1(a). Sodium and sodium compounds are involved in many different types of reactions.

The equations for four reactions, **A**, **B**, **C** and **D** are shown below.

A $2NaBr(aq) + Cl_2(g) \rightarrow 2NaCl(aq) + Br_2(aq)$

B $Na^+(l) + e^- \rightarrow Na(s)$

C $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$

D $2HCl(aq) + Na_2S_2O_3(aq) \rightarrow 2NaCl(aq) + SO_2(g) + S(s) + H_2O(l)$

(i) Which reaction, **A**, **B**, **C** and **D**, can be followed by looking at an orange colour change in the solution?

Answer _____ **[1]**

(ii) Which reaction, **A**, **B**, **C** and **D**, can be followed by looking at a precipitate forming in a solution?

Answer _____ **[1]**

(iii) Which reaction, **A**, **B**, **C** and **D**, shows sodium being reduced?

Answer _____ **[1]**

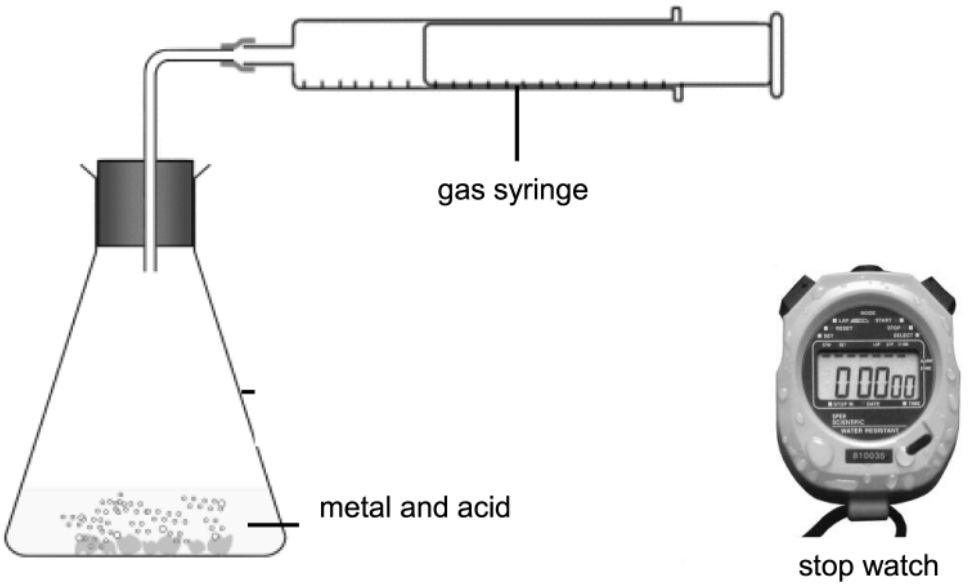
(b). Reaction **C** is faster if the solid sodium hydrogencarbonate is used as a powder rather than as a large lump.

Explain why.

--- **[2]**

2(a). Joe investigates the rate of reaction between a metal and an acid.

He uses this apparatus.



Joe investigates how changing the concentration of the acid affects the volume of gas collected in 10s.

What factors should Joe control to make sure that his results are repeatable?

Justify your answer.

---

[5]

(b).

Joe repeats his experiment three times for four different concentrations of acid.

The table shows his results.

Concentration of acid in	Volume of gas collected after 10 seconds in cm^3	Mean volume of gas

mol/dm^3	Repeat 1	Repeat 2	Repeat 3	in cm^3
0.50	3	2	4	3
1.00	4	5	4	4
1.50	5	6	6	
2.00	6	7	6	

Joe makes this comment on his results.

If I show the mean volumes for the last two concentrations to one significant figure, they are the same .

I need to show the mean volumes to at least two significant figures to see a difference.

(i) Use calculations to show that Joe is right.

[3]

(ii) * Evaluate Joe's results and explain how he could change his method to improve the quality of his data.

