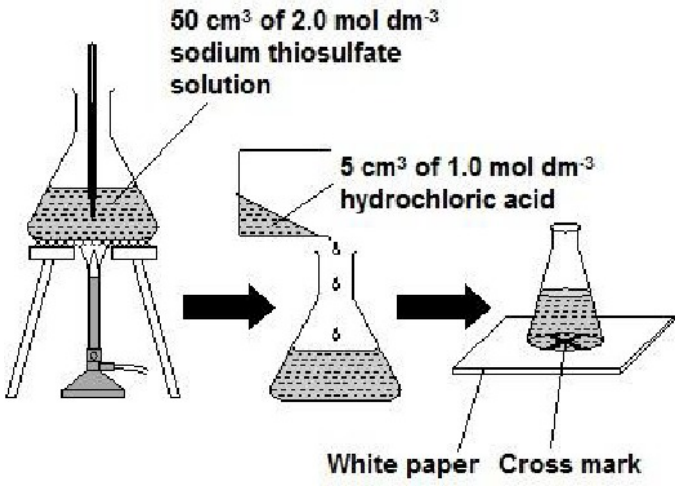
1. This question is about rates of reaction.

Mark investigates the reaction between sodium thiosulfate and hydrochloric acid at different temperatures.

Look at how Mark does the experiment.



1 He measures 50 cm^3 of sodium thiosulfate into the conical flask and heats it to the required temperature. He records the temperature.
2 He takes the flask off the tripod and gauze and places it on the bench.
3 He adds 5 cm^3 of hydrochloric acid and then places the flask on the cross.
4 He times how long it takes for the cross to disappear.

How should Mark improve his method?

Explain your answer.

---

[2]

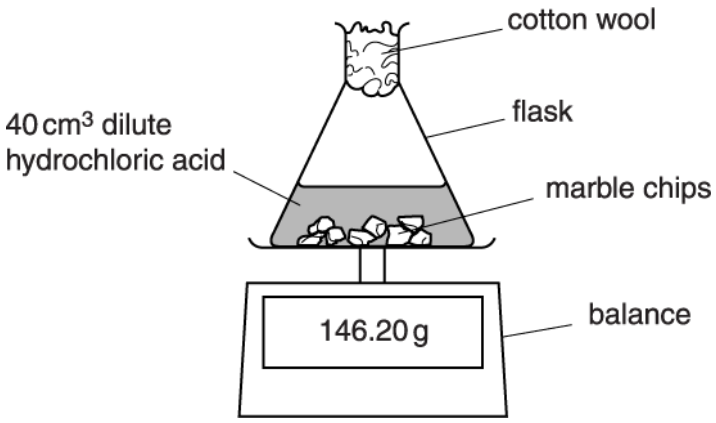
2. This question is about rates of reaction.

Julie and Trevor investigate the reaction between marble chips (calcium carbonate) and dilute hydrochloric acid.

They use 20.0 g of marble chips and 40 cm^3 of dilute hydrochloric acid.

The temperature of the acid is 25 °C.

