

**Q6.**

This question is about a toxic chloroalkane, **X**, that has a boiling point of 40 °C.

A student carried out an experiment to determine the  $M_r$  of **X** by injecting a sample of **X** from a hypodermic syringe into a gas syringe in an oven at 97 °C and 100 kPa. The student's results are set out in **Table 1** and **Table 2**.

**Table 1**

Mass of hypodermic syringe filled with <b>X</b> before injection / g	10.340
Mass of hypodermic syringe with left over <b>X</b> after injection / g	10.070
Mass of <b>X</b> injected / g	

**Table 2**

Volume reading on gas syringe before injection of <b>X</b> / cm <sup>3</sup>	0.0
Volume of <b>X</b> in gas syringe after injection of <b>X</b> / cm <sup>3</sup>	105.0
Volume of <b>X</b> / cm <sup>3</sup>	

- (a) Complete **Table 1** and **Table 2** by calculating the mass and volume of **X**.

**(1)**

- (b) **X** is known to be one of the following chloroalkanes: CCl<sub>4</sub> CHCl<sub>3</sub> CH<sub>2</sub>Cl<sub>2</sub> or CH<sub>3</sub>Cl

Justify this statement by calculating a value for the  $M_r$  of **X** and use your answer to suggest the most likely identity of **X** from this list.

Give your answer for the  $M_r$  of **X** to an appropriate precision.  
(The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )

$M_r$  of **X**

$M_r$  of **X** = \_\_\_\_\_



Identity of **X**

(If you have been unable to calculate a value for  $M_r$ , you may assume that the  $M_r$  value is 52. This is **not** the correct value).

Identity of **X** = \_\_\_\_\_

(5)

- (c) Suggest a reason, other than apparatus inaccuracy, why the  $M_r$  value determined from the experimental results differs from the actual  $M_r$ . Explain your answer.

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(2)

- (d) Suggest, with a reason, an appropriate safety precaution that the student should take when using the toxic chloroalkane, **X**, in the experiment.

Safety precaution \_\_\_\_\_

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Reason \_\_\_\_\_

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(2)

(Total 10 marks)