---

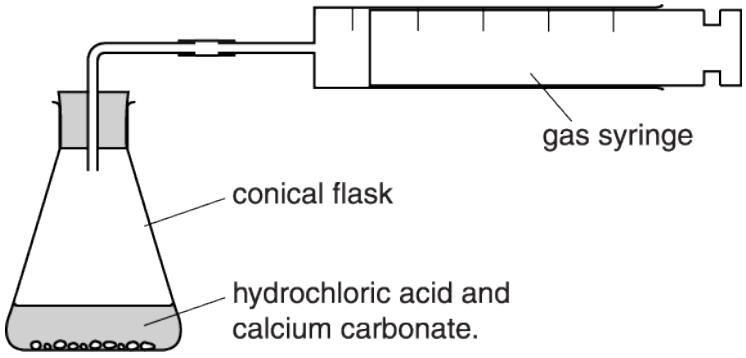
[6]

3(a).

Alex predicts that the more concentrated the acid, the faster the reaction.

He plans some experiments to find out if his prediction is right.

He has this equipment.



He has three different concentrations of hydrochloric acid.

Acid	Concentration
1	20 g/dm^3
2	10 g/dm^3
3	5 g/dm^3

Describe how Alex could use the equipment and his results to show that the more concentrated the acid, the faster the reaction.

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

---

[6]

(b). The results of an experiment to react dilute hydrochloric acid and calcium carbonate confirm that the reaction is faster with more concentrated acid.

Why does this happen?

Put ticks (✓) in the boxes next to the **two** correct answers.

More concentrated acids have larger acid particles. ☐

At higher concentrations there are more particles in the same volume. ☐

Collision rate increases when particles are closer together. ☐

Higher concentrations of acid split the calcium carbonate to give a bigger surface area. ☐

Reactions are faster when particles have less energy. ☐

[2]

4. The conversion of fats and oils into biodiesel needs a catalyst.
The usual catalyst is hot concentrated sodium hydroxide.

Scientists are investigating a new catalyst. The new catalyst is an enzyme.

Here is some information about both catalysts.

Feature of enzyme	Feature of hot concentrated sodium hydroxide
speeds up reaction a lot	speeds up reaction
easily damaged	not easily damaged
needs warm conditions	needs hot conditions
can be coated onto a solid surface	mixed in with the products at the end
speeds up this reaction only	speeds up other reactions of the esters as well as this reaction
expensive	very cheap

Evaluate both catalysts. Suggest which catalyst would be best and explain why.

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

---

[6]

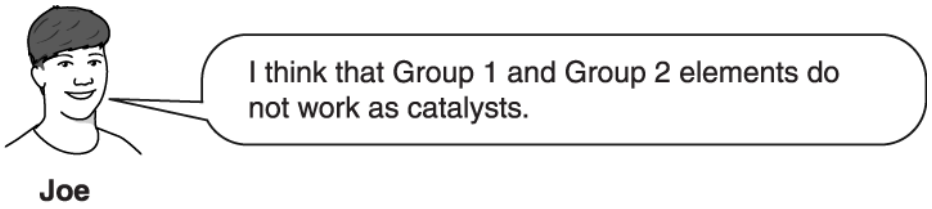
5. Joe wants to find out how effective different compounds are when they are used as catalysts.

He does some experiments to find the time taken for a reaction to finish when different catalyst compounds are used.

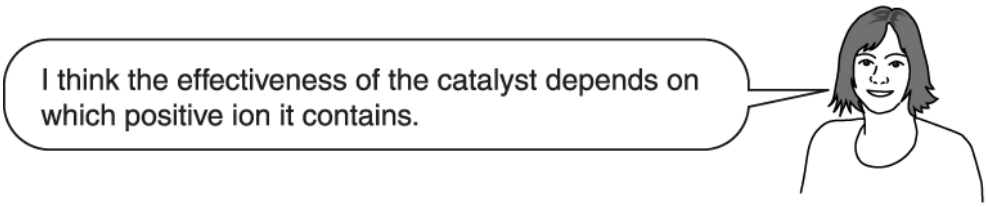
The table shows some information about the catalysts he used and his results.