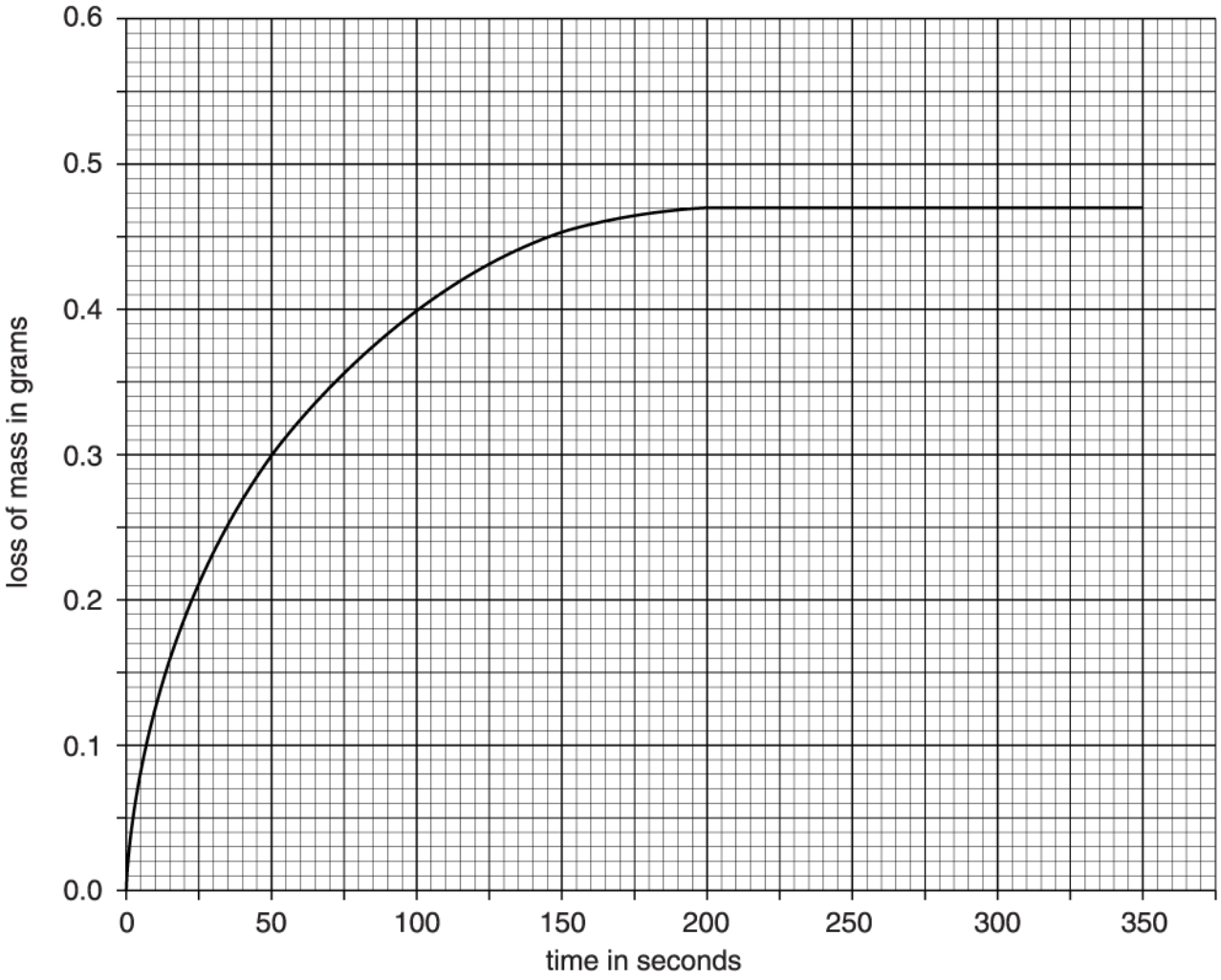
Look at the diagram. It shows the apparatus they use.



They measure the mass every 50 seconds until the reaction stops.

They calculate the loss in mass.

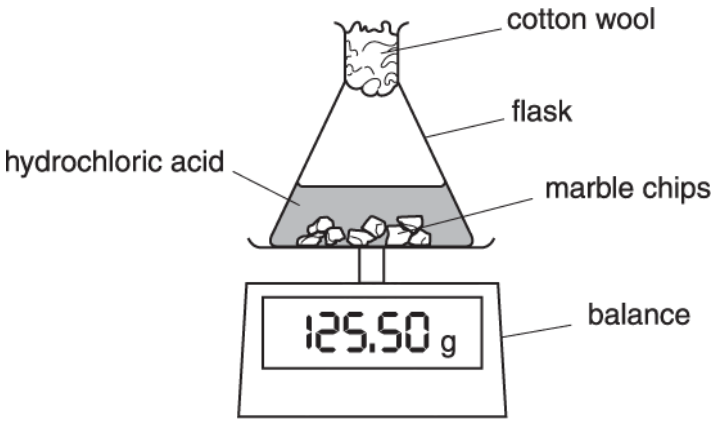
Look at the graph on the next page.



How long does it take for the reaction to stop?

_____ seconds **[1]**

3. Harneet investigates the reaction of marble chips with hydrochloric acid.



The total mass of the flask and its contents decreases during the experiment.

Harneet records this decrease every 4 minutes.

She does the experiment with large marble chips.

She repeats the experiment with small marble chips.

Look at her results.

Time in minutes	Loss in mass in g	
	Large marble chips	Small marble chips
0	0	0
4	0.4	0.8
8	0.8	1.4
12	1.2	1.6
16	1.5	1.7
20	1.7	1.7

(i) Look at the results for **small** marble chips.

How long does it take for the reaction to finish?

answer _____ minutes **[1]**

(ii) Harneet wants to choose the best way to present her results.