### Q7.

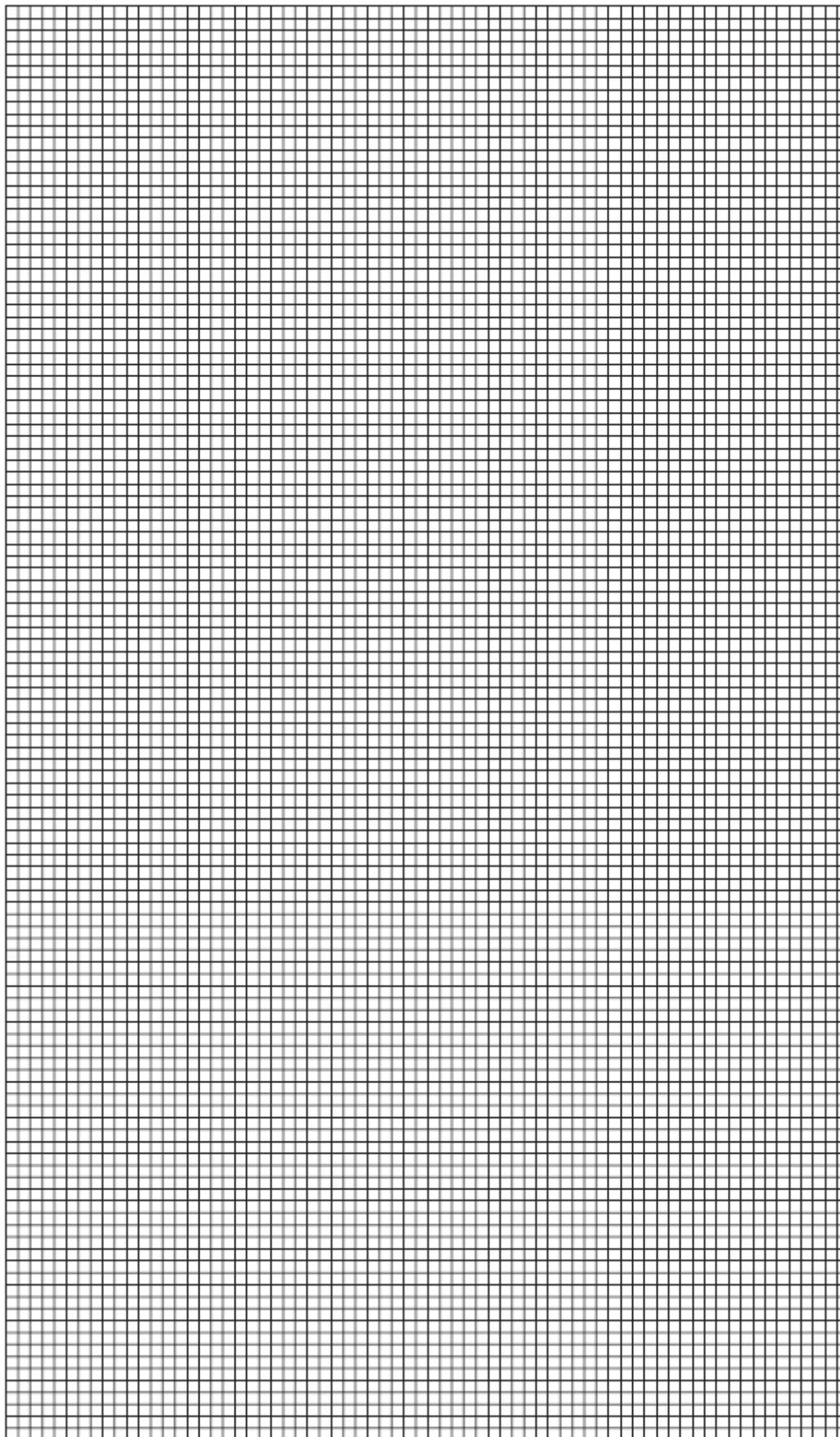
Calamine lotion can contain a mixture of zinc carbonate and zinc oxide in suspension in water. A manufacturer of calamine lotion claims that a sample contains 15.00 g of zinc carbonate and 5.00 g of zinc oxide made up to 100 cm<sup>3</sup> with distilled water.

- (a) A chemist wanted to check the manufacturer's claim. The chemist took a 20.0 cm<sup>3</sup> sample of the calamine lotion and added it to an excess of sulfuric acid. The volume of carbon dioxide evolved was measured over time. The chemist's results are shown in the table.

Time / s	0	15	30	45	60	75	90	105	120	135
Volume / cm <sup>3</sup>	0	135	270	380	470	530	560	570	570	570



- (i) Plot a graph of the results in the table on the grid. The volume should be on the y-axis. Draw a best-fit curve through **all** the points.



**(3)**

- (ii) Estimate the time taken for the reaction to be completed.

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**(1)**

- (b) (i) The volume of carbon dioxide in part (a) was measured at 293 K and at a pressure of 100 kPa.

Use information from your graph to calculate the maximum amount, in moles, of carbon dioxide evolved from the zinc carbonate in this 20.0 cm<sup>3</sup> sample.

The gas constant,  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Show your working.

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**(3)**

- (ii) Use your answer to part (i) to calculate the mass of zinc carbonate in the 20.0 cm<sup>3</sup> sample of calamine lotion.

(If you were unable to complete part (i), you may assume that the amount of carbon dioxide evolved was 0.0225 mol. This is **not** the correct answer.)

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**(2)**



- (iii) Calculate the difference between your answer to part (ii) and the manufacturer's claim that there are 15.00 g of zinc carbonate in 100 cm<sup>3</sup> of the calamine lotion.

Express this difference as a percentage of the manufacturer's claim.

(If you were unable to complete part (ii), you may assume that the mass of zinc carbonate in the 20 cm<sup>3</sup> sample of calamine lotion was 2.87 g. This is **not** the correct answer.)

Difference \_\_\_\_\_

Percentage \_\_\_\_\_

(2)

- (c) Draw a diagram of a suitable apparatus needed to perform the experiment outlined in part (a). Include in your diagram a method for collecting and measuring the carbon dioxide. The apparatus should be airtight.