Experiment	Catalyst	Positive ion in catalyst	Negative ion in catalyst	Time taken for reaction to finish in s
1	none	none	none	45
2	sodium chloride	Na^+	Cl^-	45
3	iron chloride	Fe^{2+}	Cl^-	22
4	potassium chloride	K^+	Cl^-	45
5	magnesium chloride	Mg^{2+}	Cl^-	46
6	sodium nitrate	Na^+	NO_3^-	45
7	iron nitrate	Fe^{2+}	NO_3^-	22
8	potassium nitrate	K^+	NO_3^-	45
9	magnesium nitrate	Mg^{2+}	NO_3^-	46

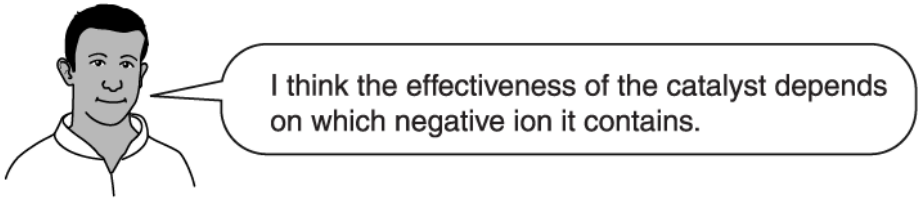
Joe talks about his results with Eve and Jay.



Joe



Eve



Jay

Discuss whether or not the results in the table support the ideas of Joe, Eve and Jay.

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

[6]

6. Calcium hydroxide is dropped into lakes from helicoptersto neutralize the water.

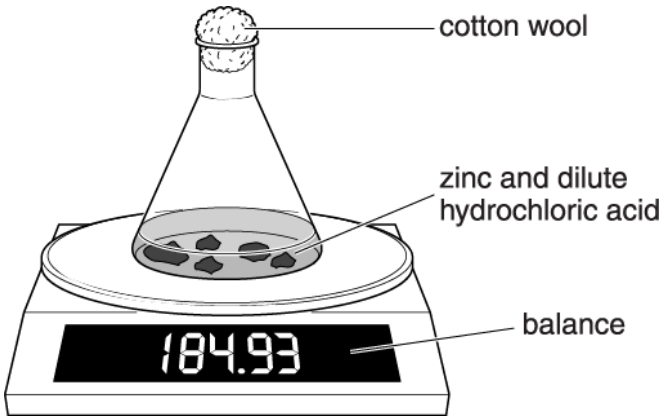
It is in the form of a fine powder to make sure that the reaction is as fast as possible.

Use ideas about collisions to explain why fine powders react faster than larger pieces.

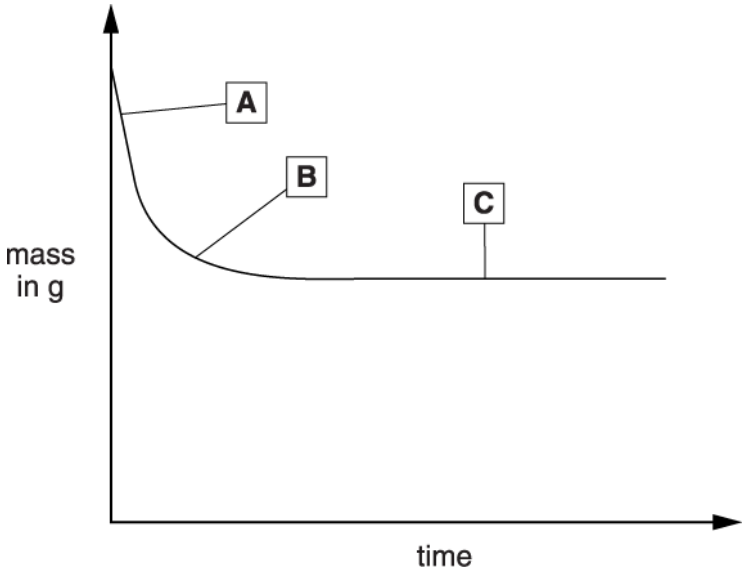
[3]

7(a). Liz does an experiment to investigate the rate of reaction between zinc and dilute hydrochloric acid.

She measures the mass of the flask during the reaction.



Liz plots her results on the graph below.



Explain how and why the rate of reaction changes between points **A**, **B** and **C**, using ideas about the collisions between particles.

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

[6]

(b). Liz reads an article on the internet which says that copper acts as a catalyst for this reaction.

