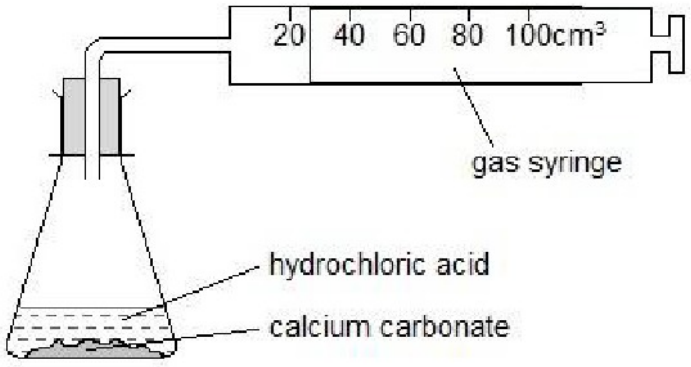
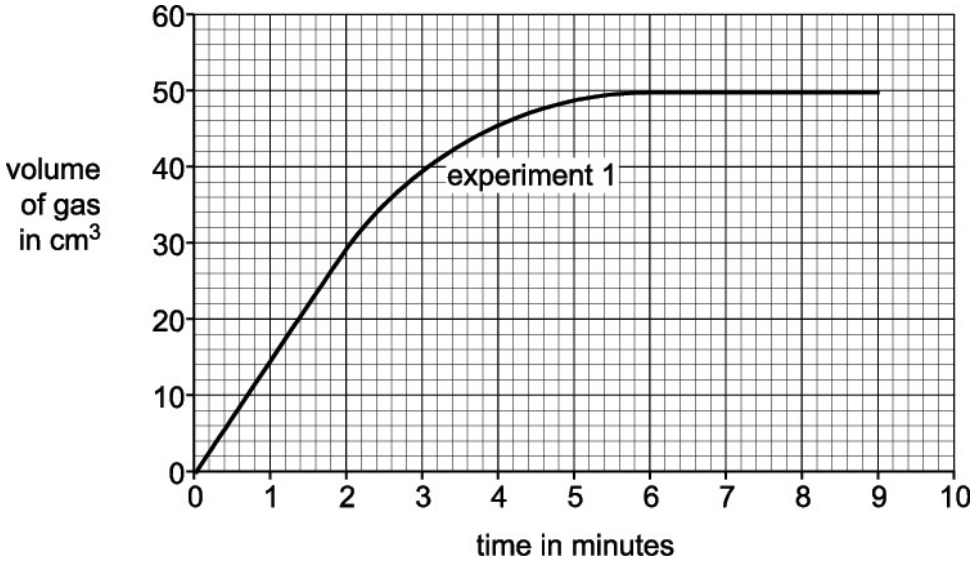
1. Alfie investigates the reaction between calcium carbonate and hydrochloric acid.

Look at the diagram. It shows the apparatus he uses.



Look at the graph. It shows his results for the experiment.



What is the rate of reaction between 0 and 2 minutes in cm^3/minute?

A 7.5 cm^3/minute
B 15 cm^3/minute
C 30 cm^3/minute
D 60 cm^3/minute

Your answer ☐

[1]

2. Explain why the rate of reaction of sodium thiosulfate and hydrochloric acid is different at different temperatures.

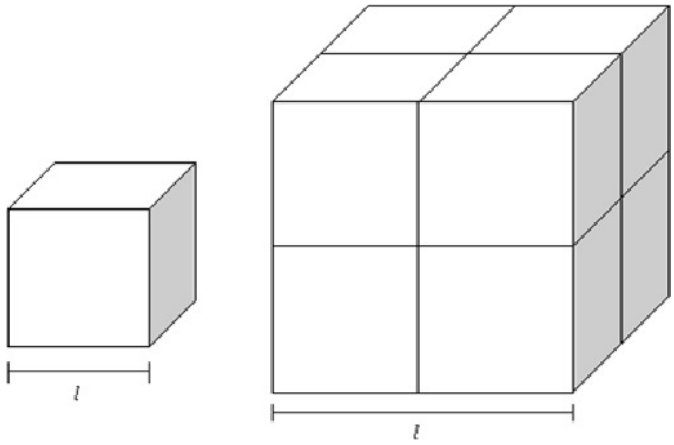
---

[2]

3(a). William investigates the reaction between calcium carbonate and hydrochloric acid.

He thinks the reaction will be faster if he uses smaller pieces of calcium carbonate.

He uses different sized cubes of calcium carbonate.



William finds out that the larger the surface area to volume ratio, the faster the reaction.

The surface area to volume ratio for a cube with *l* = 1cm is 6.0.

Calculate the surface area to volume ratio for a cube with *l* = 5cm.

surface area to volume ratio _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

[3]

(b). William reacts hydrochloric acid with excess calcium carbonate to produce carbon dioxide gas.

He measures the rate at which the carbon dioxide gas is produced.

He finds that when he uses cubes of calcium carbonate with l = 5cm the gas is produced at a rate of 1.6 cm^3 per second.

William assumes the surface area to volume ratio is proportional to the rate.

Predict the rate of reaction for cubes of calcium carbonate with l = 1 cm.

Use your answer to the previous question part to help you answer.

rate of reaction _____ cm^3 per s

[2]

(c). Other factors affect the rate of a reaction.

The graph below shows the rate of a reaction in which a gas product is made at 60 °C, without a catalyst.

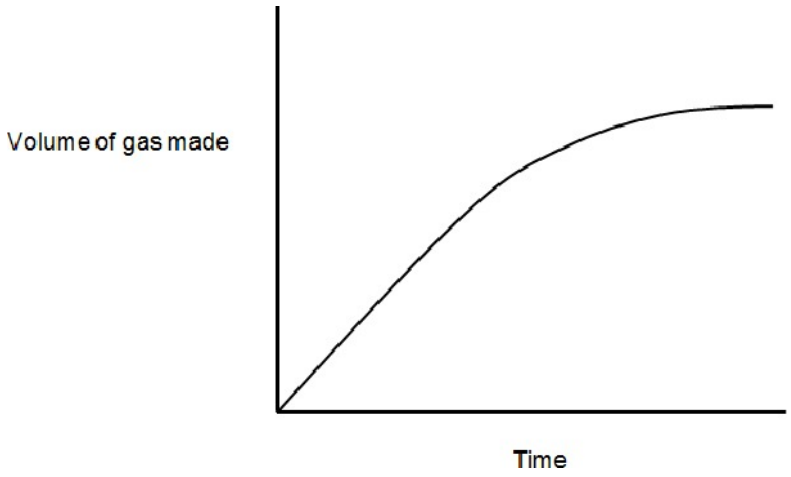
Add two curves to this graph:

(i) One for the same reaction which is carried out at 30 °C, without a catalyst. Label the line, **A**.

[1]

(ii) One for the same reaction which is carried out at 60 °C, with a catalyst. Label the line, **B**.