(2)

(Total 13 marks)

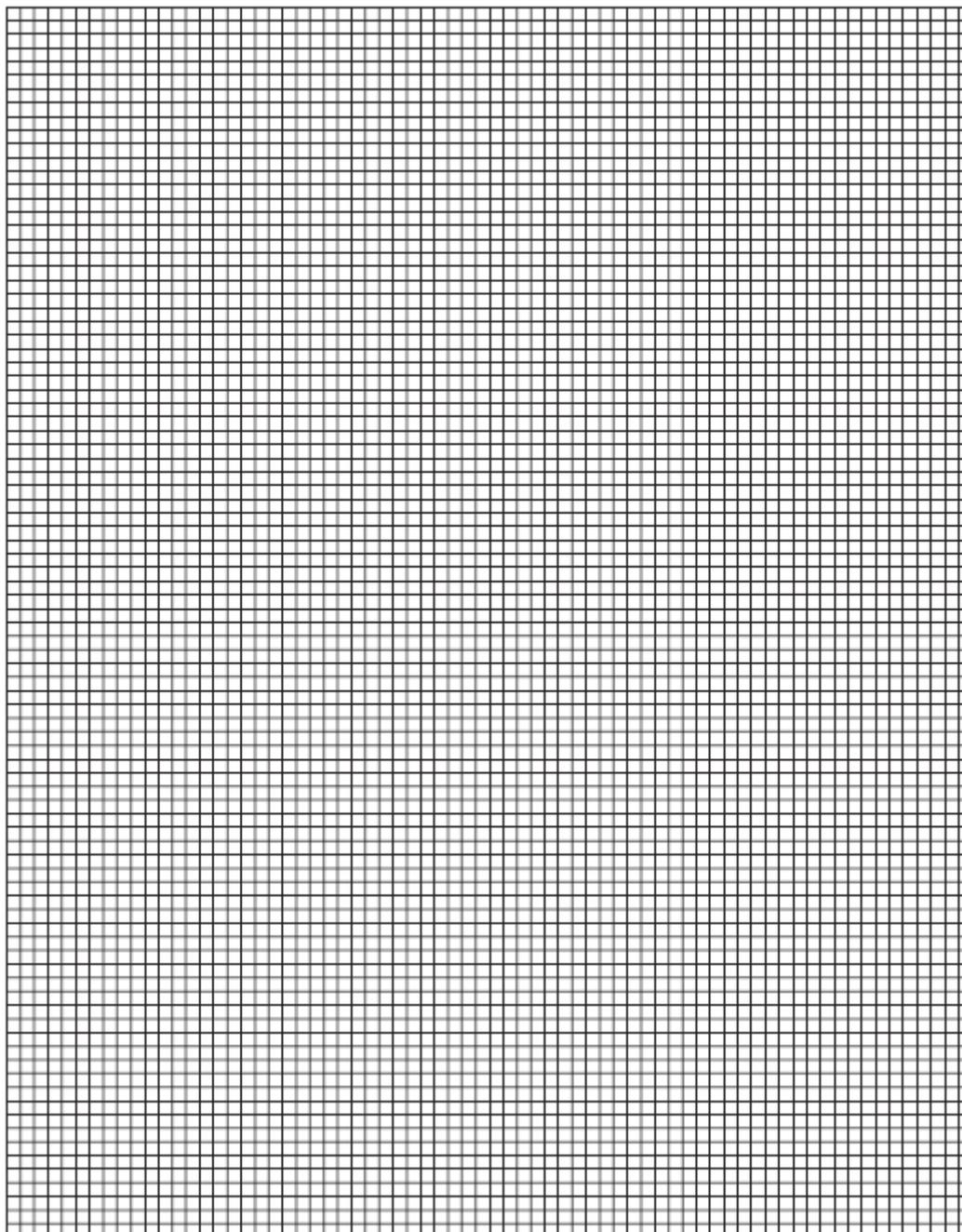
### Q8.

- (a) A student investigated the acid content of a different crater-lake solution. The student used a 50.0 cm<sup>3</sup> burette to measure out different volumes of this crater-lake solution. Each volume of crater-lake solution was titrated with a 0.100 mol dm<sup>-3</sup> sodium hydroxide solution. Each titration was repeated. The results are shown below.

