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International Education

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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

2778914083

CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2026**

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. Do **not** use correction fluid or tape.
- 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 **16** pages. Any blank pages are indicated.

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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 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 You will determine the concentration of hydrochloric acid by reacting it with magnesium and collecting the gas produced.

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

FA 1 is hydrochloric acid, HC*l*, of unknown concentration.
FA 2 is magnesium pieces, Mg.

(a) Method

- 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.
- Check that the bung fits tightly into the neck of the conical flask. Clamp the flask and place the end of the delivery tube into the inverted 250 cm^3 measuring cylinder.
- Use the 50 cm^3 measuring cylinder to measure out 30.0 cm^3 of **FA 1**. Carefully pour it into the conical flask.
- Measure and record the mass of the container, stopper and **FA 2**.
- Remove the bung from the neck of the flask and add all of the **FA 2** to the **FA 1** in the conical flask. **Immediately** replace the bung.
- Remove the flask from the clamp and swirl to mix the contents.
- Replace the flask in the clamp and leave until the fizzing stops. Swirl the flask occasionally.
- Measure and record the mass of the container and stopper.
- Calculate and record the mass of **FA 2** used.
- When no more gas is collected, record the final volume of gas produced to the nearest cm^3.

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

Results

I	
II	
III	
IV	

[4]

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(b) Calculations

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

amount of H_2 = ... mol [1]

(ii) Calculate the concentration, in mol dm^{-3}, of hydrochloric acid in **FA 1**.

concentration of HCl = ... mol dm^{-3} [1]

(iii) State the uncertainty in a single balance reading for the balance you used in **1(a)**.

uncertainty = ± ..... g

Hence, calculate the maximum percentage error in the mass of magnesium, **FA 2**, used.

maximum percentage error = ...% [1]

(iv) One of the reagents is assumed to be in excess. State which reagent you have assumed is in excess.

State an observation that confirms your assumption.

reactant in excess .....

observation .....

.....
[1]

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(c) (i) A student repeats the experiment in **1(a)** using magnesium powder instead of magnesium pieces. The concentration of hydrochloric acid calculated from the experiment using magnesium powder is **lower** than the concentration calculated from the experiment using magnesium pieces.

Explain why the calculated concentration is lower.

.....

.....

.....

..... [2]

(ii) Another student determines the concentration of the same hydrochloric acid by measuring the mass loss when it reacts with magnesium carbonate.

Suggest why this method **cannot** be used to determine the concentration of hydrochloric acid by reaction with magnesium.

.....

..... [1]

[Total: 11]

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2 You will determine the concentration of a different solution of hydrochloric acid by reaction with a known concentration of sodium hydroxide.

FA 3 is 1.90 mol dm^{-3} sodium hydroxide, NaOH.
FA 4 is hydrochloric acid, HC*l*, of unknown concentration.

(a) Method

- Support the cup in the 250 cm^3 beaker.
- Pipette 25.0 cm^3 of **FA 3** into the cup.
- Fill the burette with **FA 4**. The initial reading of **FA 4** in the burette must be 0.00 cm^3.
- Place the thermometer in the **FA 3** and tilt the cup, if necessary, so that the bulb of the thermometer is fully covered. Record in Table 2.1 the initial temperature of **FA 3**.
- Use the burette to add 4.00 cm^3 of **FA 4** into the cup containing **FA 3**.
- Stir the mixture gently. Record in Table 2.1 the highest temperature reached after the addition of 4.00 cm^3 of **FA 4**.
- Run further 4.00 cm^3 portions of **FA 4** into the same cup.
- On each addition of **FA 4**, stir the contents of the cup. Record the total volume of **FA 4** added and the highest temperature reached after each addition.
- Continue until a total of 44.00 cm^3 of **FA 4** has been added.

Results

Table 2.1

total volume of FA 4 added / cm^3	0.00	4.00	8.00			
temperature of solution / °C						

total volume of FA 4 added / cm^3						
temperature of solution / °C						

I	
II	
III	

[3]

(b) (i) Plot a graph of temperature (*y*-axis) against total volume of **FA 4** added (*x*-axis) on the grid. The scale on the *y*-axis should include a temperature of 3.0 °C above your maximum temperature.

Label any points you consider to be anomalous.

I	
II	
III	

[3]