[1]

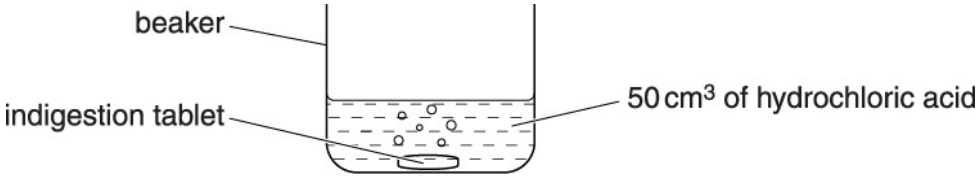


4. This question is about rates of reaction.

Indigestion tablets neutralise acids.

Chris investigates indigestion tablets.

He adds an indigestion tablet to 50 cm^3 of hydrochloric acid.



Chris measures the time it takes for the indigestion tablet to react completely.

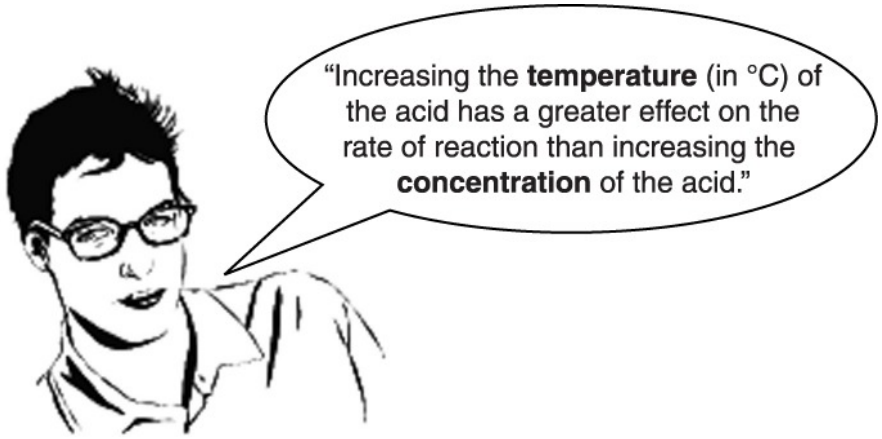
He then calculates the relative rate of reaction.

He does four experiments.

Look at his results.

Experiment	Volume of acid in cm^3	Relative concentration of acid	Temperature of acid in °C	Relative rate of reaction
1	50	2.0	40	8
2	100	2.0	20	2
3	50	2.0	20	2
4	50	1.0	20	1

Chris uses his results to make a conclusion.



Is Chris correct? Use his results to justify your answer.

Explain, using the reacting particle model, why **increasing** the temperature **increases** the rate of reaction.

The quality of written communication will be assessed in your answer to this question.

[6]

5. Reactions are faster at **higher temperatures**.

Write down **two** other ways of making reactions faster.

[2]

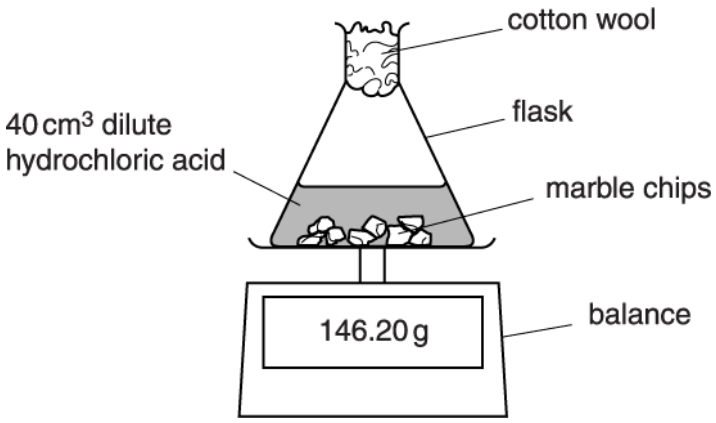
6(a). This question is about rates of reaction.

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.

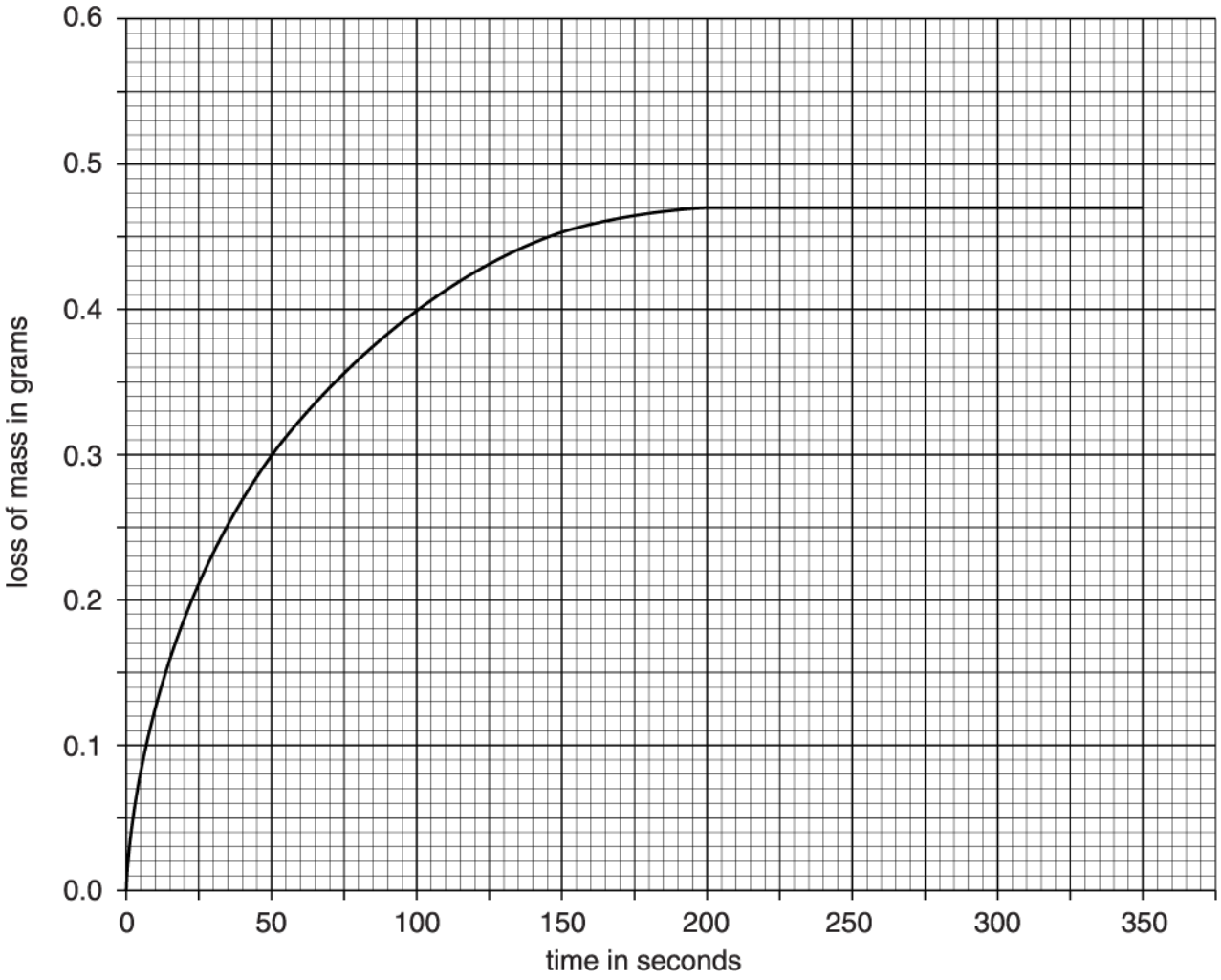
Look at the diagram. It shows the apparatus they use.