Volume of crater-lake solution / cm <sup>3</sup>		10.0	20.0	30.0	40.0	50.0
Volume of sodium hydroxide solution / cm <sup>3</sup>	Experiment 1	5.85	17.00	20.00	26.50	32.45
	Experiment 2	6.15	13.00	19.90	26.50	32.55
Average titre / cm <sup>3</sup>		6.00	15.00	19.95	26.50	32.50



- (i) On the graph paper below, plot a graph of average titre (y-axis) against volume of crater-lake solution. Both axes must start at zero.



**(3)**

- (ii) Draw a line of best fit on the graph.

**(1)**

- (iii) Use the graph to determine the titre that the student would have obtained using a 25.0 cm<sup>3</sup> sample of crater-lake solution.

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**(1)**



- (iv) Excluding any anomalous points, which average titre value would you expect to be the least accurate value? Give **one** reason for your choice.

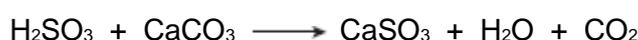
Least accurate average titre \_\_\_\_\_

Reason \_\_\_\_\_

\_\_\_\_\_

(2)

- (b) Another 100 cm<sup>3</sup> sample of crater-lake solution was reacted with an excess of powdered limestone. The gas produced was collected in a gas syringe. The equation for the reaction between the sulfuric(IV) acid in the crater-lake solution and the calcium carbonate in the powdered limestone is shown below.



The volume of gas collected from the reaction of the sulfuric(IV) acid in 100 cm<sup>3</sup> of crater-lake solution with an excess of powdered limestone was 81.0 cm<sup>3</sup> at 298 K and  $1.00 \times 10^5$  Pa.

- (i) State the ideal gas equation.

\_\_\_\_\_

(1)

- (ii) Use the ideal gas equation to calculate the amount, in moles, of carbon dioxide formed.

Show your working.

(The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(3)

- (iii) Use the equation for the reaction and your answer from part (b)(ii) to calculate the minimum mass of calcium carbonate needed to neutralise the sulfuric(IV) acid in 1.00 dm<sup>3</sup> of crater-lake solution.

Show your working.

(If you could not complete the calculation in part (b)(ii) assume that the amount of carbon dioxide is  $1.25 \times 10^{-2}$  mol. This is **not** the correct value.)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(3)



- (iv) The percentage by mass of calcium carbonate in the powdered limestone was 95.0%.  
Calculate the minimum mass of this powdered limestone needed to neutralise the sulfuric(IV) acid in 1.00 dm<sup>3</sup> of this crater-lake solution.

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(2)

- (v) Give **one** reason, other than cost, why limestone rather than solid sodium hydroxide is often used to neutralise acidity in lakes.

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(1)

(Total 17 marks)

### Q9.

Some antacid tablets contain sodium hydrogencarbonate, sucrose and citric acid.

- (a) Analysis of a pure sample of citric acid showed that it contained 37.50% of carbon and 4.17% of hydrogen by mass, the remainder being oxygen. Use these data to show that the empirical formula of the acid is C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>.

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(3)

- (b) When the antacid tablet is added to water, sodium hydrogencarbonate and citric acid react together to form a gas. Identify this gas.

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(1)



- (c) A weighed portion of this antacid was added to water. The gas formed was collected and its volume measured.
- (i) Draw a diagram to show how this experiment could have been carried out to collect and measure the volume of the gas.

