* 0000800000001 *

Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 7 2 1 9 3 3 6 0 0 7 *

CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2025**

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 (WW) 338080/3

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 answer to **each** step of your calculations.

1 Group 1 metal carbonates react with dilute acids to form a salt, water and carbon dioxide. The identity of the metal, **M**, can be determined by measuring the volume of carbon dioxide produced when excess acid is added to a known mass of the carbonate, $\mathbf{M}_2CO_3$.

FA 1 is the metal carbonate, $\mathbf{M}_2CO_3$.
FA 2 is 0.250 mol dm^{-3} sulfuric acid, H_2SO_4.

(a) Method

- Weigh the container with **FA 1**. Record the mass in the space for results.
- 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 2** into the flask labelled **X**. Check that the bung fits tightly into the neck of flask **X**, clamp flask **X** and place the delivery tube into the inverted 250 cm^3 measuring cylinder.
- Remove the bung from the neck of the flask. Add all of the **FA 1** into the acid in the flask and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents.
- Replace the flask in the clamp and leave until the fizzing stops. Swirl the flask occasionally.
- Weigh the container with any residual **FA 1**. Record the mass.
- Calculate and record the mass of **FA 1** that is added to the acid.
- When no more gas is collected, record the final volume of gas.

You may wish to start Question 2 or Question 3 while the gas is being collected.

Results

I	
II	
III	

[3]

(b) Calculations

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

amount of CO_2 = ... mol [1]

(ii) Write an equation for the reaction between sulfuric acid and the metal carbonate, $\mathbf{M}_2CO_3$. Include state symbols.

.... [1]

(iii) Use your answers to **(b)(i)** and **(b)(ii)** to deduce the amount, in mol, of the metal carbonate in the mass of **FA 1** you used in your experiment.

amount of $\mathbf{M}_2CO_3$ = ... mol

Hence, calculate the relative formula mass, M_r, of the metal carbonate.

M_r of $\mathbf{M}_2CO_3$ = ...
[1]

(iv) Use your answer to **(b)(iii)** to calculate the relative atomic mass, A_r, of metal **M**.
Hence, identify metal **M** in **FA 1**.

A_r of **M** = ...

M is ....
[2]

(c) A student carries out a similar experiment on a powdered Group 2 carbonate. The student determines the relative atomic mass, A_r, to be 49.3 and concludes that the metal in the carbonate is calcium.
Calculate the percentage error in the student's result. Show your working.

percentage error in A_r of Ca = ... % [1]

(d) Suggest why the method you used in **(a)** would be unsuitable for use with small lumps of calcium carbonate.

....

.... [1]

[Total: 10]

2 The identity of a Group 1 metal in a metal carbonate may also be determined by titration with acid. $\mathbf{Z}_2CO_3$ is a Group 1 metal carbonate. The metal may or may not be the same as that in **FA 1**. You will determine which metal is present in $\mathbf{Z}_2CO_3$.

FA 3 is 7.26 g dm^{-3} $\mathbf{Z}_2CO_3$.
FA 4 is 0.0500 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 5 is bromophenol blue indicator.

(a) Method

- Fill the burette with **FA 4**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Add a few drops of **FA 5** to the same conical flask.
- 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 sure any recorded results show the precision of your practical work.
- Record, in a suitable form in the space below, all your burette readings and the volume of **FA 4** added in each accurate titration.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, calculate a suitable mean value to use in your calculations. Show clearly how you obtain the mean value.

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

(c) **Calculations**

(i) Calculate the amount, in mol, of sulfuric acid present in the volume of **FA 4** in **(b)**.

amount of H_2SO_4 = ... mol [1]

(ii) Use your answer to **(c)(i)** to calculate the amount, in mol, of $\mathbf{Z}_2CO_3$ in 1.0 dm^3 of **FA 3**.

amount of $\mathbf{Z}_2CO_3$ = ... mol [1]

(iii) Use your answer to **(c)(ii)** to determine the identity of metal **Z**.

Metal **Z** is .... [2]

(d) $\mathbf{Z}_2CO_3$ also exists as the hydrated salt.

State whether your titre will increase or decrease if 7.26 g of hydrated $\mathbf{Z}_2CO_3$ is dissolved to prepare 1 dm^3 of **FA 3**. Explain your answer.

....

....

.... [1]

(e) A titration is a more accurate method of determining the relative atomic mass of the metal in a metal carbonate than gas collection.

Give **two** reasons why titration is a more accurate method.

1 ....

....

2 ....

....

[2]

[Total: 15]

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. If any solid is heated, a hard-glass test-tube must be used.

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

No additional tests should be attempted.

3 Half-fill the 250 cm^3 beaker with water and place it on a tripod and gauze. Heat the water until boiling then switch off your Bunsen burner. This is your hot water bath for use in **(b)**.

(a) **FA 6** and **FA 7** are aqueous solutions that each contain one cation and one anion. All the ions are listed in the Qualitative analysis notes. None of the ions contains nitrogen.

(i) Carry out the following tests using a 1 cm depth of **FA 6** or **FA 7** in a test-tube for each test. Record your observations in Table 3.1.

Table 3.1

test	*observations*	
	FA 6	**FA 7**
Test 1 Add aqueous sodium hydroxide.		
Test 2 Add aqueous ammonia, then		
let the mixture stand for 5 minutes.		
Test 3 Add hydrogen peroxide, mix well, then		
add aqueous sodium hydroxide.		

[4]

(ii) Carry out tests to identify the anions in **FA 6** and **FA 7**.

Record your tests and observations in a suitable form in the space below.

[4]

(iii) Use your observations from **(a)(i)** and **(a)(ii)** to deduce the formulae of **FA 6** and **FA 7**.

FA 6 is ....

FA 7 is ....

[2]

Ensure your water bath is hot and the Bunsen burner is turned off before you start **(b)**.

(b) **FA 8** is an organic liquid containing **one** functional group and **only** the elements C, H and O. You will carry out two tests to investigate **FA 8**.

For each test you will record your observations and then conclude one of the following:

- at least two types of compound that **FA 8** could be

or

- one type of compound that **FA 8 cannot** be.

(i) To a 1 cm depth of **FA 8** in a test-tube, add a few drops of acidified aqueous potassium manganate(VII), then place the test-tube in the hot water bath.

observation ....

....

conclusion ....

[2]

(ii) To a 1 cm depth of **FA 8** in a test-tube, add a small spatula measure of sodium carbonate.

observation ....

....

conclusion ....

[2]

(iii) Suggest a further test you could carry out to identify one of the types of compound that you have concluded could be **FA 8**.

State the reagent you would use. State what a positive result would indicate about the identity of **FA 8**.

Do **not** carry out your test.

reagent ....

conclusion from a positive result ....

....

[1]

[Total: 15]

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	$L = 6.02 \times 10^{23}\,mol^{-1}$
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											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	3	4	5	6	7	8	9	10	11	12	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 144.2	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 –