols.

.... [1]

[Total: 12]

2 In **Question 1** you determined the percentage purity of a sample of magnesium by measuring the volume of the gas produced when it reacts with an acid. In **Question 2** you will use the enthalpy change of the reaction between magnesium and hydrochloric acid to find the percentage purity. This reaction is exothermic.

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

FA 3 is hydrochloric acid, HC*l*. This is used in excess.
FA 4 is magnesium, Mg. You should assume it has a mass of 0.40 g.

(a) **Method**

- Support the cup in the 250 cm^3 beaker.
- Rinse the 50 cm^3 measuring cylinder with a little **FA 3**.
- Use the 50 cm^3 measuring cylinder to transfer 25.0 cm^3 of **FA 3** into the cup.
- Place the thermometer in the acid and tilt the cup, if necessary, so that the bulb of the thermometer is fully covered. Measure and record the temperature at time 0 minutes in Table 2.1.
- Start timing and do not stop the clock until the whole experiment has been completed at time 7 minutes.
- Record the temperature of **FA 3** in the cup every $\frac{1}{2}$ minute for $1\frac{1}{2}$ minutes.
- At time 2 minutes place **FA 4** into the acid and stir the mixture.
- Record the temperature every $\frac{1}{2}$ minute. Stir the mixture between thermometer readings.

Results

Table 2.1

time / minutes	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$
temperature / °C					X			

time / minutes	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7
temperature / °C							

I	
II	
III	

[3]

(b) **(i)** Plot a graph of temperature (on the *y*-axis) against time (on the *x*-axis) on the grid. The scale for the *y*-axis should extend 15 °C above the maximum temperature you recorded.

Label any points you consider to be anomalous.

I	
II	
III	

[3]

(ii) Draw two lines of best fit on your graph. The first is for the temperature before adding **FA 4** and the second is for the cooling of the mixture. Extrapolate both lines to 2 minutes and determine the theoretical temperature rise at this time.

theoretical temperature rise at 2 minutes = ... °C [2]

(c) Calculations

(i) Use your answer to **(b)(ii)** to calculate the energy change when **FA 4** is added to **FA 3**.

energy change = ... J [1]

(ii) Use your answer to **(c)(i)** to calculate the enthalpy change, ΔH, in $kJ\,mol^{-1}$, when 1 mol of magnesium reacts with hydrochloric acid, **FA 3**.

Show your working.

ΔH = ... $kJ\,mol^{-1}$ [2]
sign *value*

(iii) Use your answer to **(c)(ii)** and the fact that the literature value of the enthalpy change of this reaction is $-452\,kJ\,mol^{-1}$ (of Mg) to calculate the percentage purity of your sample of magnesium.

purity of Mg = ... % [1]

[Total: 12]

Qualitative analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:
- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed you should write ‘no change’.

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

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

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

No additional tests should be attempted.

3 **(a)** Devise and carry out tests to determine whether **FA 5** is magnesium carbonate. Record your tests, observations and conclusions in the space below.

[5]

(b) **(i)** **FA 6** is an aqueous solution containing two anions and two cations. Three of these ions are included in the Qualitative analysis notes.

Carry out the following tests using a 1 cm depth of **FA 6** in a test-tube for each test.

Record your observations for each test in Table 3.1.

Table 3.1

test	*observations*
Test 1 Add aqueous sodium hydroxide.	
Test 2 Add an equal depth of hydrogen peroxide, then divide the solution into two portions.	
To the first portion, add a few drops of starch solution.	
To the second portion, add aqueous sodium hydroxide.	
Test 3 Add a few drops of aqueous silver nitrate, then	
add aqueous ammonia.	
Test 4 Add a few drops of aqueous barium chloride or barium nitrate, then	
add nitric acid.	
Test 5 Add a few drops of acidified aqueous potassium manganate(VII).	

[6]

(ii) Identify as many ions present in **FA 6** as possible from your observations in **(b)(i)**.

Write the formulae of these ions in Table 3.2. If an ion cannot be positively identified from the tests, write 'unknown' in the space.

Table 3.2

cations	anions

[3]

(c) Acidified potassium manganate(VII) acts as an oxidising agent.

(i) State the colour change that occurs when acidified potassium manganate(VII) oxidises aqueous sodium nitrite.

colour change from …………………… to ……………………….. [1]

(ii) The change in oxidation number is equal to the number of electrons added to or subtracted from a reactant. An equation which includes electrons is called a half-equation.

The incomplete half-equation for acidified potassium manganate(VII) acting as an oxidising agent is shown.

Balance the half-equation for acidified potassium manganate(VII).

$MnO_4^-(aq) + 8H^+(aq) + \text{.........}\ e^- \rightarrow Mn^{2+}(aq) + \text{.........}\ H_2O(l)$

[1]

[Total: 16]

Qualitative analysis notes

1 Reactions of cations

cation	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 warming	–
barium, Ba^{2+}(aq)	faint white ppt. is observed unless $[Ba^{2+}$(aq)] is very low	no ppt.
calcium, Ca^{2+}(aq)	white ppt. unless $[Ca^{2+}$(aq)] is very low	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	pale 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

anion	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 / off-white ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives pale 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; decolourises acidified aqueous $KMnO_4$
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids); gives white ppt. with high $[Ca^{2+}$(aq)]
sulfite, SO_3^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids); decolourises acidified aqueous $KMnO_4$
thiosulfate, $S_2O_3^{2-}$(aq)	gives off-white / pale yellow ppt. slowly with H^+

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
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint

4 Tests for elements

element	test and test result
iodine, I_2	gives blue-black colour on addition of starch solution

Important values, constants and standards

molar gas constant	$R = 8.31\,J\,K^{-1}\,mol^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,C\,mol^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23}\,mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,C$
molar volume of gas	$V_m = 22.4\,dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,dm^3\,mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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 –