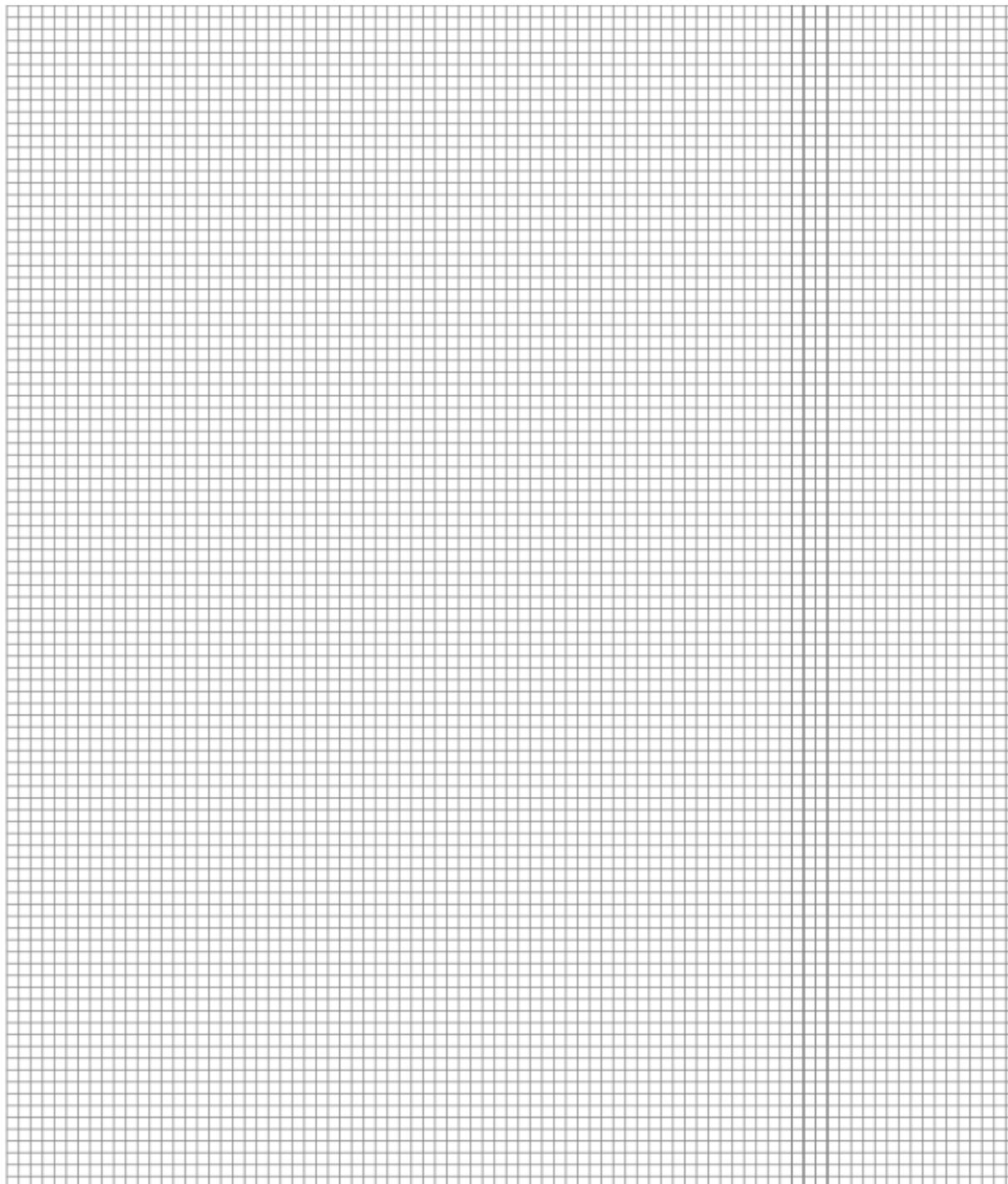
- (ii) The experiment was repeated with further weighed portions of the same antacid.

The results are shown below.

Experiment	1	2	3	4	5
Mass of antacid / g	2.60	1.17	0.88	2.31	1.80
Volume of gas collected / cm <sup>3</sup>	168	86	57	149	116



- 1 On the graph paper below, plot a graph of mass of antacid ( $x$ -axis) against volume of gas collected.



- 2 Draw a line of best fit on the graph, ignoring any anomalous points.
- 3 Use the graph to determine the volume of gas which would have been collected using 2.00 g of antacid.

Volume of gas collected \_\_\_\_\_

(3)

(1)

(1)



- (d) Suggest **one** reason why the presence of sodium hydrogencarbonate in the stomach may cause a person to suffer some extra discomfort for a short time.