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]**

(b). Some marble chips are still left at the end of the experiment.

The hydrochloric acid is the **limiting reactant**.

What is meant by the limiting reactant?

_____

_____ **[1]**

7(a). Jan and Mike investigate the reaction between magnesium lumps and hydrochloric acid, HC*l*.

Magnesium chloride solution, $MgCl_2$, and hydrogen gas, H_2, are made.

Increasing the temperature of the hydrochloric acid increases the rate of the reaction.

Use the reacting particle model to explain why.

---

[3]

(b). Breaking the lumps of magnesium into a **powder** increases the rate of the reaction.

Use the reacting particle model to explain why.

---

[2]

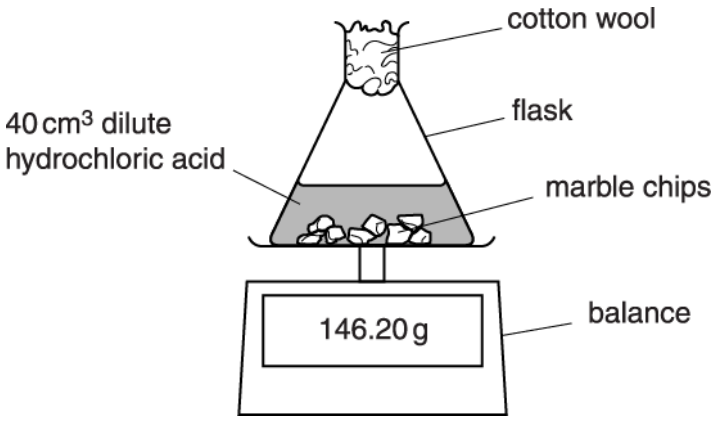
8(a). This question is about rates of reaction.

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.

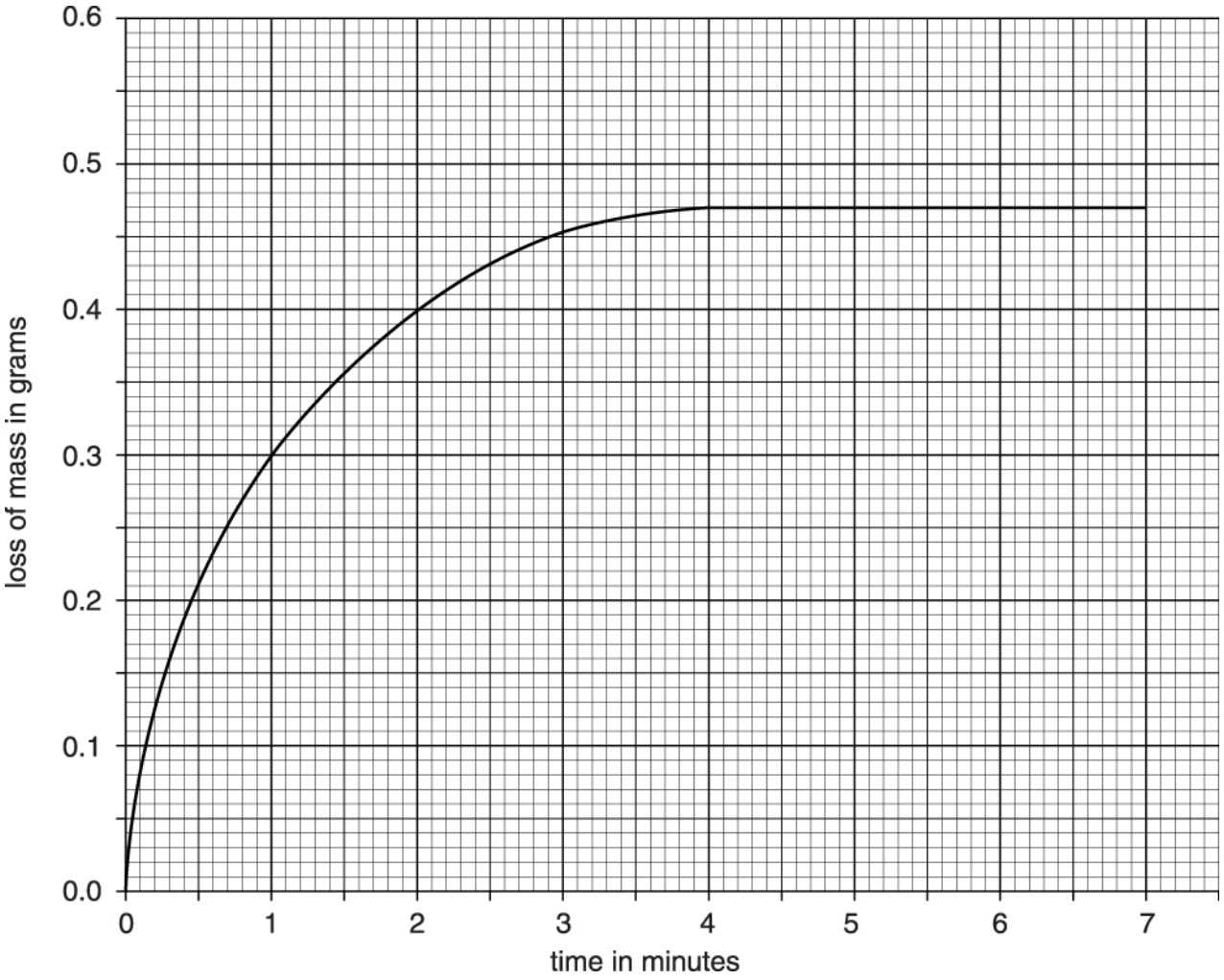
Look at the diagram. It shows the apparatus they use.



They measure the mass every minute until the reaction stops.

They calculate the loss in mass.

Look at the graph on the next page.



(i) Julie and Trevor repeat the experiment using different sized marble chips.

They use the same volume of hydrochloric acid at the same temperature.

Look at the results for their second experiment.

Time in minutes	0	1	2	3	4	5	6	7
Loss of mass in grams	0	0.20	0.36	0.43	0.46	0.47	0.47	0.47

Plot their results on the graph. Draw the best line through the points.

[2]

(ii) What do the results tell you about the size of the marble chips in the second experiment compared to their

first experiment?

Explain your answer.

---------- [1]

(b). Julie and Trevor can increase the rate of reaction between marble chips and hydrochloric acid by:

- increasing the concentration of the hydrochloric acid
- increasing the temperature of the hydrochloric acid.

Explain, in terms of the reacting particle model, why both these methods increase the rate of this reaction.