How should she present her results?

Choose from the list.

bar chart

histograph

line graph

pie chart

[1]

4. Magnesium, Mg, reacts with hydrochloric acid, HC*l*.

Hydrogen, H_2, and magnesium chloride, $MgCl_2$, are made.

Peter adds 0.10 g of magnesium powder to 25.0 dm^3 of dilute hydrochloric acid.

The mean (average) rate of this reaction is 50 cm^3 of hydrogen per minute.

(i) Estimate the total volume of hydrogen made in the first 3 minutes.

volume of hydrogen = ---------- cm^3 [1]

(ii) Peter repeats this experiment but uses magnesium lumps instead of powder.

The average rate of reaction is 10 cm^3 of hydrogen per minute.

Use the reacting particle model to explain why.

---

[2]

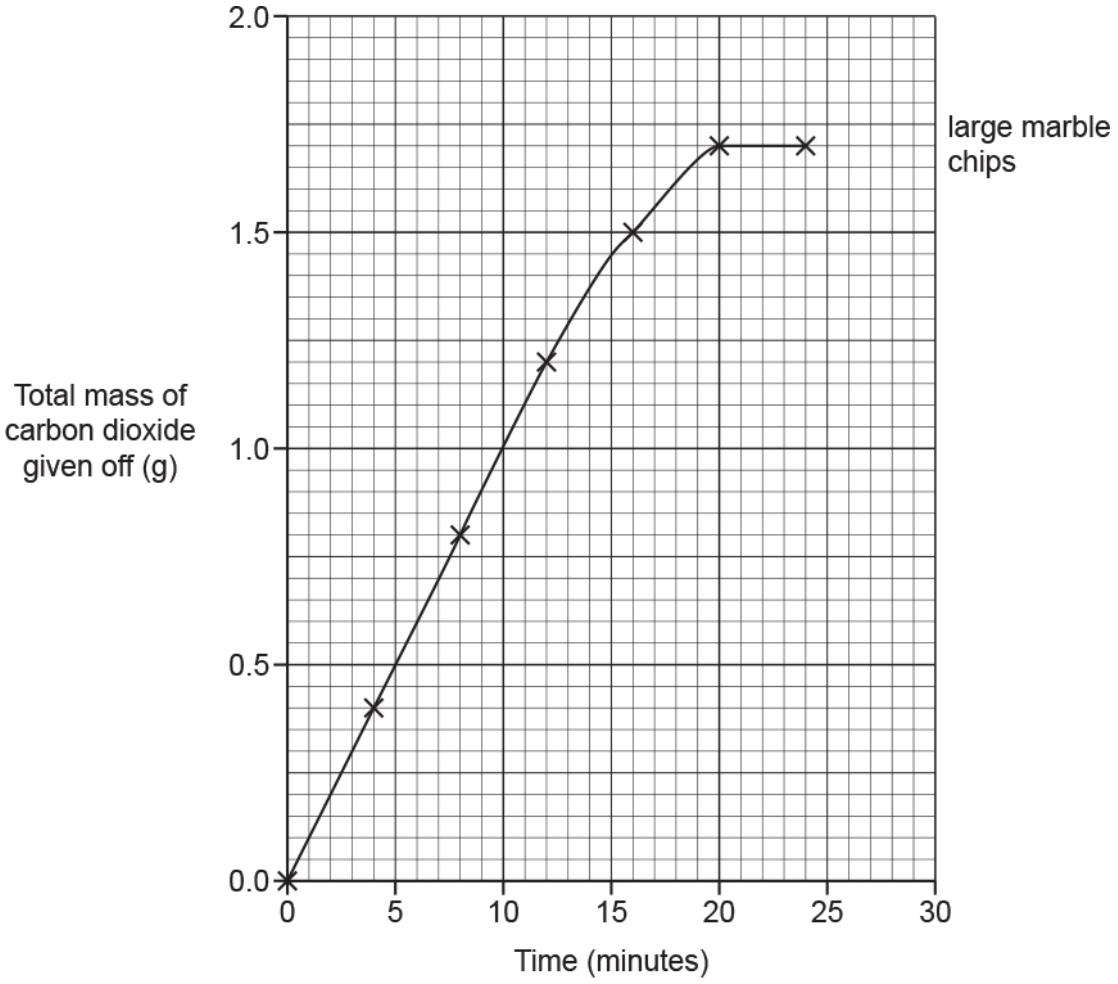
5(a). A student investigates the rate of reaction between marble chips and hydrochloric acid.

