



Cambridge International AS & A Level

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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.



- 1 Solution **X** is dilute hydrochloric acid of unknown concentration. A student uses titration with aqueous sodium carbonate, $\text{Na}_2\text{CO}_3(\text{aq})$, to determine the concentration of solution **X**.

The student plans to prepare 250.0cm^3 of 0.500mol dm^{-3} aqueous sodium carbonate, $\text{Na}_2\text{CO}_3(\text{aq})$.

- (a) (i) Calculate the mass of $\text{Na}_2\text{CO}_3(\text{s})$ needed to make 250.0cm^3 of 0.500mol dm^{-3} $\text{Na}_2\text{CO}_3(\text{aq})$, using a **two** decimal place balance.

mass of $\text{Na}_2\text{CO}_3(\text{s}) = \dots\dots\dots \text{g}$ [1]

- (ii) Describe how the student should make 250.0cm^3 of 0.500mol dm^{-3} $\text{Na}_2\text{CO}_3(\text{aq})$ starting from the mass of $\text{Na}_2\text{CO}_3(\text{s})$ calculated in (i) supplied in a 50cm^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 $\text{Na}_2\text{CO}_3(\text{aq})$ 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.

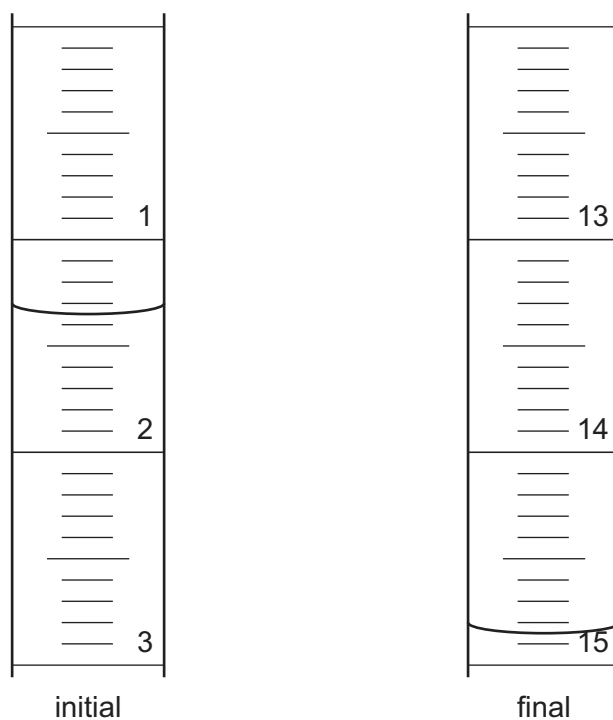


Fig. 1.1

(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]

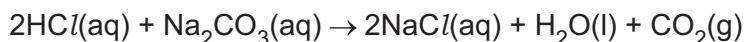


- (d) A second student repeats the experiment in (b) using solution **X** and 25.0 cm³ of solution **Y**. The results are shown in Table 1.2.

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:



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.

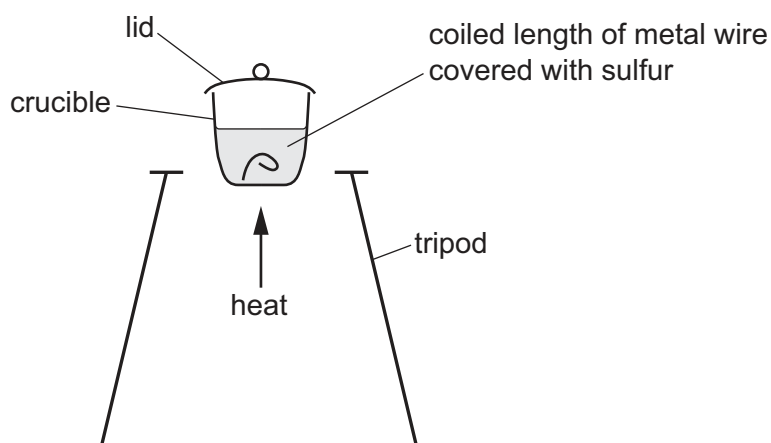


Fig. 2.1

- (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.