She does an investigation to find out if this is true.

How should she do the investigation, and what results should she expect?

[3]

8(a). Eve measures the volume of gas given off when solid calcium carbonate reacts with a dilute acid.

Fig. 9.1 shows a graph of her results.

She draws a tangent at the start of her graph.

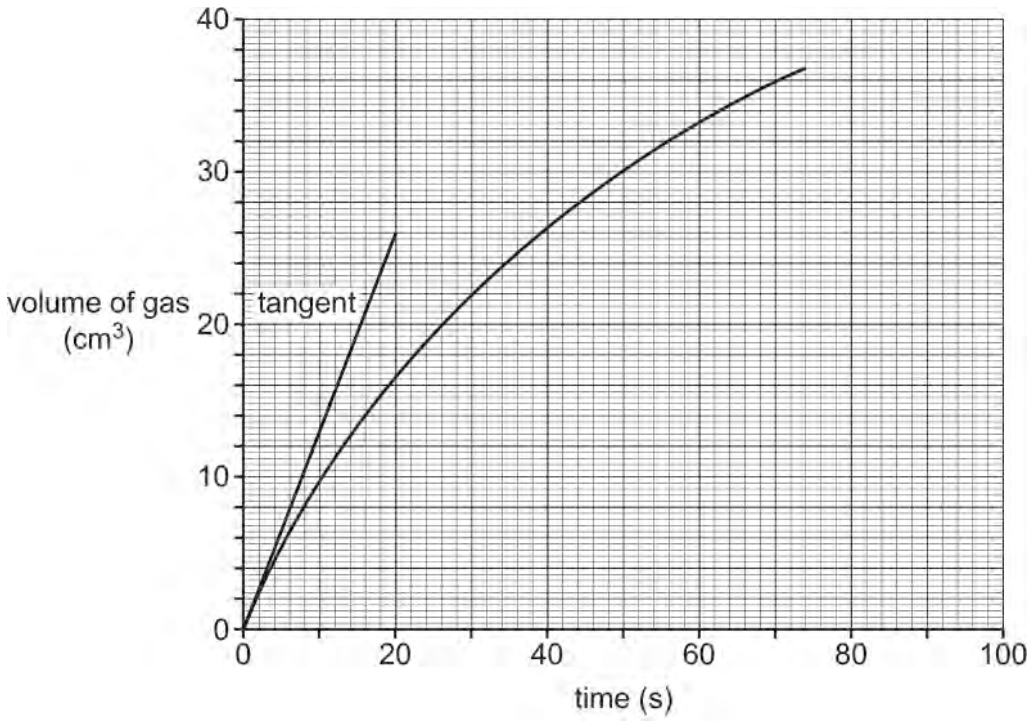


Fig. 9.1

(i) Calculate the rate of reaction at the start by calculating the gradient of the tangent.

Rate = ---------- cm^3/s **[3]**

(ii) Draw a new tangent on the graph at time = 60 s. **[1]**

(iii) How do the tangents show that the rate of reaction has changed from the start to 60 s?

---

[2]

(b). Eve does some more experiments.

This time she finds out the rate of reaction at the start when she reacts different concentrations of acid with solid calcium carbonate.

She plots a graph of rate of reaction against concentration, as shown in **Fig. 9.2**.

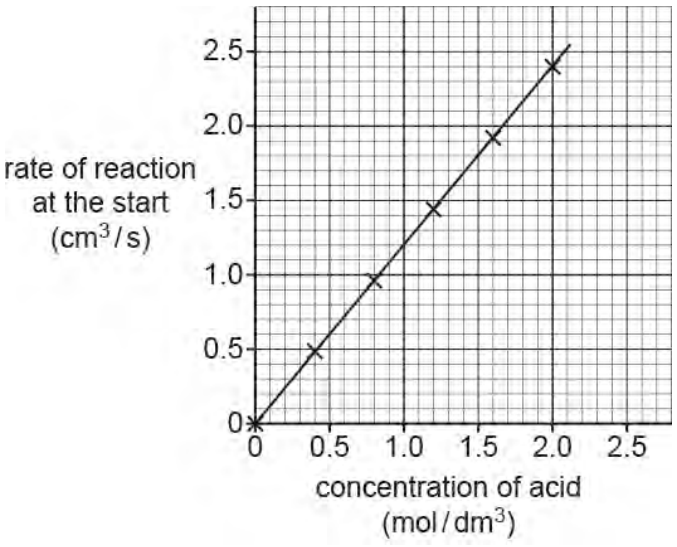


Fig. 9.2

(i) Eve thinks that the relationship between rate and concentration in the **graph** in **Fig. 9.2** can be shown using this equation: rate α concentration

Does the graph in **Fig. 9.2** agree with this equation?