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(1)

- (e) Explain why the value for the  $M_r$  of citric acid does not need to be an exact value to deduce the molecular formula of citric acid from its empirical formula.

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(2)

- (f) Apart from misreading the gas volume, suggest **two** reasons why the volumes of gas collected may be lower than the volumes of gas produced.

Reason 1 \_\_\_\_\_

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Reason 2 \_\_\_\_\_

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(2)

- (g) Explain why it is important to record the temperature and pressure when measuring the volume of a gas.

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(1)

- (h) Suggest why, in an analysis of an antacid, it is important to test samples from more than one bottle of the antacid.

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(1)

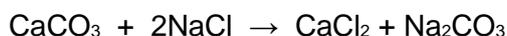


- (i) In the industrial production of sodium hydrogencarbonate, ammonia and carbon dioxide are bubbled through a saturated solution of sodium chloride. The equation for this reaction, and some solubility data, are shown below.



Compound	Solubility in water at 20 °C / g dm <sup>-3</sup>
sodium chloride	360
sodium hydrogencarbonate	96
ammonium chloride	370

- (i) Suggest **one** reason why sodium hydrogencarbonate precipitates from the reaction mixture at this temperature.
- \_\_\_\_\_
- (1)
- (ii) Explain how this reaction could be used to remove carbon dioxide from the gases formed when fossil fuels are burned.
- \_\_\_\_\_
- \_\_\_\_\_
- (1)
- (j) The thermal decomposition of sodium hydrogencarbonate produces sodium carbonate. The other products are water and carbon dioxide. Write an equation for this thermal decomposition.
- \_\_\_\_\_
- (1)
- (k) Sodium carbonate is produced on an industrial scale by a multi-step process. The equation which summarises the reactions taking place is shown below.



Calculate the percentage atom economy for the production of sodium carbonate by this reaction.

\_\_\_\_\_

(1)

(Total 20 marks)



## Q6.

(a) Mass of **X** = 0.270Volume of **X** = 105.0*Both must be correct*

1

(b)  $pV = nRT$ 

$$\frac{100\,000 \times 105 / 1000000}{8.31 \times 370} = n$$

1

$$n = 3.41 \times 10^{-3}$$

1

$$M_r = \frac{\text{mass}}{\text{mol}} \quad \text{or} \quad \frac{0.270}{3.41 \times 10^{-3}}$$

1

$$M_r = 79.1$$

1

Identity of **X** =  $\text{CH}_2\text{Cl}_2$ *If  $M_r = 52$  used, allow  $\text{CH}_3\text{Cl}$* 

1

(c) **M1** The volume of the gas in the syringe ( $V$ ) is greater than the true volume (because some air leaked into the syringe)*If the  $M_r$  value of 52 is used and  $\text{CH}_3\text{Cl}$  is identified in 01.2:*

1

**M2**  $M_r = m/n = m \times RT/PV$  so if  $V$  is too large,  $M_r$  is too small**OR****M1** The temperature measured ( $T$ ) is less than the temperature of the gas in the syringe (because the syringe heated faster than the oven and the oven temperature was not constant)**M2**  $M_r = m/n = m \times RT/PV$  so if  $T$  is too small,  $M_r$  is too small**OR****M1** The measured mass of liquid transferred to the syringe ( $m$ ) is less than the actual mass transferred**M2**  $M_r = m/n = m \times RT/PV$  so if  $m$  is too small,  $M_r$  is too small**M1** *The volume of the gas in the syringe ( $V$ ) is less than the true volume (because not all the liquid vaporised in the syringe)***M2**  *$M_r = m/n = m \times RT/PV$  so if  $V$  is too small,  $M_r$  is too large***OR****M1** *The temperature measured ( $T$ ) is greater than the temperature of the gas in the syringe (because the syringe heated more slowly than the thermometer and the oven temperature was not constant)*



**M2**  $M_r = m/n = m \times RT/PV$  so if  $T$  is too large,  $M_r$  is too large

**OR**

**M1** The measured mass of liquid transferred to the syringe ( $m$ ) is greater than the actual mass transferred

**M2**  $M_r = m/n = m \times RT/PV$  so if  $m$  is too large,  $M_r$  is too large

1

(d) Carry out in a fume cupboard

*Do not allow safety glasses / labcoat*

1

To avoid toxic vapour

1

[10]

### Q7.

(a) (i) Uses sensible scales.