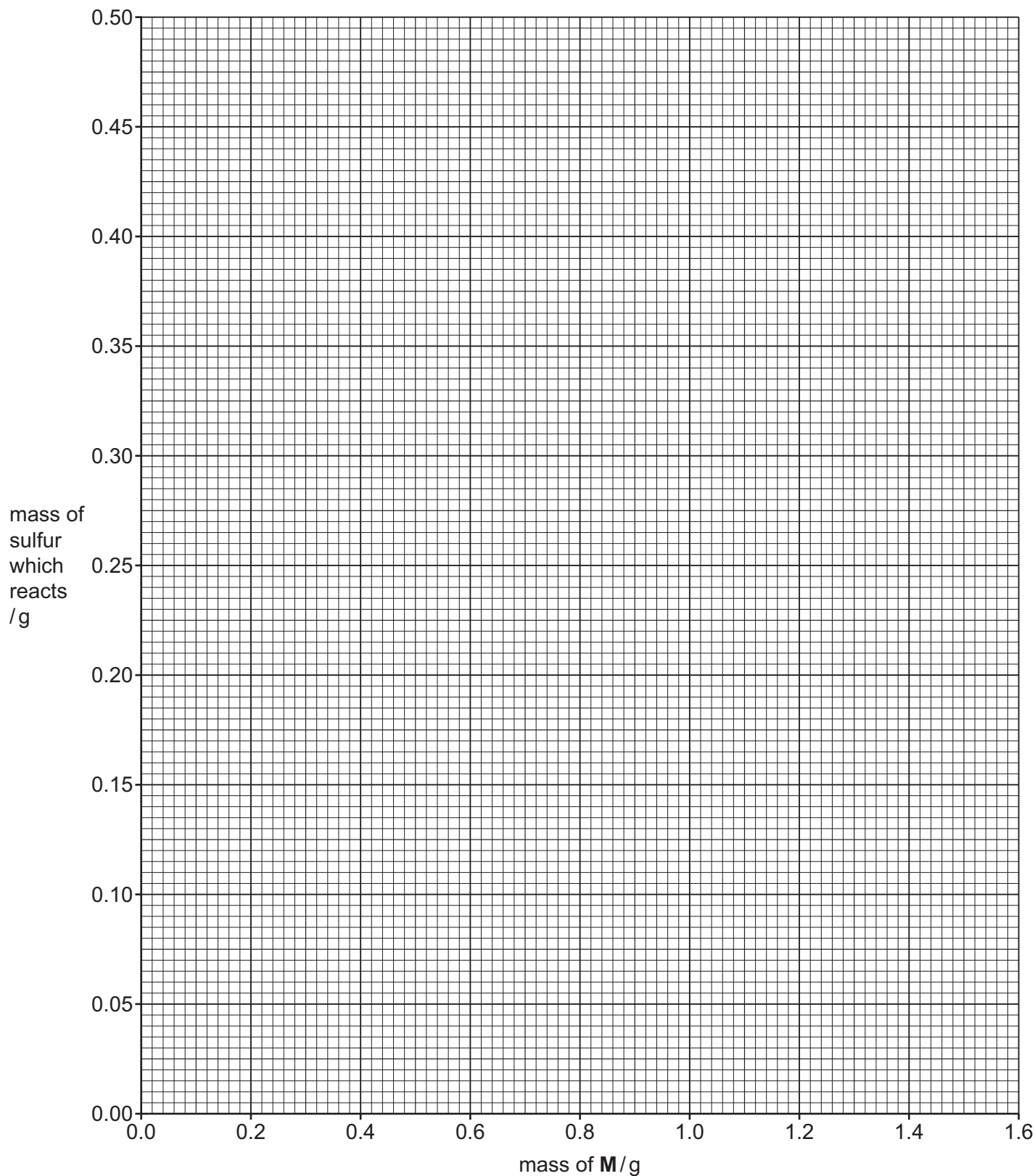


Fig. 2.2





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





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The Periodic Table of Elements

Group																			
1	2	Key														17	18		
		1 H hydrogen 1.0																	
		2 He helium 4.0																	
3	4	atomic number atomic symbol name relative atomic mass																	
Li lithium 6.9	Be beryllium 9.0																		
11	12																		
Na sodium 23.0	Mg magnesium 24.3																		
		3	4	5	6	7	8	9	10	11	12								
19	20	21	22	23	24	25	26	27	28	29	30								
K potassium 39.1	Ca calcium 40.1	Sc scandium 45.0	Ti titanium 47.9	V vanadium 50.9	Cr chromium 52.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4								
37	38	39	40	41	42	43	44	45	46	47	48								
Rb rubidium 85.5	Sr strontium 87.6	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4								
55	56	57–71	72	73	74	75	76	77	78	79	80								
Cs caesium 132.9	Ba barium 137.3	lanthanoids		Ta tantalum 180.9	W tungsten 183.8	Re rhenium 186.2	Os osmium 190.2	Ir iridium 192.2	Pt platinum 195.1	Au gold 197.0	Hg mercury 200.6								
87	88	89–103	104	105	106	107	108	109	110	111	112								
Fr francium —	Ra radium —	actinoids		Rf rutherfordium —	Db dubnium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —								