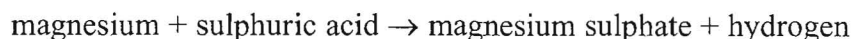




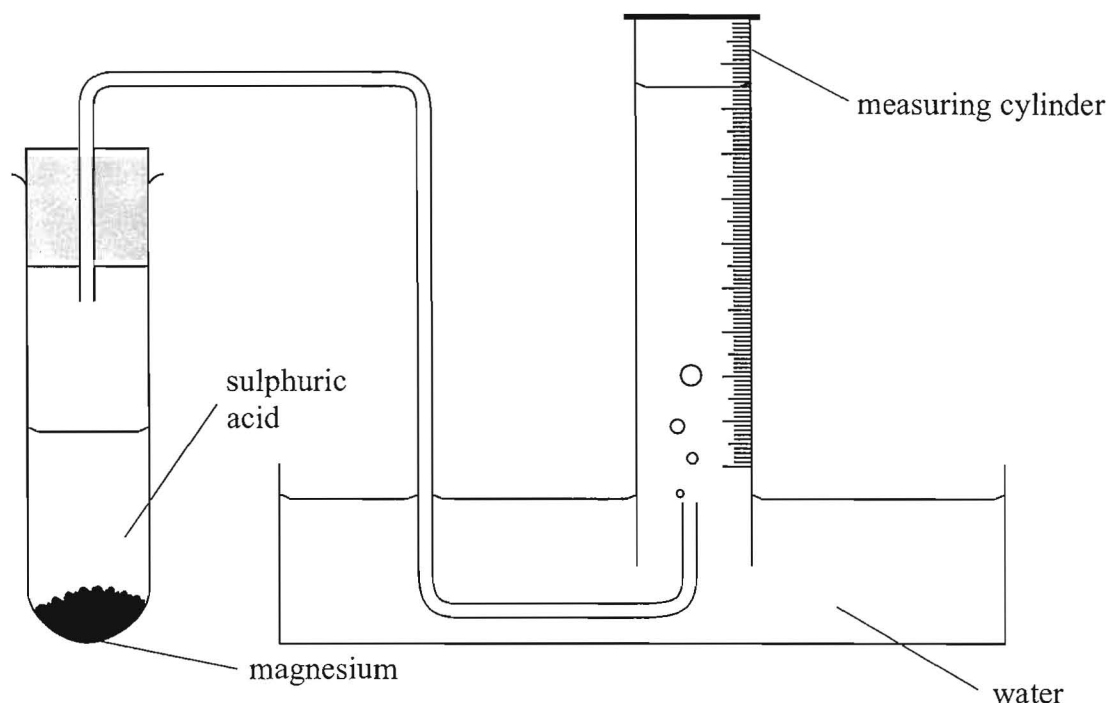
A teacher investigates how the rate of reaction between magnesium and excess sulphuric acid changes as the concentration of the acid changes.

The word equation for the reaction is:



The method she follows is:

- add concentrated sulphuric acid to water to make acid of the required concentration
- use a measuring cylinder to pour  $25\text{cm}^3$  of the diluted acid into a boiling-tube
- add magnesium to the boiling-tube and collect the gas produced as shown
- measure the volume of gas collected after 20 seconds.



- (a) State one change that could be made to the apparatus that would give more accurate results.

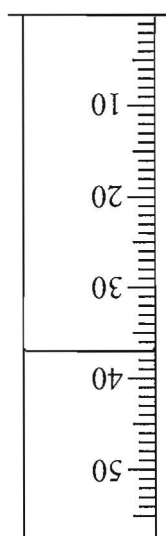
- Use pipette / burette (to measure acid volume)
- collect gas in syringe / burette

(1)

(accept idea of sealed system eg  
partitioned flask or tube in flask)  
~~and~~ t



(b) The diagram shows the level of water in the measuring cylinder after one run.



What volume of gas has been collected?

37 (cm<sup>3</sup>) (1)

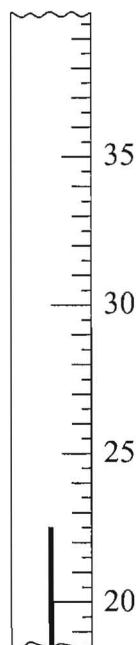
(c) On what property of hydrogen does this method of gas collection depend?

insoluble in water / no reaction  
with water (1)

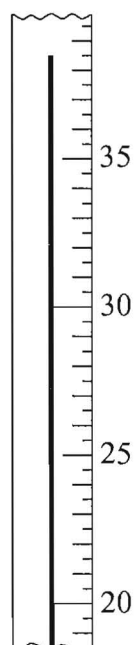


- (d) The teacher notices that the boiling-tube felt hot after the reaction.  
She repeats the experiment and uses a thermometer to measure the temperature change of the reaction mixture.
- (i) The diagrams show the thermometer readings before and after the reaction.  
Record the temperatures shown in the diagrams.

Before



After



Temperature before 22.5 °C

Temperature after 38.5 °C

(2)

- (ii) Calculate the temperature change.

16.0

(1)

- (iii) What could be done to keep the temperature of the reaction mixture more constant?

Use water bath / use bigger  
volume of acid / more acid

(1)

(reject insulation or lagging)



- (e) State two variables, other than temperature, that must be kept constant to make the investigation a fair test.

Variable 1 Same mass of magnesium  
 Variable 2 Same form of magnesium (eg powder)  
 3. same volume of acid (2)

- (f) The table shows the teacher's results.

Concentration of sulphuric acid (%)	Volume of gas (cm <sup>3</sup> ) collected in 20 seconds		
	Run 1	Run 2	Run 3
10	46	48	47
15	62	63	62
20	75	74	71
30	65	63	67
40	50	33	46
50	33	34	35
60	27	23	22

- (i) For which concentration of acid are the results most reliable?

15% / second one (1)

- (ii) One of the results is anomalous.

Circle this result and explain what may have happened to cause this anomaly.

(33 circled)  
 • gas leaked out / not collected. Acid too conc / acid less than 10% / acid cooler (2)

- (iii) Calculate the mean volume of gas collected in 20 seconds when the acid had a concentration of 60%.

24 (cm<sup>3</sup>)

Cont.

bigger pieces of metal / mass of metal too small / time less than 20 seconds (1)



(g) The rate of the reaction can be calculated using the equation:

$$\text{rate} = \frac{\text{total volume of gas collected}}{\text{total time taken to collect gas}}$$

The rate of reaction at each concentration is:

Concentration (%)	Rate
0	0.00
10	2.35
15	3.12
20	3.67
30	3.25
40	2.40
50	1.70
60	1.20

(i) Place a cross (☒) in one box to show the correct units for the rate in this experiment.