The quality of written communication will be assessed in your answer to this question.

---------- [6]

9. Jan and Mike investigate the reaction between magnesium lumps and hydrochloric acid.

Magnesium chloride solution and hydrogen gas are made.

Jan and Mike want to speed up the reaction.

They do not want to change the mass of magnesium or the volume of the hydrochloric acid.

They know that using magnesium powder changes the speed of the reaction.

Write about **other** ways they could speed up the reaction.

---

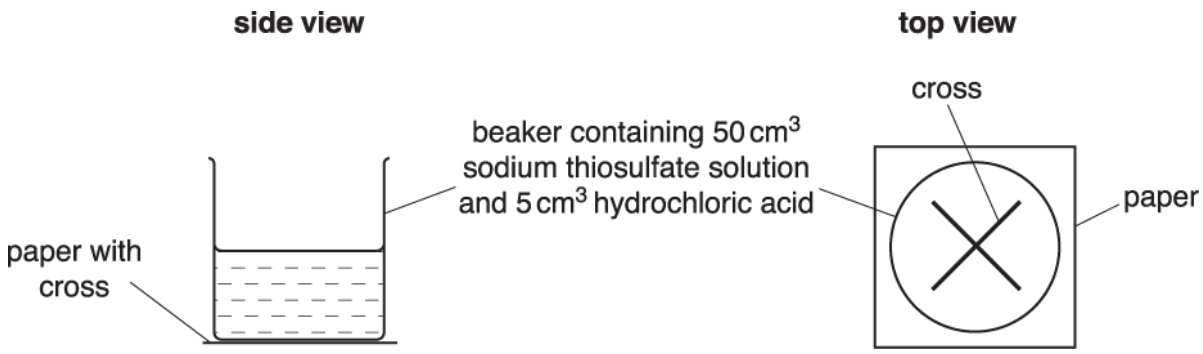
[3]

10(a) Harneet and Mike investigate the reaction between sodium thiosulfate, $Na_2S_2O_3$, and hydrochloric acid, HC*l*.

.

Sodium chloride NaC*l*, sulfur dioxide SO_2, sulfur S and water H_2O are made.

Look at the diagram. It shows their experiment.



Harneet and Mike look down at the cross.

The liquid in the beaker goes cloudy.

After a time they cannot see the cross on the paper.

Harneet and Mike measure this time. This is the reaction time.

They do the experiment at four different temperatures.

They repeat the experiment at each temperature.

Look at their results.

Temperature in °C	Reaction time in seconds	
	1st	2nd
20	51.9	48.2
30	39.7	40.1
40	29.2	27.9
50	16.7	17.4

At which temperature is the reaction **fastest**?

---------- [1]

(b). Mike thinks the reaction will be faster if they use a **more concentrated** solution of sodium thiosulfate.

Explain, in terms of the reacting particle model, why this reaction is faster.

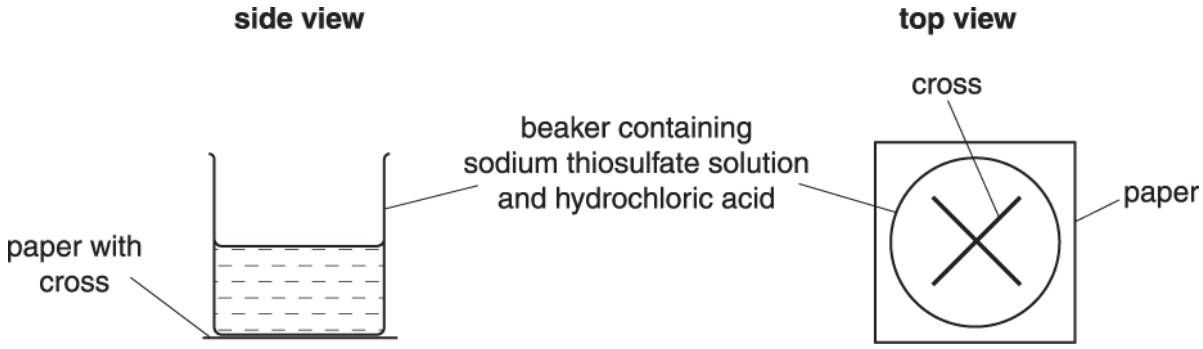
---

[2]

11(a) Harneet and Mike investigate the reaction between sodium thiosulfate and hydrochloric acid.

.

Look at the diagram. It shows their experiment.



Harneet and Mike look down at the cross.

The liquid in the beaker goes cloudy.

After a time they cannot see the cross on the paper.

Harneet and Mike measure this time. This is the reaction time.

They do the experiment four times at 20°C.

They use four different concentrations of sodium thiosulfate solution, **A**, **B**, **C** and **D**.

Look at their results.

Concentration	Reaction time in seconds
A	43
B	72
C	124
D	61

Which is the **most concentrated** solution of sodium thiosulfate?

Choose from **A**, **B**, **C** or **D**.

[1]

(b). Changing the concentration of sodium thiosulphate changes the rate of this reaction.
Write about **two other** ways of speeding up this reaction.

---

[2]

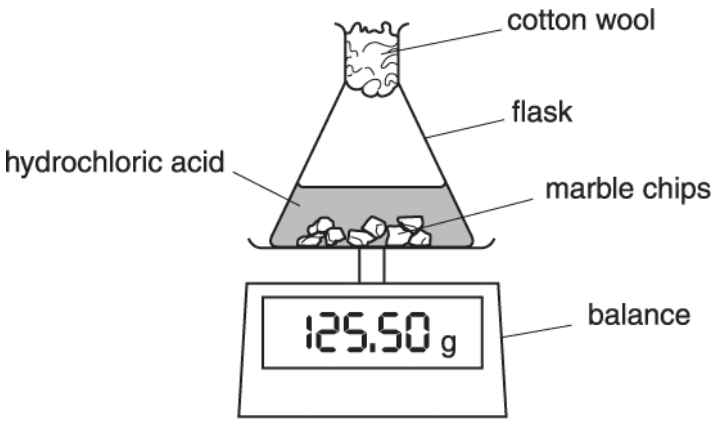
(c). Eventually the reaction stops.

Explain why.

---

[1]

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

How should she present her results?

Choose from the list.

bar chart

histogram

line graph

pie chart

answer _____ [1]

(ii) Harneet thinks that the reaction is faster with **small** marble chips.

Is she correct?

Use her results to give **two** reasons to explain your answer.

_____

_____

_____

_____ [2]

12. Magnesium reacts with hydrochloric acid.

Hydrogen and magnesium chloride 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 mean rate of reaction is 10 cm^3 of hydrogen per minute.

Use the reacting particle model to explain why.

---

[2]

(iii) Peter repeats the experiment with magnesium lumps but also adds a catalyst.

Predict a value for the mean rate of reaction.

---------- cm^3 of hydrogen per minute [1]

13. 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]

14. Which statement about catalysts is correct?

A A catalyst decreases the rate of many different reactions.

B A catalyst for one reaction will be the catalyst for many different reactions.

C A catalyst has no effect on the rate of the reaction.