Use the data to explain your reasons.

---

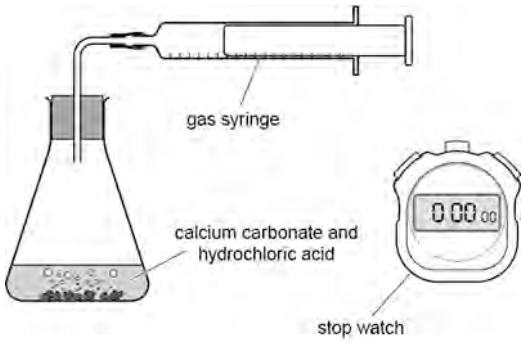
[2]

(ii) Using the graph in **Fig. 9.2** estimate the rate of reaction when acid of concentration 3.0 mol / dm^3 is used.

Rate of reaction = ---------- cm^3/s **[2]**

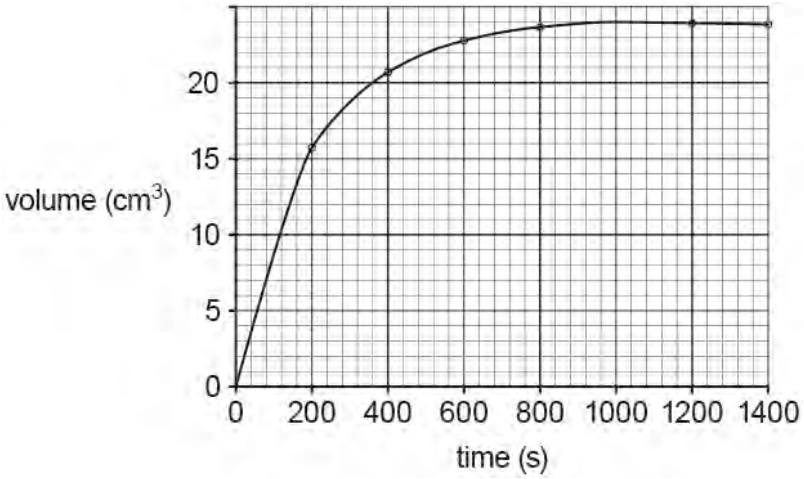
9(a). Calcium carbonate reacts with excess hydrochloric acid to make carbon dioxide.

Here is the apparatus Jack uses to investigate the reaction.



Jack records the volume of carbon dioxide made every 200 seconds.

Here is a graph of his results.



Use the graph to calculate the rate of reaction over the first 100 s.

Rate = ---------- cm^3 / s **[2]**

(b). Amaya wants to repeat Jack's experiment.

She uses the same mass of calcium carbonate.

She uses the same volume and concentration of hydrochloric acid.

Which **two** other factors does she need to keep the same?

1 ----------

2 ----------

[2]

(c). Jack repeats his experiment with more concentrated hydrochloric acid.

He keeps **all** other factors the same. The rate of reaction is faster.

Explain why.

Write about particles in your answer.

---**[2]**

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a	i	**A** ✓	1	
		ii	**D** ✓	1	
		iii	**B** ✓	1	
	b		higher surface area to volume ratio ✓ higher rate of collisions per unit time ✓	2	
			Total	**5**	
2	a		volume of acid ✓ temperature of acid ✓ mass of magnesium ✓ surface area of magnesium ✓ correct link between increase in rate of reaction and factor (e.g. if surface area is greater, rate increase) ✓	5	
	b	i	(1.50) 5 + 6 + 6/3 = 5.7(to two sig figs) ✓ (2.00) 6 + 7 + 6/3 = 6.3 (to two sig figs) ✓ Both values round to 6 (to one sig fig) ✓	3	**ALLOW** 5.67 etc if correctly rounded (last number must be 7)