Both experiments use 50 cm^3 of hydrochloric acid and an excess of marble chips.

He measures the total mass of carbon dioxide given off for different sizes of marble chips.

Look at his results.

Time (minutes)	Total mass of carbon dioxide given off (g)	
	Large marble chips	Small marble chips
0	0.0	0.0
4	0.4	0.8
8	0.8	1.4
12	1.2	1.6
16	1.5	1.7
20	1.7	1.7
24	1.7	1.7



The student has plotted his results for the large marble chips on the graph.

(i) Plot the results for the **small** marble chips. **[2]**

(ii) Draw a line of best fit. **[1]**

(b). Look at the line for the **large** marble chips.

(i) How long does it take for the reaction to finish?

Answer = ---------- minutes **[1]**

(ii) What mass of carbon dioxide is given off after 15 minutes?

Answer = ---------- g **[1]**

(c). The reaction is faster with small marble chips.
Write down **two** ways that the graph shows this is correct.

1 ----------

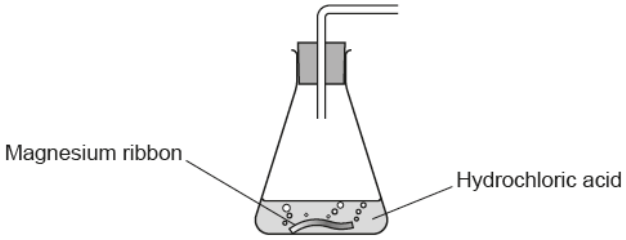
---

2 ----------

---

[2]

6. A student investigates the rate of reaction between magnesium and hydrochloric acid. The reaction gives off hydrogen gas.



The student wants to investigate how changing the **concentration** of the hydrochloric acid affects the rate of reaction.

Look at her plan.

First experiment

I will put 0.5 g of magnesium ribbon into the flask.

I will add 50 cm^3 of hydrochloric acid.

I will measure how fast the gas is given off.

Second experiment

I will put another 0.5 g of magnesium ribbon into the flask.

I will add 100 cm^3 of the same hydrochloric acid.

I will measure how fast the gas is given off.

Another student thinks that the plan will not work and he does not understand exactly what he has to do.

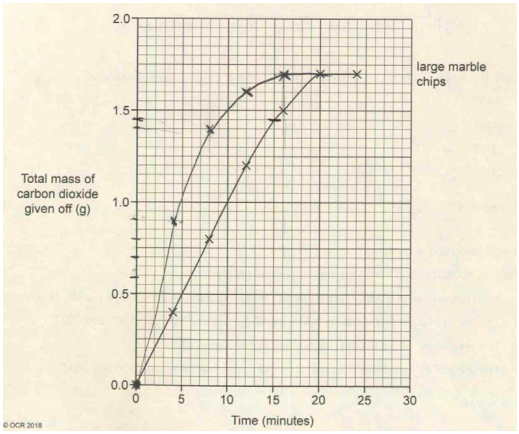
Suggest how the plan for this investigation can be improved.

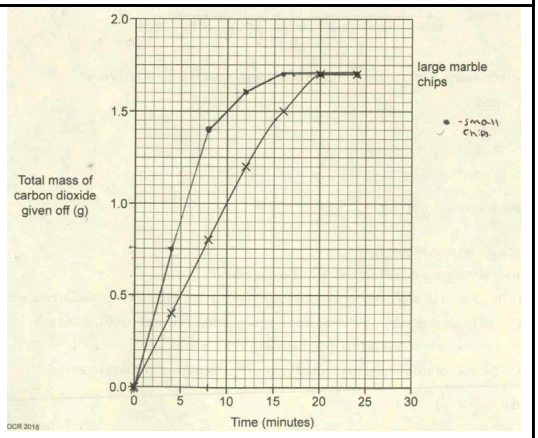
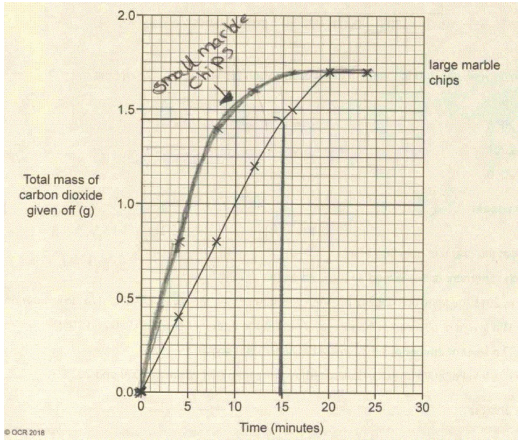
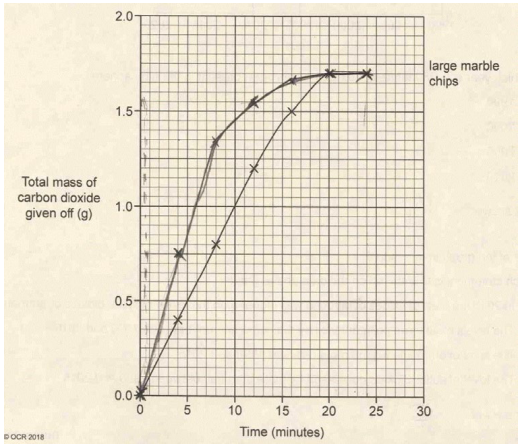
--- [4]