D A catalyst usually increases the rate of a reaction.

Your answer [ ] [1]

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

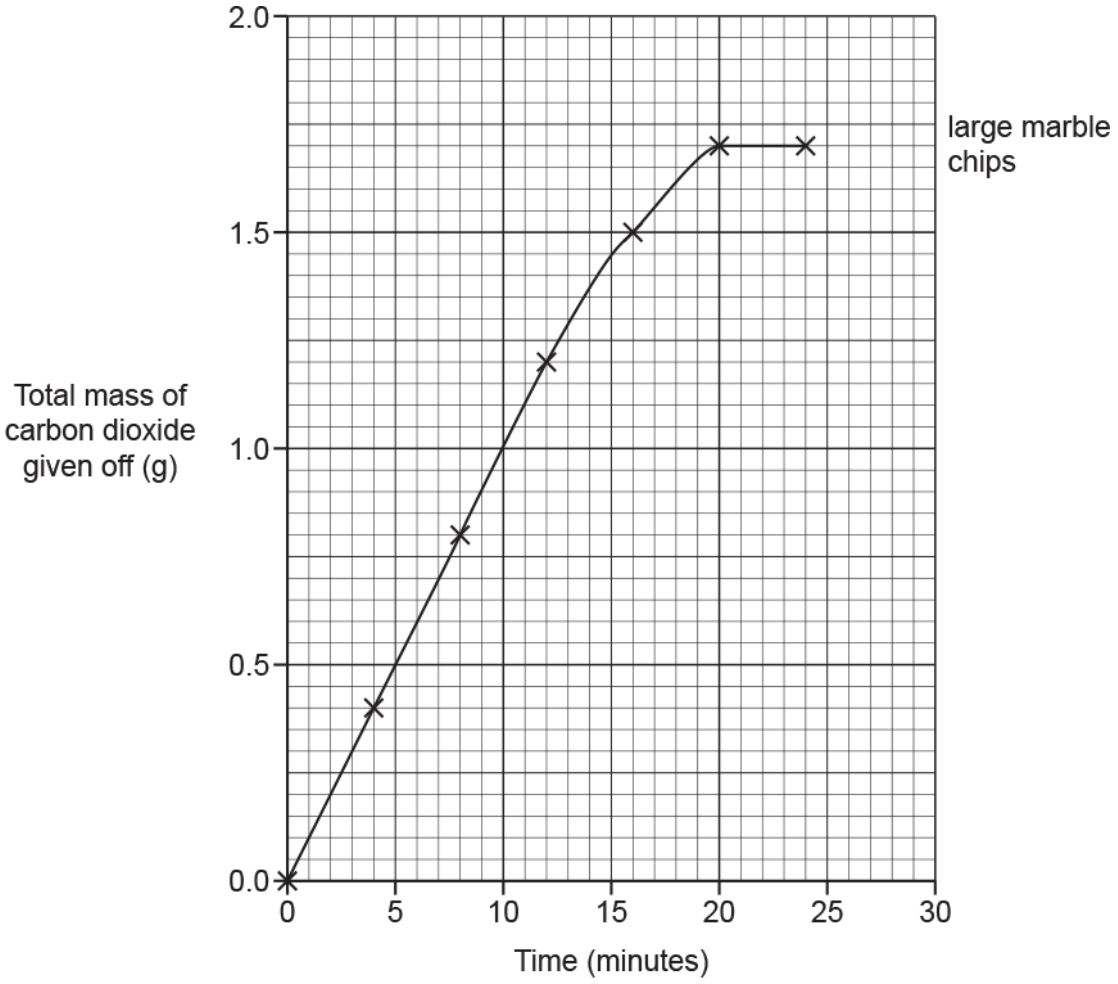
.

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 ----------

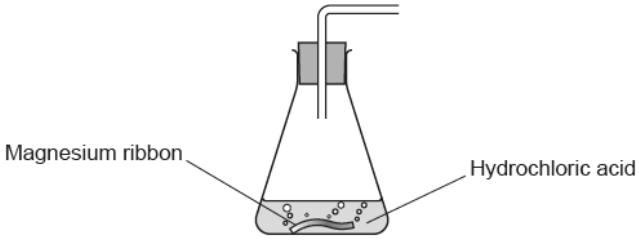
---

2 ----------

---

[2]

16. 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.

<u>First experiment</u> 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. <u>Second experiment</u> 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]

17. Why does a catalyst speed up a chemical reaction?

A It causes the reactants to collide less frequently.

B It decreases the overall energy change of the reaction.

C It lowers the activation energy of the reaction.

D It makes more product.

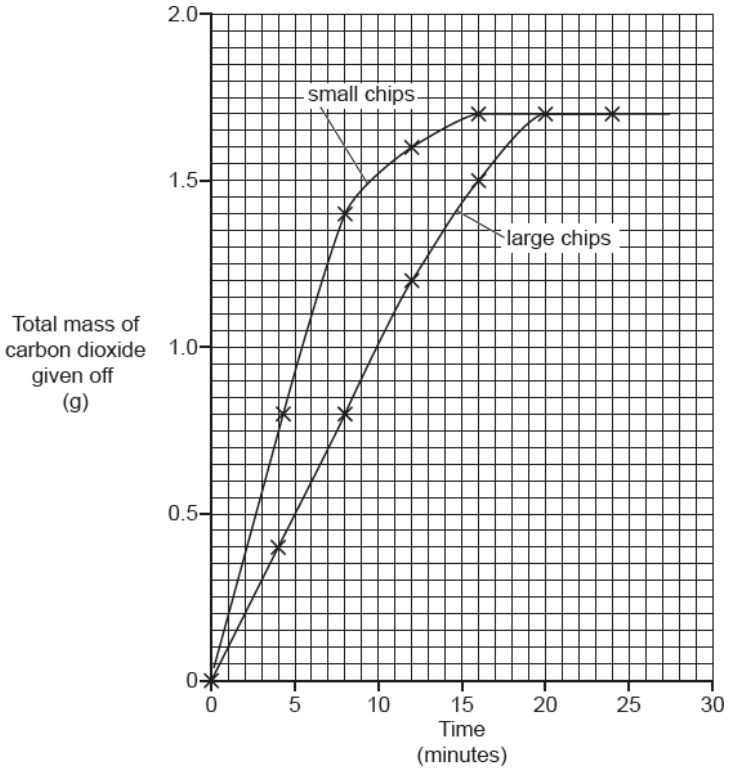
Your answer [ ] [1]

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

.

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

Look at a graph of his results.



(i) Calculate the rate of reaction during the first 8 minutes for the small marble chips **and** the large marble chips.

Include the units.

Give your answers to **2** decimal places.

Small marble chips	Large marble chips
Answer = ... Unit = ...	Answer = ... Unit = ...

[3]

(ii) Which reaction is faster?

Explain how you can tell using data from the graph.

---

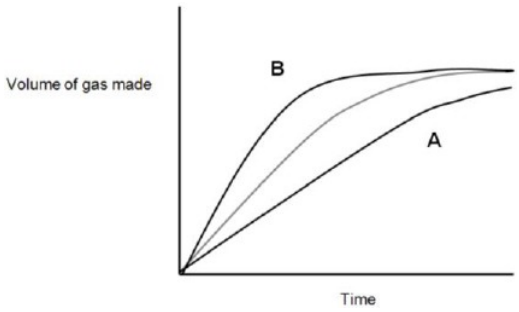
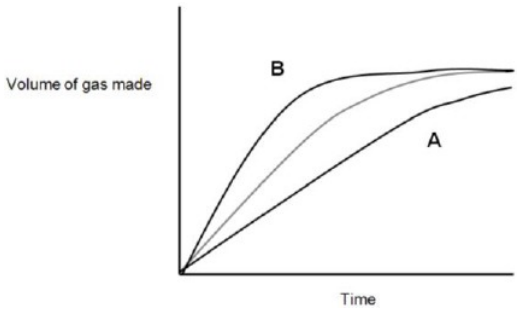
[2]

(b). Explain why changing the size of the marble chips changes the rate of the reaction.

---

[3]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			B	1	
			Total	**1**	
2			At higher temperatures ion/molecules of sodium thiosulfate and hydrochloric acid have more energy (1) So more frequent and more successful collisions (1)	2	
			Total	**2**	
3	a		surface area = (5 × 5) × 6 = 150 (1) volume= 5 × 5 × 5 = 125 (1) surface area: volume= 150: 125 = 1.2 (1)	3	**Allow** 6:5
	b		6/1.2 = rate of reaction (1cm) / 1.6 (1) 6/1.2 × 1.6 = 8 (cm^3 per second) (1)	2	
	c	i		2	Curve A should be drawn completely under the original, it should not quite reach the plateau but approach near to it at the end of the time axis Curve B should be drawn completely above the original, rising more steeply to start with and reaching the plateau before that of the original
		ii		2	Curve A should be drawn completely under the original, it should not quite reach the plateau but approach near to it at the end of the time axis Curve B should be drawn completely above the original, rising more steeply to start with and reaching the plateau before that of the original
			Total	**7**	

Question			Answer/Indicative content	Marks	Guidance
4			[Level 3] Analyses the data to explain why Chris has made a correct conclusion AND Answer applies a detailed understanding of the reacting particle model. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Explains quantitatively why Chris has made a correct conclusion AND Answer applies an understanding of the reacting particle model Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Explains why Chris has made a correct conclusion OR Answer applies a basic understanding of the reacting particle model. Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A* **allow** ora throughout e.g when temp is halved, rate is quartered Level 3 indicative scientific points may include: to explain that Chris is correct; • when the concentration doubles the rate doubles but when the temperature doubles the rate quadruples to show the reacting particle model; idea that when the temperature is higher; • there are more **frequent successful** collisions / the collisions are more **frequent** and more of the collisions are **successful** / **higher chance** of **successful** collisions / **increased rate** of successful collisions **allow** more energetic collisions (for successful) Level 2 indicative scientific points may include: to explain that Chris is correct; idea that when the temperature is higher; • when the temperature doubles the rate quadruples • when the concentration doubles the rate doubles to show the reacting particle model; • particles have more (kinetic) energy • more chance of collision / increased collision frequency / collisions more often • more successful collisions Level 1 indicative scientific points may include: to explain that Chris is correct;

Question			Answer/Indicative content	Marks	Guidance
					• as temperature increases the rate increases • as concentration increases the rate increases to show the reacting particle model: • the particles move faster • there are more collisions ignore faster collisions / quicker collisions Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This question was the second level of response question on the paper. The majority of candidates were able to apply a basic understanding of the reacting particle model to the information in the table about relative rates of reaction for four experiments. They tended to quote the data in the table about the relative rates of reaction. They did not analyse the data to explain that when the concentration doubles the rate or reaction doubles or when the temperature doubles the rate of reaction quadruples.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
5			**any two from:** increase concentration (1) make particles more crowded (1) have more (frequent) collisions (1) use powdered or crushed material (1) use more surface area (1) stir / shake (1) add a catalyst (1)	2	 **ignore** pressure / more acid / more calcium carbonate **allow** cutting reactant smaller **ignore** use smaller particles **Examiner's Comments** Catalyst was frequently seen but also increased concentration and larger surface area were responses correctly given. Many also incorrectly referred to temperature, despite it being in the stem of the question.
			Total	2	
6	a		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.
	b		reactant not in excess / reactant that is all used up (at the end of the reaction) / reactant that is used up first (1)	1	**ignore only** lasts a limited time **Examiner's Comments** Only better candidates understood that the limiting reactant is used up first or is not in excess. There were vague references to ‘the reactant that doesn?t last long‘ which failed to score.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
7	a		idea that (acid) particles move faster or have more energy (1) idea that there are more (frequent) collisions (between acid and magnesium particles) (1) **but** idea that there are more successful / energetic / effective / harder collisions (between acid and magnesium particles) (2)	3	**ignore** vibrate more **allow** more chance of a collision **ignore** faster collisions all marking points are comparative **Examiner's Comments** Many candidates had learnt this explanation and scored all 3 marks.
	b		more surface area (on magnesium) (1) more (frequent) collisions (between acid and magnesium particles) (1)	2	**allow** reverse argument for lumps / more particles exposed (on the surface) **allow** collisions are more likely **allow** reverse argument for lumps all marking points are comparative **Examiner's Comments** Again, many candidates understood the idea of more surface area and scored full marks.
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
8	a	i	all points plotted correctly (1) best curve through points (1)	2	points plotted to within ± 0.5 of a square **allow** 2 errors in plotting **line must go through most points** **not** dot to dot marking points are independent **Examiner's Comments** The majority of candidates could accurately plot the points although many forgot to plot a point at 0,0. However many candidates found it difficult to draw a curve though most of the points. Sketched lines and thick lines were common.
		ii	(marble chips) are larg(er) because (rate of reaction is) slow(er) (1)	1	**allow** small(er) surface area because reaction is slow(er) **Examiner's Comments** Very few candidates correctly identified the marble chips as being larger and even less were able to explain their answer in terms of reaction rate being slower. Many referred to mass incorrectly believing that more or less mass had been used or collected.

Question	Answer/Indicative content	Marks	Guidance
b		6	**This question is targeted at grades up to C**
	(Level 3) **Applies knowledge and understanding of reacting particle model to explain both factors in detail although the reference to more collisions may only be made for one of the factors.** Quality of written communication does not impede communication of the science at this level. (5–6 marks)		At all levels **ignore** reference to faster collisions and to more particles and **ignore** particles vibrate more **allow** answers that give ora but it must be very clear that this is what candidate has done **indicative scientific points at levels 2 and 3 may include:** rate increases with **temperature** because
	(Level 2) **Applies knowledge and understanding of reacting particle model to explain one of the factors in detail or partially explain both factors** Quality of written communication partly impedes communication of the science at this level. (3–4 marks)		• acid particles move faster / acid particles have more energy • more collisions between particles of acid and marble - this does not have to be qualified e.g. more (successful) collisions or more collisions (per second) **allow** - higher level answers for temperature that refer to more acid particles having sufficient energy to react or more acid particles having energy above that of the activation energy
	(Level 1) **Appreciation that the rate of any reaction depends on the number of collisions in whatever context it is used.** Quality of written communication impedes communication of the science at this level. (1–2 marks)		**concentration of hydrochloric acid:** • idea of more crowded acid particles / more acid particles in same volume • more collisions between particles of acid and marble - this does not have to be qualified e.g. more (successful) collisions or more collisions (per second) **ignore** references to ‘more particles’
	(Level 0) Insufficient or irrelevant science. Answer not worthy of credit.		**indicative scientific points at level 1 may include:** • more collisions gives a faster reaction even if referring to particle size or pressure • link between number of collisions and

Question			Answer/Indicative content	Marks	Guidance
					rate of reaction Use L1, L2, L3 annotations in scoris; do not use ticks. Examiner's Comments A large proportion of candidates failed to answer in terms of collisions, many simply stated the reaction would be faster without explain why. Of those candidates that achieved level 2 most talked about particles moving faster at higher temperatures or they mentioned more collisions. Very few candidates successfully explained concentration in terms of more crowded particles. Those that mentioned particles tended to just say there were more. Other common misconceptions included the idea that the 'reaction would be faster as the acid is stronger when it is more concentrated' and increasing the temperature 'melted the particles or marble chips' or 'increased their rate of dissolving'.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
9			**any three from:** increase temperature (of acid) / hotter (acid) / AW (1) use more concentrated acid / AW (1) use a catalyst (1) stir / shake (1)	3	**allow** heat (the acid) **ignore** use more acid / stronger acid **ignore** pressure / pH **allow** explanations of methods given e.g. increase temperature (1) because particles have more energy / particles move faster (1) and more collisions (1) increase concentration (1) because particles are more crowded (1) and more collisions (1) add a catalyst (1) which will speed up the reaction whilst remaining unchanged itself (1) **Examiner's Comments** This question differentiated well. To get all the marks candidates had to write about different ways of increasing the rate of reaction. Good answers included different methods or an explanation of a particular method.
			Total	3	

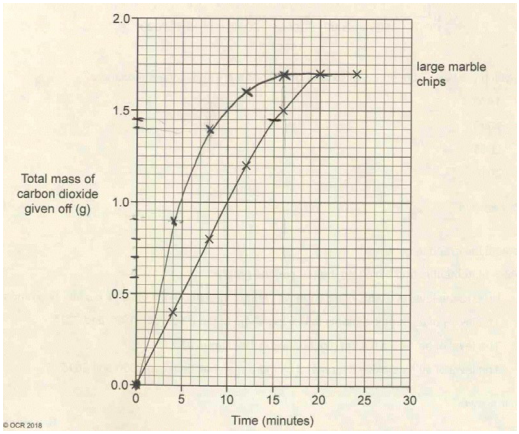
Question			Answer/Indicative content	Marks	Guidance
10	a		50 (°C) (1)	1	**allow** correct answer ticked, circled or underlined in table if answer line is blank Examiner's Comments The majority of candidates selected 50C for when the reaction is the fastest. A few interpreted a long time as a faster reaction and gave 20C instead of 50C.
	b		more crowded particles (of thiosulfate) / more particles (of thiosulfate) in the same volume / AW (1) more **frequent** collisions (1)	2	**allow** particles closer together / more particles in the same space / more particles per cm^3 / less space for particles (1) **ignore just** more particles **ignore** more particles in same area **ignore** faster particles **allow** molecules for particles **not** atoms for particles **allow** collisions more often / more chance of a collision / greater rate of collisions / more collisions per second (1) **ignore** faster collisions **if no other mark awarded allow** more (effective / successful) collisions (1) Examiner's Comments This question was about the reacting particle model in terms of a more concentrated solution. The majority of candidates gave the answer that a more concentrated solution would have more collisions, better answers explained that these would be more frequent collisions. Fewer candidates conveyed the idea of more particles in the same volume or more crowded particles.
			Total	3	

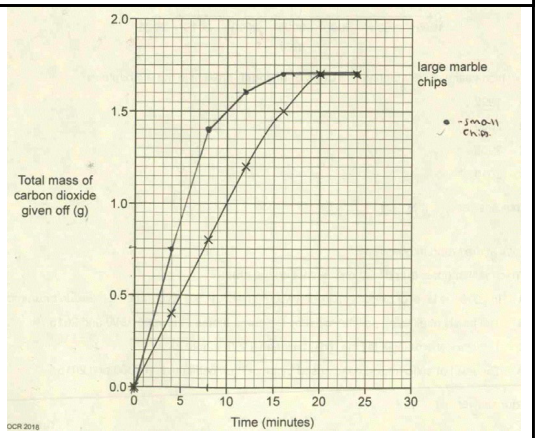
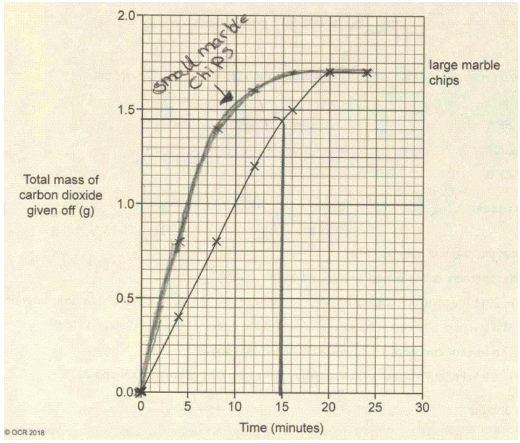
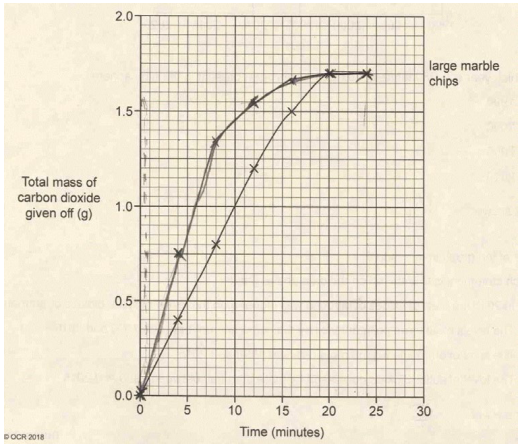
Question			Answer/Indicative content	Marks	Guidance
11	a		**A** (1)	1	**allow** correct answer ticked, circled or underlined in table if answer line is blank **allow** (concentration at) 43 (seconds) Examiner's Comments Most were correct but 'C' was also a common incorrect response.
	b		**any two from:** increase concentration of (hydrochloric) acid (1) increase temperature (1) stir / shake (1) add a catalyst (1)]	2	assume **it** refers to thiosulfate **allow** more heat **ignore** references to using a powder / larger surface area **ignore** increase pressure **allow** particles move faster or have more energy (1) **allow** more (frequent or effective) collisions (1) Examiner's Comments A significant number of candidates wrote 'changing temperature' and 'changing amount' of reactants. This misconception needs addressing as they need to be aware that changing can mean an increase or decrease. The most common response to score two marks was increasing the temperature and using a catalyst. The idea of stirring was occasionally seen together with more collisions.
	c		all (hydrochloric) acid used up / all sodium thiosulfate / limiting reactants used up / (1)	1	**allow** (all) reactant(s) used up / ran out **allow** no more chemicals to react **not** they are dissolved Examiner's Comments Well-answered with a few not scoring for the idea of dissolving, evaporating or no more particles.

