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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	
CENTRE NUMBER	
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CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

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 30.
- 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.

This document has **12** pages. Any blank pages are indicated.

DC (EF/CT) 326152/3

1 Solution **X** is dilute hydrochloric acid of unknown concentration. A student uses titration with aqueous sodium carbonate, $Na_2CO_3(aq)$, to determine the concentration of solution **X**.

The student plans to prepare $250.0\,cm^3$ of $0.500\,mol\,dm^{-3}$ aqueous sodium carbonate, $Na_2CO_3(aq)$.

(a) **(i)** Calculate the mass of $Na_2CO_3(s)$ needed to make $250.0\,cm^3$ of $0.500\,mol\,dm^{-3}$ $Na_2CO_3(aq)$, using a **two** decimal place balance.

mass of $Na_2CO_3(s)$ = ... g [1]

(ii) Describe how the student should make $250.0\,cm^3$ of $0.500\,mol\,dm^{-3}$ $Na_2CO_3(aq)$ starting from the mass of $Na_2CO_3(s)$ calculated in **(i)** supplied in a $50\,cm^3$ beaker.

Give the name and size of any key apparatus to be used.

Write your answer using a series of numbered steps.

....

....

....

....

....

....

.... [3]

(b) The student incorrectly makes up the $250.0\,cm^3$ of $Na_2CO_3(aq)$ and the concentration is **not** $0.500\,mol\,dm^{-3}$. The student calls this solution **Y**.

The student uses the following method to determine both the concentration of solution **X** and the concentration of solution **Y**.

step 1 Transfer $25.0\,cm^3$ of solution **Y** into a conical flask using a volumetric pipette. Add a few drops of methyl orange.

step 2 Titrate the sample in the conical flask with solution **X**.

step 3 Transfer a fresh $25.0\,cm^3$ portion of solution **Y** into a second conical flask, but do **not** add methyl orange.

step 4 Use the burette to add the volume of solution **X** used in **step 2** to the second conical flask.

step 5 Measure and record the mass of a dry evaporating basin.

step 6 Transfer the contents of the second conical flask into the evaporating basin.

step 7 Use a water bath to heat the solution in the evaporating basin until all the water is evaporated and only solid remains.

step 8 Measure and record the mass of the evaporating basin and solid residue.

(i) In **step 1**, $25.0\,cm^3$ of solution **Y** is transferred using a volumetric pipette.

State what the volumetric pipette should be rinsed with before carrying out **step 1**.

.... [1]

(ii) Describe how the student detects the end-point of the titration in **step 2**.

.... [1]

(iii) Explain why the evaporating basin is not heated directly with a Bunsen burner in **step 7**.

....

.... [1]

(iv) Suggest what the student should do to ensure all of the water has evaporated from the residue before completing **step 8**.

....

....

.... [1]

(c) The student's burette readings taken in **step 2** are shown in Fig. 1.1.

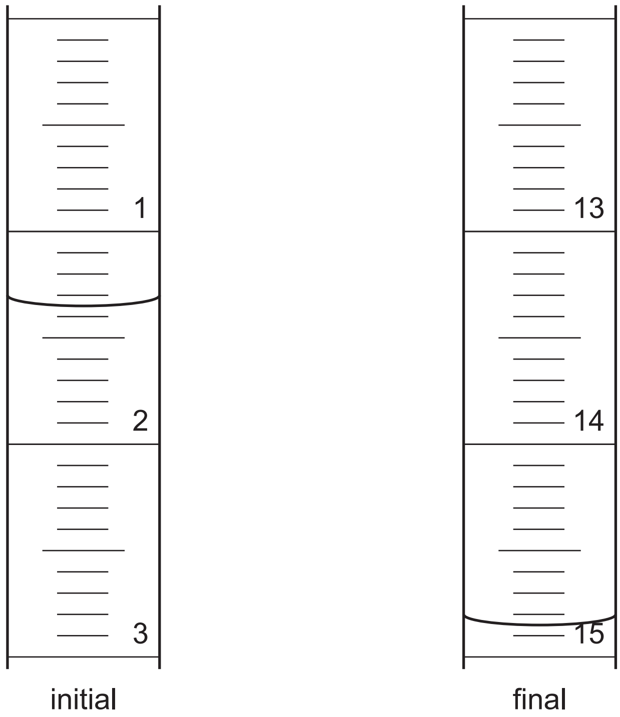

Fig. 1.1

(i) Use Fig. 1.1 to complete Table 1.1.

Table 1.1

burette reading (final) / cm^3	
burette reading (initial) / cm^3	
volume of solution **X** added / cm^3	

[2]

(ii) Calculate the percentage error in the volume of solution **X** calculated in **(i)**.