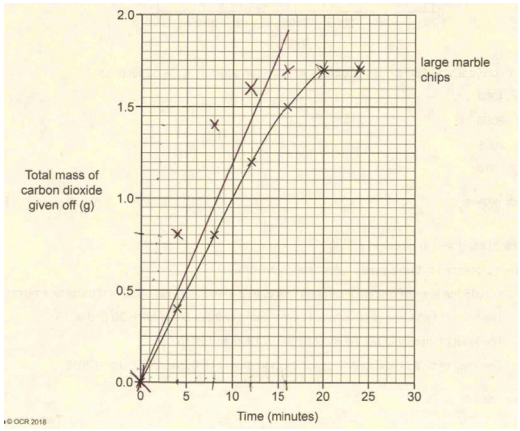
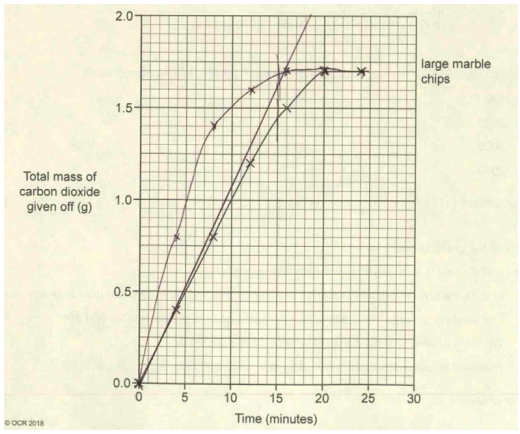
END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			measure temperature of sodium thiosulfate and acid mixture (1) (because) temperature will be different from sodium thiosulfate solution alone (1) **OR** place flask on cross before adding acid (1) idea that reaction has started before timing begins / idea that moving flask will increase mixing (1)	2	**ALLOW** measure temperature of sodium thiosulfate solution when it has been removed from tripod (1) (because) temperature will continue to rise after flask is removed from tripod (1)
			Total	2	
2			200 (seconds) (1)	1	**allow** any answer in range 190–200 seconds (1) **ignore** units **Examiner's Comments** Most candidates could read 200 seconds off the graph and scored the mark.
			Total	1	
3		i	16 (minutes) (1)	1	**allow** 13,14 or 15 (1) Examiner's Comments The majority of candidates gave 16 minutes as the correct answer for the time taken for the reaction to finish, although 1.7 and 20 were common incorrect answers.
		ii	line graph (1)	1	**allow** correct answer ticked, circled or underlined in list if answer line is blank Examiner's Comments The majority of candidates correctly chose line graph as the way to present the results. A few chose bar chart, while others chose histograph.
			Total	2	
4		i	150 (cm^3) (1)	1	**ignore** units **allow** 0.15 dm^3