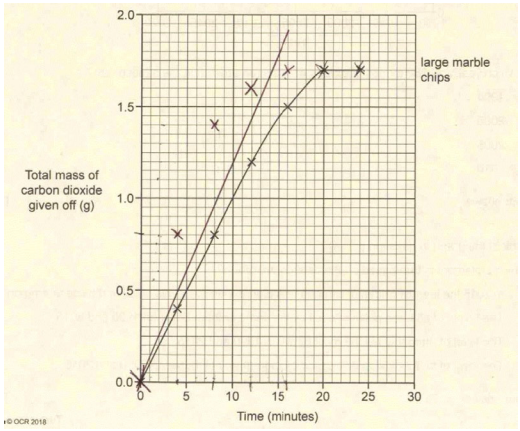
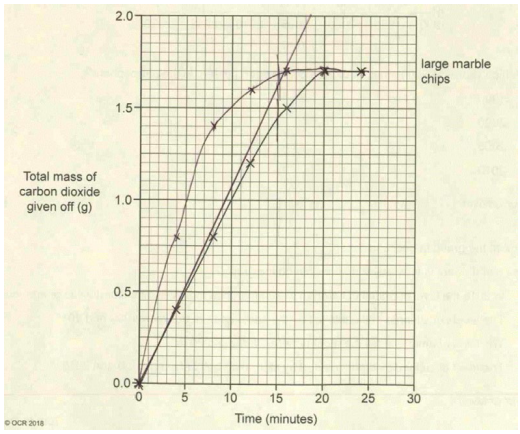
Question			Answer/Indicative content	Marks	Guidance
	d	i	line graph (1)	1	**allow** correct answer ticked, circled or underlined in list if answer line is blank Examiner's Comments Most candidates attempted this question and it was answered correctly in most cases. All four types of graphs were selected in the responses.
		ii	(yes because) **then any two from:** reaction with small marble chips finishes first / 16 mins ora (1) more mass is lost in the first 4 minutes with small marble chips / ora (1) smaller chips have more surface area (1)	2	**marks are for explanation** **no = zero** **assume unqualified answer refers to small marble chips** **allow** more mass is lost with small marble chips in any correct time period e.g. first 8 minutes (1) **allow** more mass is lost at the start of the reaction with small marble chips (1) **allow** any two times correctly compared (1) Examiner's Comments This question often tended to score 1 mark, occasionally 2. The most common correct response was comparing the loss of mass after 4 minutes between the two marble chip sizes. Where candidates discussed surface area, many incorrectly believed that small marble chips had the smaller surface area and that this is why they dissolved quicker.
			Total	7	

Question			Answer/Indicative content	Marks	Guidance
12		i	150 (cm^3) (1)	1	**ignore** units **allow** 0.15 dm^3 (1)
		ii	(lumps) have smaller surface area / have less exposed particles (1) (lumps) have less collisions (per second) (1)	2	**assume answer refers to magnesium lumps** **answers must be comparative** **allow** ora if powder specified **ignore** references to volume **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
		iii	any value above 10 (cm^3 per minute) (1)	1	
			Total	4	
13		i	150 (cm^3) (1)	1	**ignore** units **allow** 0.15 dm^3
		ii	(lumps) have smaller surface area / have less exposed particles (1) (lumps) have less collisions (per second) (1)	2	**assume answer refers to magnesium lumps answers must be comparative** **allow** ora if powder specified **ignore** references to volume **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
14			D ✓	1 (AO 1.1)	Examiner's Comments A small number of candidates gave A or B as their response. This question was answered well with three quarters of candidates selecting the correct response.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
15	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
16			**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 <u>Examiner's Comments</u> Candidates found this very challenging. Most said that the method needed to contain more detail, be written down correctly or be in steps that a candidate could follow. Many mentioned repeating or stopwatch but did not consider the variables to be controlled or varied or how the gas would be collected or how the stopwatch would be used. Many increased the amount of magnesium to be in line with the increased amount of acid. A significant number omitted the question.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
17			C ✓	1 (AO 1.1)	Examiner's Comments Most candidates answered this correctly.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
18	a	i	Small chips rate of reaction = 0.18 ✓ Large chips rate of reaction = 0.10 ✓ Units (for either size) = g / min ✓	3 (AO 3×2.2)	ALLOW 0.175 (for small) and 0.1 (for large) for 1 mark for rate calculations ALLOW for 1 mark 5.71 and 10.00 in that order with inverted calculations shown. ALLOW g / s or g / sec if minutes converted to seconds DO NOT ALLOW g / m for both <u>Examiner's Comments</u> This question requires candidates to read information off the graph. They need to use these figures to calculate rate. They also have to give their answer to 2 decimal places. Most candidates correctly read the figures from the graph. A common error was converting the minutes to seconds. This was not asked for and made the calculation difficult. It also gave answers that could not reasonably be given as 2 decimal places. Another common error was not giving the answers to 2 decimal places. The answer for large chips was 0.1 and many candidates did not write this as 0.10 and so lost a mark. Many candidates did not know the units and gave g / m for an answer. This was not credited as m is a unit of distance not time.

Question			Answer/Indicative content	Marks	Guidance
		ii	small chips (No mark) because **any two from:** rate of reaction is greater over first 8 minutes / more gas is made in first 8 minutes / in same time ✓ (slope of graph) is steeper / has larger gradient ✓ reaction with small chips finishes sooner/(graph) levels off first ✓	2 (AO 2×3.2b)	**ECF** from part (a)(i) for 1 mark. If large chips chosen scores **Max 1** mark only for rate of reaction is greater over first 8 minutes / more gas is made in first 8 minutes / in same time **ALLOW** small chips stop reacting at 16 mins but large chips stop at 20 mins Examiner's Comments This question required candidates to interpret the graph. Many got a mark for the small chip line being steeper. A few understood that more gas was made in 8 minutes. It was important that they stated 'in 8 minutes' or 'over same period of time' as by the end of the practical both gave off the same amount of gas. Only a few mentioned that the line levels off first.
	b		small chips have greater surface area ✓ **BUT** small chips have greater surface area to volume ratio ✓✓ so more frequent / successful collisions ✓	3 (AO 3×1.2)	**ALLOW** ORA Examiner's Comments Candidates lost marks here because they did not say which size chips had the greatest surface area. Some were confused and thought big chips have bigger surface area. Very few wrote about surface area: volume ratio. Other answers which lacked understanding / detail were the ideas of just "more collisions", "faster collisions" and reference to increasing amounts of energy when using smaller marble chips. The collision mark can only be credited for more frequent or more successful collisions. Carrying out practicals in the specification will help candidates understand the science involved.
			Total	8	