*Lose this mark if the **plotted points** do not cover half of the paper.*

*Lose this mark if the graph plot goes off the squared paper*

*Lose this mark if volume is plotted on the x-axis*

1

**All** points plotted correctly

*Allow  $\pm$  one small square.*

1

Smooth curve from 0 seconds to at least 135 seconds – the line must pass through or close to all points ( $\pm$  one small square).

*Make some allowance for the difficulties of drawing a curve but do not allow very thick or doubled lines.*

1

(ii) Any value in the range 91 to 105 s

*Allow a range of times within this but not if 90 quoted.*

1

(b) (i) Using  $pV = nRT$

*This mark can be gained in a correctly substituted equation.*

1

$$100\,000 \times 570 \times 10^{-6} = n \times 8.31 \times 293$$

*Correct answer with no working scores one mark only.*

1

$$n = 0.0234 \text{ mol}$$

*Do not penalise precision of answer but must have a minimum of 2 significant figures.*

1

(ii) Mol of  $\text{ZnCO}_3 = 0.0234$

*Mark consequentially on Q6*

**M1**



1

Mass of  $\text{ZnCO}_3 = M1 \times 125.4 = 2.9(3)$  or  $2.9(4)$  g  
*If 0.0225 used then mass = 2.8(2) g*

M2  
1

(iii) Difference =  $(15.00 / 5) - \text{Ans to b}$   
*If 2.87 g used then percentage is 4.3*

M1  
1

Percentage =  $(M1 / 3.00) \times 100$   
*Ignore precision beyond 2 significant figures in the final answer*  
*If 2.82 g used from (ii) then percentage = 6.0*

M2  
1

(c) A reaction vessel which is clearly airtight round the bung

1

Gas collection over water or in a syringe

*Collection vessel must be graduated by label or markings*  
*Ignore any numbered volume markings.*

1

[13]

## Q8.

(a) (i) Volume of crater-lake solution on  $x$ -axis  
*Do not penalise missing axes labels.*  
*If axes unlabelled use data to decide.*  
*Lose this mark if axes mis-labelled.*

1

Sensible scales

*Lose this mark if **plotted points** do not cover at least half the paper or plot goes off the squared paper.*

1

All points plotted correctly +/- one square

1

(ii) Draws appropriate line of best fit, omitting point at  $20 \text{ cm}^3 / 15 \text{ cm}^3$   
*Lose this mark if the line deviated towards the anomalous result.*  
*Lose this mark if the candidate's line is doubled or kinked.*  
*Candidate does not have to extrapolate to the origin.*

1

(iii)  $16.5 \text{ cm}^3 \pm 0.5 \text{ cm}^3$   
*Accept this answer only.*



- Do not mark consequentially on candidate's graph.* 1
- (iv) Value corresponding to 10 cm<sup>3</sup> crater-lake solution / 6.00 cm<sup>3</sup>  
*Must have correct identity for explanation mark.*  
*Accept results aren't concordant.* 1
- Greatest % error from use of burette  
*Accept difficult to be accurate with small volumes (owtte).* 1
- (b) (i)  $pV = nRT$   
*Accept any correct rearrangement.*  
*Ignore case.* 1
- (ii)  $V = 81.0 \times 10^{-6}$  or  $8.1 \times 10^{-5}$  1
- $n = (1 \times 10^5 \times 81.0 \times 10^{-6}) / (8.31 \times 298)$   
*Mark consequentially on candidate's volume.* 1
- $n = 3.27 \times 10^{-3}$  (mol)  
*Correct answer without working scores one mark only.*  
*Allow consequential mark using incorrect conversion.*  
*Incorrect units lose this mark.* 1
- (iii)  $M_r \text{ CaCO}_3 = 100.1$  (M1)  
*Accept 100 (can score this mark in calculation for M2 and M3).* 1
- Moles  $\text{CaCO}_3 = (3.27 \times 10^{-3} \times 10) = 3.27 \times 10^{-2}$  (M2)  
*Do not penalise lack of units.*  
*Allow  $b(ii) \times 10$*   
*Allow  $1.25 \times 10^{-3} \times 10$*  1
- Mass  $\text{CaCO}_3 = M1 \times M2 (= 3.27 \text{ g})$   
*Correct mass without working scores one mark only.*  
*Allow  $1.25 \times 10^{-2} \times 10 \times 100.1 = 12.5 \text{ g}$*  1
- (iv)  $(3.27 / 95) \times 100$   
*Accept  $(b(iii) / 95) \times 100$ .*  
*Do not penalise precision.* 1
- 3.44 g  
*Do not penalise lack of units.*  
*Using 12.5 g gives 13.2 g*