Show your working.

percentage error = ... [1]

(d) A second student repeats the experiment in **(b)** using solution **X** and 25.0 cm^3 of solution **Y**. The results are shown in Table 1.2.

Table 1.2

volume of solution **X** added in titration / cm^3	13.35
mass of dry evaporating basin / g	44.52
mass of evaporating basin and solid residue / g	45.69

The reaction that takes place in the titration is:

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

Using the results in Table 1.2, calculate the following:

- the amount, in mol, of sodium chloride

amount of sodium chloride = ... mol

- the concentration of solution **X** and the concentration of solution **Y**.

concentration of solution **X** = ... mol dm^{-3}

concentration of solution **Y** = ... mol dm^{-3}
[3]

(e) State what happens to the value obtained for the concentration of solution **Y** if not all the water is evaporated in **step 7**.

Explain your answer.

....

....

.... [2]

[Total: 16]

2 A group of students uses the following method to investigate the change in mass that takes place when metal **M** combines with sulfur to form a metal sulfide.

step 1 Weigh a clean crucible and lid using a balance. Record the mass.

step 2 Place a coiled length of metal wire into the crucible and weigh the crucible, lid and wire.

step 3 Cover the metal wire in the crucible with a large quantity of powdered sulfur and replace the lid.

step 4 Heat the crucible in a fume hood until the crucible glows red. Continue heating strongly until no more sulfur can be seen.

step 5 Allow the apparatus to cool and weigh the crucible, lid and residue.

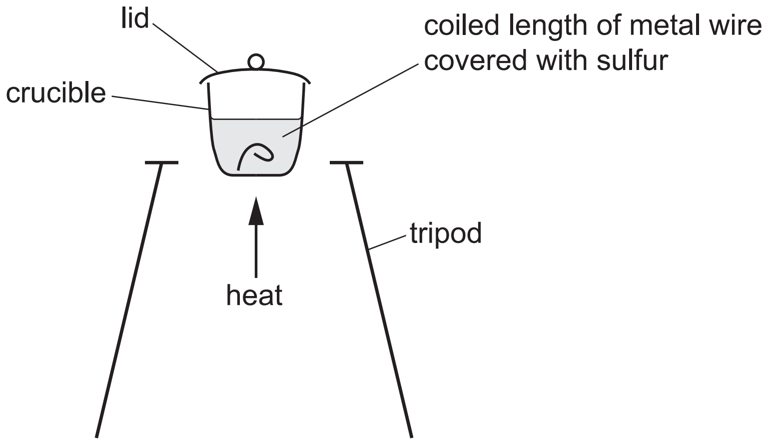

Fig. 2.1

(a) **(i)** Fig. 2.1 shows how the apparatus is set up when heating the crucible in **step 4**.

Identify the missing piece of apparatus used to support the crucible during heating.

.... [1]

(ii) Suggest why the students heat their crucibles in a fume hood in **step 4**.

....

.... [1]

(iii) Suggest why a large quantity of powdered sulfur is used in **step 3**.

....

.... [1]

(b) Five students each use a different mass of **M**.

Their results are shown in Table 2.1.

Complete Table 2.1 by inserting values for the mass of **M** and the mass of sulfur which reacts for each student.

Table 2.1

	student 1	student 2	student 3	student 4	student 5
mass of crucible and lid / g	34.15	38.28	35.68	33.70	36.84
mass of crucible, lid and **M** / g	35.58	39.42	36.54	34.27	37.13
mass of crucible, lid and residue after heating / g	36.04	39.70	36.74	34.42	37.19
mass of **M** / g					
mass of sulfur which reacts / g					

[1]

(c) Identify the independent variable in this experiment.

.... [1]

(d) (i) Plot a graph on the grid in Fig. 2.2 to show the relationship between mass of sulfur which reacts and mass of **M**.

Use a cross (×) to plot each data point. Draw a straight line of best fit which includes the origin.