cm / s ☐

cm<sup>3</sup> / s ☒

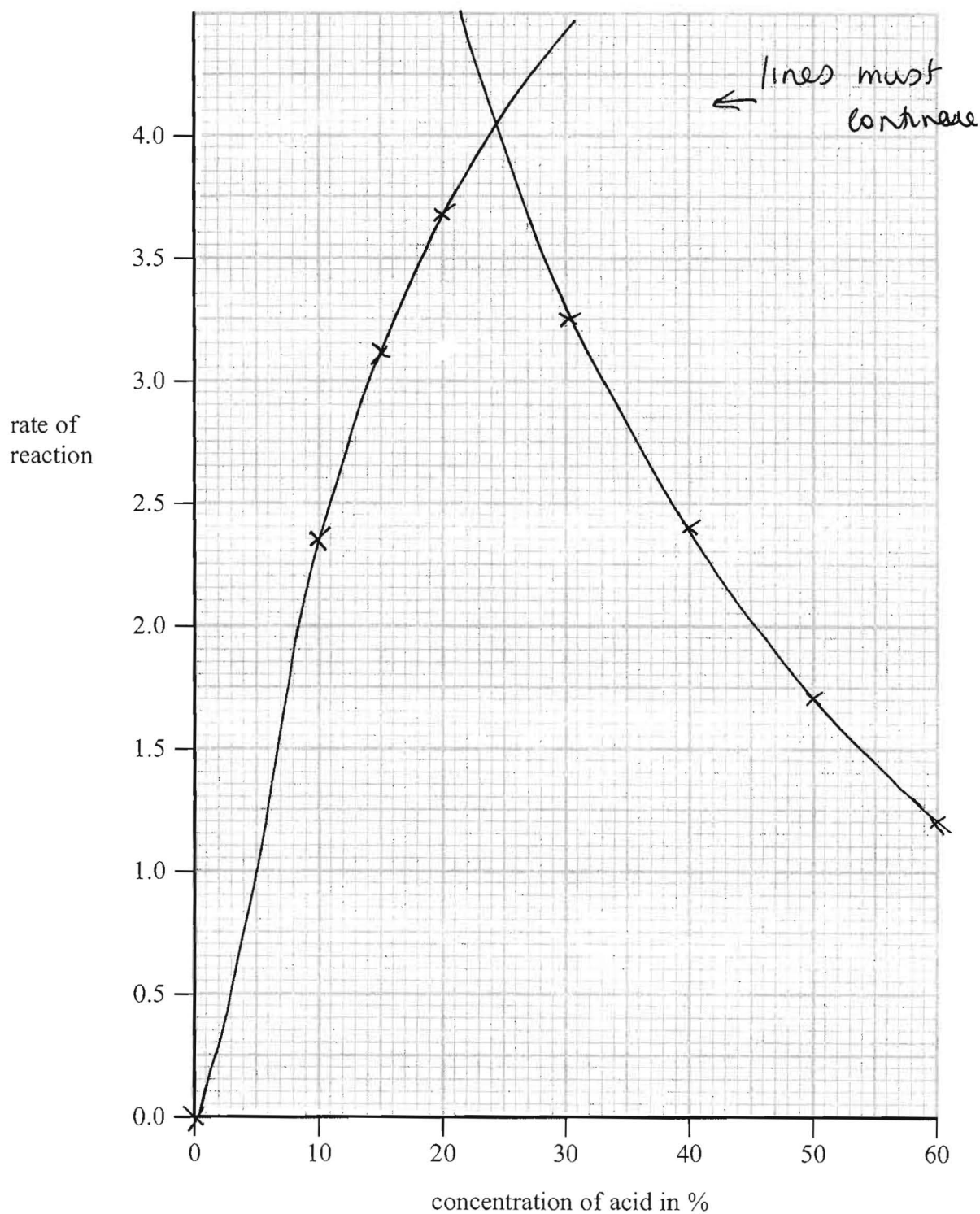
s / cm<sup>3</sup> ☐

s<sup>3</sup> / cm ☐

(1)



- (ii) Plot a graph of rate of reaction against concentration.  
 Draw two curved lines of best fit, one for the points from 0% to 20% and one for the points from 30% to 60%.  
 Extend the curved lines so that they cross.



(4)



- (h) (i) Use your graph to determine the highest rate, and the concentration of acid that will give this rate.

Highest rate .....  $4.05 \text{ cm}^3/\text{s}$  ..... } read correctly  
Concentration .....  $24.5\%$  ..... } from graph  
(2)

- (ii) Use your answers to (h)(i) to calculate the volume of gas that would be collected in 20 seconds at this concentration.

$(4.05) \times 20$   
or  $4.05 \times 20 \Rightarrow 81 \text{ cm}^3$   
(1)

- (iii) What further practical work would you do to check the accuracy of your calculated volume in (h)(ii)?