Correct answer without working scores 2 marks.

1

- (v) Abundant / readily available  
Accept not caustic or alkaline.

Non-corrosive

Accept insoluble so safe to add in excess (owtte).

1

[17]

### Q9.

- (a) percentage of oxygen is 58.33

1

correct calculation of ratios (C 3.125, H 4.17, O 3.645)

1

clearly relates ratios to formula eg

simplifies ratios (C 1, H 1.29, O 1.17) or for H then  $3.125 \times 8 / 6 = 4.17\%$  etc

1

#### Notes

\* correct percentage of oxygen can be stated or shown clearly in a calculation

\* to score final mark must **clearly** show how ratios relate to  $C_6H_8O_7$

\* allow full credit to candidate who correctly finds

percentage of oxygen

calculates  $M_r$

shows percentage of H is 8 divided by  $M_r$

- (b) carbon dioxide /  $CO_2$

1

- (c) (i) suitable reaction vessel  
eg sealed flask or test-tube with side arm or  
eg tube in bung

1

suitable collection method

eg gas syringe / over water in measuring

eg cylinder

1

#### Notes

\* collection vessel must allow measurement of gas

\* if apparatus would leak lose second mark

\* ignore heating

\* can draw tubing as single line

\* accept 2D or 3D diagrams

\* do not need labels, and ignore mis-labelling

- (ii) (1) mass on  $x$ -axis

1

#### Notes

\* If axes unlabelled use data to decide that mass



is on the  $x$ -axis

sensible scales

1

**Notes**

\* lose this mark if the **plotted points** do not cover at least half of the paper

\* lose this mark if the graph plot goes off the squared paper

plots points correctly  $\pm$  one square

1

(2) draws appropriate straight line of best fit, omitting point at  $1.17\text{g} / 86\text{ cm}^3$

**Notes**

\* lose this mark if the line deviates towards the point at  $1.17\text{g} / 86\text{ cm}^3$

\* candidates does not have to extrapolate the line to the origin to score this mark

\* when checking for best fit, candidate's line **must** go through the origin  $\pm$  one square. Extend candidate's line if necessary

1

(3)  $129 \pm 1\text{ cm}^3$

**Notes**

\* accept this answer **only**

1

(d)  $\text{CO}_2$  / gas formed distends stomach / produces wind / increases pressure in stomach

1

(e) molecular formula has to be a simple multiple of the empirical formula

1

so approximate  $M_r$  value will distinguish between the options or equivalent wording

1

(f) gas escapes before bung inserted      any  $2 \times 1$  for

syringe sticks

carbon dioxide soluble in water

**Notes**

\* do **not** accept 'operator error' / 'inaccurate equipment' / 'equipment leaks'

2

(g) volume depends on pressure and temperature

**Notes**

\* do **not** accept 'to get a more accurate result' or equivalent wording without qualification

1



- (h) Tablets could vary between samples or equivalent wording

**Notes**

\* *do not accept 'to get a more accurate / reliable result' or 'to make a fair test' without qualification*

1

- (i) (i)  $\text{NaHCO}_3$  **least** soluble

1

(ii) exhaust gases passed into mixture of  $\text{NaCl}$  and  $\text{NH}_3$

1

- (j)  $2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$

**Notes**

\* *accept multiples*

1

- (k) 106.0 divided by 217.1  $\times$  100 = 48.8%

**Notes**

\* *ignore precision of answer*

1

**[22]**