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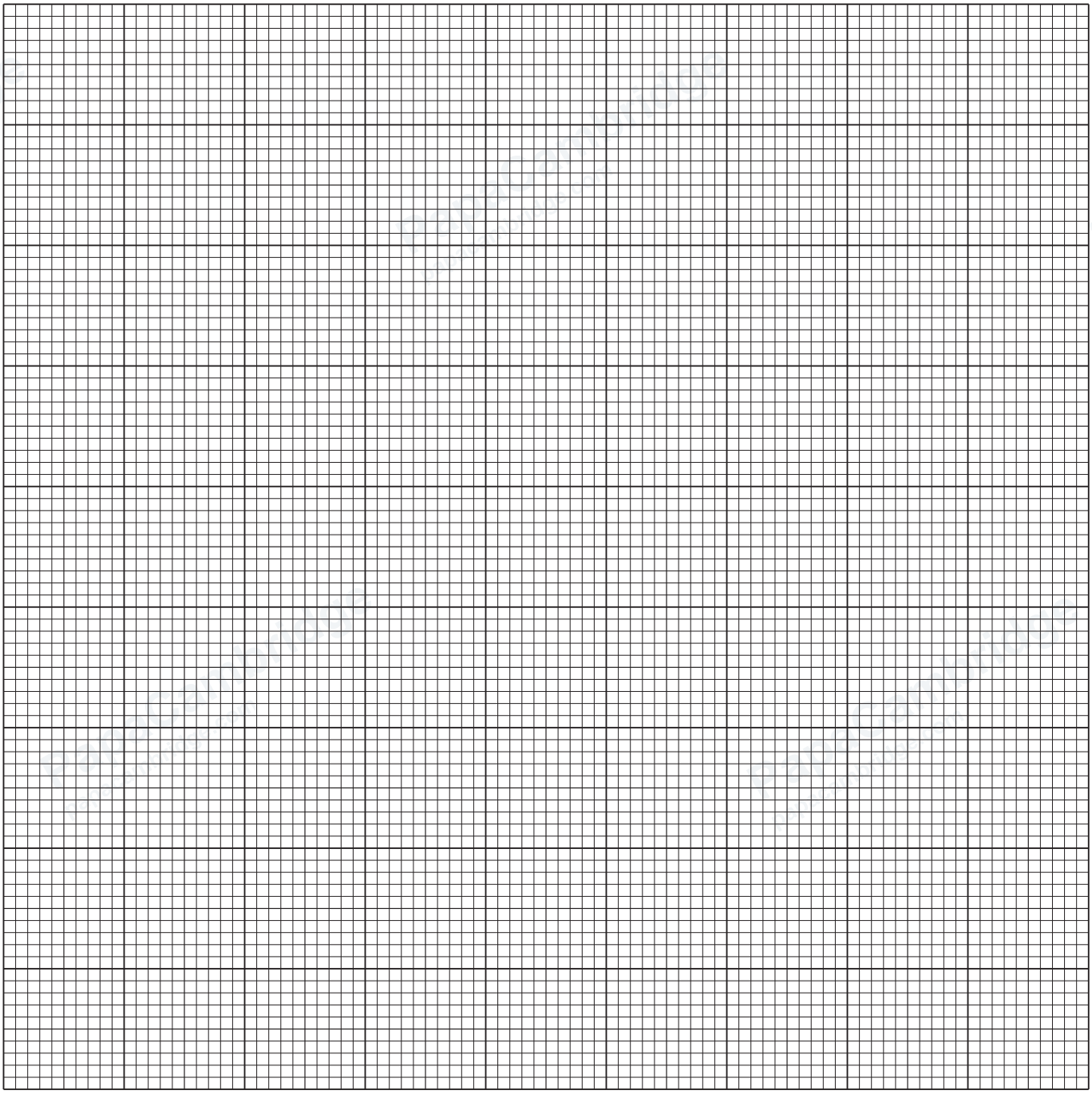

(ii) Draw **two** lines of best fit, the first for the increase in temperature and the second for after the maximum temperature has been reached. Each line should have a shape best suited to its plotted points.

Extrapolate both lines so that they intersect. The intersection corresponds to the volume of **FA 4** required to form a neutral solution.

[1]

(iii) Use your graph to determine the volume of **FA 4** required to neutralise 25.0 cm^3 of **FA 3**.

volume of **FA 4** = ... cm^3 [1]

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(c) Calculations

(i) Calculate the concentration, in mol dm^{-3}, of hydrochloric acid in **FA 4**.

concentration of HCl = ... mol dm^{-3} [1]

(ii) **FA 1** was prepared by diluting **FA 4** with water. Use your answers to **1(b)(ii)** and **2(c)(i)** to calculate the volume of **FA 4**, in cm^3, required to prepare 1.0 dm^3 of **FA 1**.
Show your working.

volume of **FA 4** = ... cm^3 [1]

(d) A titration experiment using an acid–base indicator results in a more accurate volume of **FA 4** required to neutralise 25.0 cm^3 of **FA 3** than that determined in **2(b)(iii)**.

State **two** reasons why a titration experiment is more accurate.

.....

.....

.....

..... [2]

[Total: 12]

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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 a 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 (a) **FA 5**, **FA 6** and **FA 7** are solutions each of which contains one cation of a d-block element.
One of the solutions contains two cations.
Each of the solutions contains one anion.
All the ions are listed in the Qualitative analysis notes.

(i) Carry out the tests in Table 3.1 and record your observations.

Use approximately 1 cm depth of solution in a test-tube for each test unless heating is required.

If heating is required, use approximately 0.5 cm depth of solution in a boiling tube.

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Table 3.1

test	observations		
	FA 5	**FA 6**	**FA 7**
Test 1 Add a few drops of aqueous barium chloride or aqueous barium nitrate, then			
add nitric acid to any precipitate formed.			
Test 2 Add a few drops of acidified aqueous potassium manganate(VII). Leave to stand.			
Test 3 Add aqueous sodium hydroxide until no further change, then			
warm, then			
add a piece of aluminium foil.			

[9]

(ii) Use your results from **3(a)(i)** to identify the formulae of the ions present in **FA 5**, **FA 6** and **FA 7** in Table 3.2. If you cannot positively identify an ion or ions, write 'unknown'.

Table 3.2

	FA 5	**FA 6**	**FA 7**
cation(s)			
anion			

[3]

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(iii) Write an ionic equation for the reaction taking place between aqueous sodium hydroxide and **FA 5**. Include state symbols.

..... [2]

(iv) State the role of **FA 6** when it reacts with acidified potassium manganate(VII).

Explain your answer.

.....

..... [1]

(b) Place a small spatula measure of **FA 8** into a hard-glass test-tube. Heat the test-tube, gently at first and then more strongly.
Record all your observations.

.....

.....

..... [2]

[Total: 17]

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Qualitative analysis notes

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

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^+

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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

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	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

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The Periodic Table of Elements

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 –

Key

atomic number
atomic symbol
name
relative atomic mass

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 –

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