- Repeat experiment using same concentrations
  - Measure gas volume collected  
(in 20 seconds)
- (2)

Q3

(Total 23 marks)

TOTAL FOR PAPER: 50 MARKS

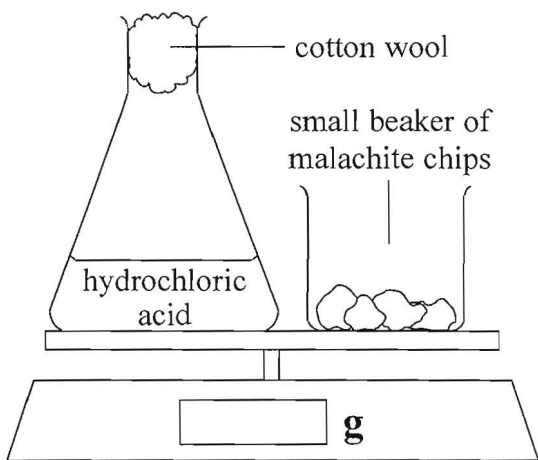
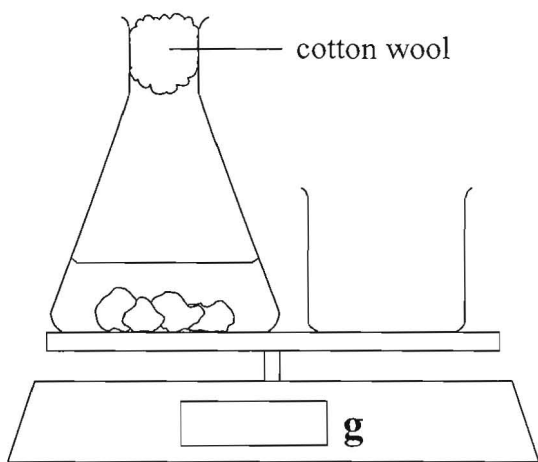
END



2. Malachite chips, containing copper(II) carbonate, react with hydrochloric acid.



Some students investigate the effect of changing the concentration of acid on the rate of the reaction. They use this method.

	<p>Pour some hydrochloric acid into a flask and place it on a balance.</p> <p>Place a beaker of malachite chips (an excess) on the balance.</p> <p>Set the balance to zero.</p>
	<p>Add the malachite chips to the flask and replace the cotton wool.</p> <p>At the same time start a stopwatch.</p>

The balance shows the loss in mass as carbon dioxide gas is given off.

After 1 minute the reading on the balance is recorded.

Some students repeat the experiment at the same temperature using acid with the same volume but a different concentration.

- (a) Suggest **two** features of the malachite chips that need to be the same to ensure that the experiment is a fair test.

- 1 mass/weight/number of moles
- 2 surface area/size (of chips)

(2)





- (b) The teacher gave four students some dilute hydrochloric acid that was labelled 100%. They did some experiments using different dilutions of this acid. They wrote down these results.

Student 1 When the concentration of acid was 100% the reading on the balance was -1.12 grams after 1 minute

Student 2 The flask lost 0.87 g in one minute when I used 75% hydrochloric acid

Student 3 The mass of gas given off was 0.62 g when there were no more bubbles coming from the malachite chips and the acid was 50%

Student 4 0.24 grams of carbon dioxide were given off in 60 seconds when the acid concentration was 25%

- (i) Which student wrote down results that cannot be compared with the other three? Explain your choice.

Student .....3.....

Explanation .....did not do expt for 1 minute/did not record time/ waited for bubbles to stop/ waited for reaction to end. (2)

- (ii) Draw a suitable table using column headings that show what was recorded, with units. Enter the three results that can be used.