Question			Answer/Indicative content	Marks	Guidance
		ii		2	**assume answer refers to magnesium** **lumps answers must be comparative**
			(lumps) have small**er** surface area / have less exposed particles (1)		**allow** ora if powder specified **ignore** references to volume
			(lumps) have less collisions (per second) (1)		**allow** ora if powder specified **allow** lower chance of collisions / less frequent collisions / less successful collisions (1) **allow** collisions less likely for lumps (1) **ignore** references to speed e.g. collisions are slower
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
5	a	i	6 points plotted correctly ✓ ✓	2 (AO 2 × 2.2)	ALLOW ± ½ square 4 points plotted correctly 1 mark. Examiner's Comments Many candidates found the scale on the y-axis challenging, 4 minutes was often plotted at 0.65 and 16 minutes at 1.60.
		ii	curve passing through all the points ✓	1 (AO 2.2)	ecf on their points one line, not feathery, not thicker than half a small square Examiner's Comments Candidates found the line challenging. Many candidates drew thick or feathery lines, joined the points with a ruler drew multiple lines or drew a curve and a straight line. Exemplar 1  This is an example of a good line of best fit. Exemplar 2

Question	Answer/Indicative content	Marks	Guidance
			 Many candidates joined the points with straight lines drawn with a ruler. Exemplar 3  Some candidates drew thick or feathery lines. Exemplar 4 

Question			Answer/Indicative content	Marks	Guidance
					Some candidates drew multiple lines. Exemplar 5  Some candidates drew one straight line. Exemplar 6  Some candidates drew a best fit curve and a straight line.
	b	i	20 (minutes) ✓	1 (AO 2.2)	<u>Examiner's Comments</u> Many candidates gave 24 minutes which is the time of the last reading rather than when the graph stopped rising at 20 minutes

Question			Answer/Indicative content	Marks	Guidance
		ii	1.45 (g) ✓	1 (AO 2.2)	ALLOW 1.4 to 1.5 Examiner's Comments Some candidates misread the scale and 1.7 was a popular incorrect response.
	c		idea that slope or gradient of line for small chips is (twice as) steep(er) / ORA ✓ small chips reaction finishes (3 to 5 minutes) before (large chips reaction)/ ORA ✓	2 (AO 2 × 3.1b)	IGNORE all points are higher (0 isn't) ALLOW line goes up faster ALLOW finishes earlier / small finishes at 16 and large at 20 ALLOW small chips get to 1.7 before the large chips ALLOW (smaller chips have) given off a larger mass in a named time / earlier Examiner's Comments Many candidates rewrote the stem of the question or answered in terms of the reaction rather than the graphs. Many discussed the points being closer together or further apart or thought that more gas was evolved by the small marble chips. Steepness of the line was the more common correct response and higher ability candidates gained full credit.
			Total	7	

Question			Answer/Indicative content	Marks	Guidance
6			**Any four from:** (plan should) state how to measure how fast gas is given off/ **AW**✓ use gas syringe or (upturned) measuring cylinder / burette (filled with water) / counting bubbles✓ measure volume (of gas) given off in a fixed time ✓ **or** measure volume of gas every x seconds ✓ **or** could time how long until no more gas is given off or reaction has finished ✓ doubling the volume of acid does not double the concentration of acid✓ need to use an equal volume of acid✓ need to change the concentration ✓ use the same temperature ✓	4 (AO 2×3.3a) (AO 2×3.3b)	**ALLOW** balance / scales **ALLOW** amount for volume or mass throughout **ALLOW** mass in place of volume of gas if balance used **DO NOT ALLOW** volume in place of mass if balance used **ALLOW** changing the volume of acid does not change the concentration of acid **IGNORE** investigate how changing concentration affects rate **ALLOW** (always) use 50 cm^3 of acid **IGNORE** do repeats / carry out risk assessment **Examiner's Comments** This question requires candidates to evaluate the plan and make suggestions for improvements. No marks were credited for repeating the experiment as this does not improve the plan. This question was not generally done well. It is important that candidates are given the chance to evaluate plans when carrying out practical work. They will have to apply this skill to unfamiliar contexts such as this one. Many candidates were able to suggest a suitable way to measure how fast the gas was given off. Some just stated they needed to measure the gas given off and this was insufficient for a mark. Many suggested using a gas syringe or counting bubbles

Question			Answer/Indicative content	Marks	Guidance
					which are both creditworthy. Few understood that changing the volume did not change the concentration. A few were able to give control variables. Some candidates suggested using a balance to measure change in mass. This is a reasonable suggestion based on their knowledge. It is unlikely to work as hydrogen is given off. The hydrogen lost would make little measurable difference to the mass. This knowledge was not was being tested. So the idea of using a balance was credited. Candidates who do not gain many marks misunderstood the point of the question and gave answers to do with the writing of the plan, e.g. use bullet points or list apparatus. Some candidates suggested the mass of magnesium needed altering showing a complete lack of understanding of the investigation altogether.
			Total	4	