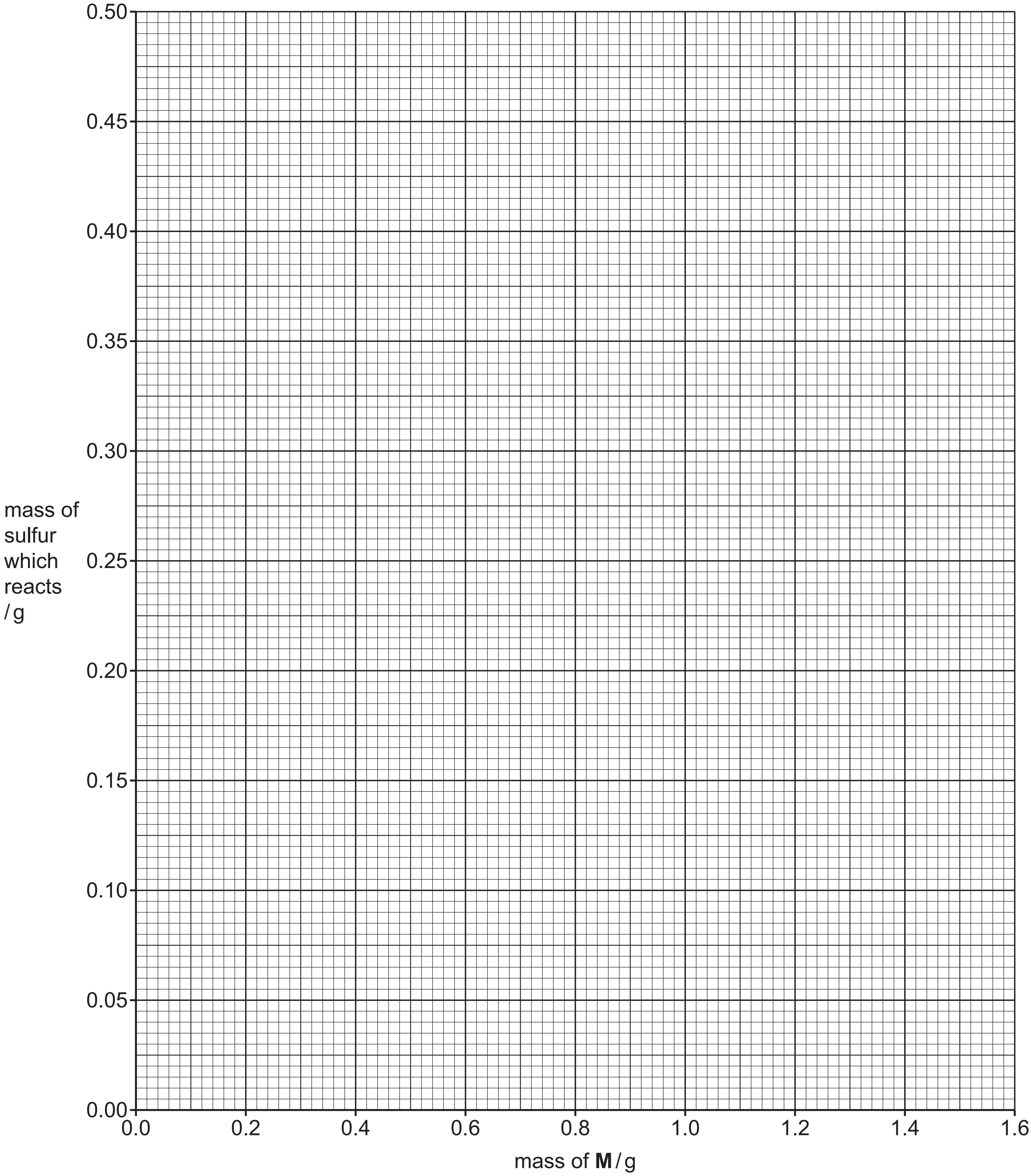

Fig. 2.2

[2]

(ii) Circle the point on the graph you consider to be most anomalous.

Suggest **one** reason why this anomaly may have occurred during this experimental procedure.

Assume no error was made in the measurement of any mass.

....

.... [2]

(e) Determine the gradient of your line of best fit.

State the coordinates of both points you used in your calculation.

These must be selected from your line of best fit.

Give your gradient to **three** significant figures.

coordinates 1 .... coordinates 2 ....

gradient = ... [2]

(f) Use your line of best fit in Fig. 2.2 to determine if the results obtained by the students are reliable.

Explain your answer.

....

....

.... [1]

(g) Another student suggests that the metal **M** used in the experiment is strontium, Sr, which forms strontium sulfide, SrS, when heated with sulfur.

(i) Deduce the gradient of the line of best fit for the graph of mass of sulfur which reacts against mass of strontium for the compound SrS.

gradient .... [1]

(ii) Use your answer to **(i)** to explain if the results of the experiment support the student's suggestion.

....

.... [1]

[Total: 14]

Important values, constants and standards

molar gas constant	R = 8.31 J K^{-1} mol^{-1}
Faraday constant	F = 9.65 × 10^{4} C mol^{-1}
Avogadro constant	L = 6.022 × 10^{23} mol^{-1}
electronic charge	e = –1.60 × 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 × 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

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 144.2	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 –