Concentration (of acid) (%)	Mass of gas lost (g) (OWTTE) (4)
100%	1.12
75%	0.87
25%	0.24

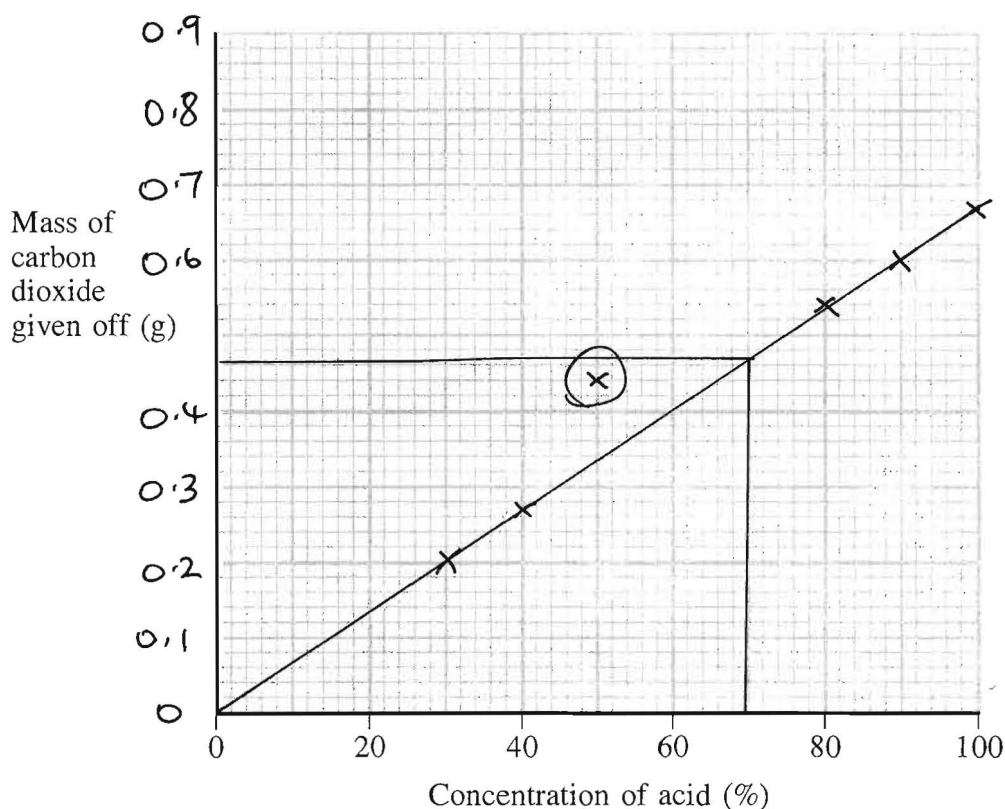


- (c) Another group of students repeated the experiment, but using a mixture of sulphuric acid and water instead of hydrochloric acid.

The table shows the results obtained by the students.

Mass of carbon dioxide given off (g)	0.20	0.27	0.44	0.54	0.60	0.67
Volume of sulphuric acid (cm <sup>3</sup> )	30	40	50	80	90	100
Volume of water (cm <sup>3</sup> )	70	60	50	20	10	0
Concentration of acid (%)	30	40	50	80	90	100

- (i) Choose a suitable scale for the mass of carbon dioxide given off. Plot these results on the grid below and draw the line of best fit.



(4)

- (ii) Circle on the graph one result that is anomalous.

(1)

- (iii) Suggest **two** errors in the experiment that may have caused this anomalous result.

any  
2

- 1 Cotton wool not put in flask / acid spray escaped / acid too concentrated / too
- 2 much acid / temp too high / gas collected longer than 1 minute / malachite pieces smaller (or larger surface area) (2)



- (iv) Use your graph to estimate the mass of carbon dioxide given off when the acid concentration is 70%. Show on your graph how you have obtained your answer.

need lines on graph

0.46 - 0.48 allowed

(2)

- (d) (i) Describe the relationship between the mass of carbon dioxide given off in one minute and the concentration of the acid.

• mass of  $\text{CO}_2$  increases as the concentration increases

• directly proportionally / mass doubles<sup>(2)</sup> as conc. doubles

- (ii) Give an explanation for this relationship.

• more collisions between particles

• correct reference to frequency  
or time

e.g. "Collisions are more frequent" (2)

(Total 21 marks)

Q3

or "more collisions in a given time"