Question			Answer/Indicative content	Marks	Guidance
		ii	* Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5 – 6 marks)** *Correctly evaluates the quality of the data as being poor with valid reasons.* ***And*** *Makes several correct suggestions for the development of the method with correct explanation of how the data will be improved.* *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated* **Level 2 (3 – 4 marks)** *Correctly evaluates the quality of the data as being poor with valid reasons.* ***And*** *Makes several correct suggestions for the development of the method or makes one suggestion with a correct explanation of how the data will be improved.* *There is a line of reasoning presented with some structure.* *The information presented is relevant and supported by some evidence.* **Level 1 (1 – 2 marks)** *Correctly evaluates the quality of the data as being poor with a valid reason.* ***And*** *Makes one suggestion for the development of the method with no explanation.* *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include** **AO3.1b evaluation of the quality of Joe's results.** For example • no spread of data • results too close together • volumes measured very small **AO3.3a suggestions for the development of Joe's method** For example • increase time before volume measured • increase volume of acid • increase surface area of magnesium • more magnesium **AO3.3b explanation of how the data will be improved** For example • volume of gas will be greater • more precise measurement of volume • larger spread of data • less overlap of ranges

Question			Answer/Indicative content	Marks	Guidance
			Total	14	

Question			Answer/Indicative content	Marks	Guidance
3	a		**Level 3 (5–6 marks)** Describes how to **process results** to compare rates. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Builds on the **basic method** and gives **more details** to compare rate of reaction. Quality of written communication partially impedes communication of the science at this level. **Level 1 (1–2 marks)** Gives a **basic method** to compare rate of reaction with different acids. Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted up to grade B Relevant points include: Basic method… • Do experiments with different acids / implies need to compare results of more than one experiment • Measure volume or amount of gas / when syringe is full / when reaction ends / measures time for reaction to happen More details… • same volume / amount of acid • same mass / amount of calcium carbonate • same size pieces / temperature • measurement of time and volume • start timing when acid is added • repeating and taking an average / mean / look for similar results Process results… • compare times to produce fixed volume of gas leading to either shorter time faster reaction OR shorter time for more concentrated acid • measure volume at regular intervals / measure volume at fixed time leading to either greater volume faster reaction OR greater volume more concentrated acid • draw graph of results volume against time leading to either steeper gradient faster reaction OR steeper gradient more concentrated acid **accept** ‘to fill the syringe’ as a volume measurement for the basic method but not at level 3 **accept** amount for mass or volume Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments

Question			Answer/Indicative content	Marks	Guidance
					This was the least well answered of the six-mark extended writing questions. There were several routes to gain marks. Candidates could discuss controlling conditions between 'runs' of the experiments or identify what they would measure during the reaction. Commonly however, they gave very low level responses such as 'He would look at the gas syringe and see the gas being made faster if the reaction was faster'. For Level 3 it was important that all aspects of the task were addressed. The question asked candidates to say how Alex would 'use his results'. Many answers did not refer to any results but only discussed vaguely 'if it looks faster, then it must be faster'.
	b		More concentrated acids have larger acid particles ☐ At higher concentrations there are more particles in the same volume ✓ Collision rate increases when particles are closer together ✓ Higher concentrations of acid split the calcium carbonate to give a bigger surface area ☐ Reactions are faster when particles have less energy ☐	2	**Examiner's Comments** Almost all candidates selected at least one of the correct statements about reaction rate.
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
4			Level 3 Discusses properties from the table. Explains advantages or disadvantages, including one correct level 3 response, and comes to a conclusion. *Quality of written communication does not impede communication of the science at this level.* (5 – 6 marks) Level 2 Discusses properties from the table. Explains at least one advantage or disadvantage, and comes to a conclusion. *Quality of written communication partly impedes communication of the science at this level.* (3 – 4 marks) Level 1 Answers in terms of the properties from the table, and comes to a conclusion. *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* Indicative scientific points may include: From the point of view of lipase Level 3 • [coated on solid] ? can be recovered / separated • [speeds up this reaction only] ? fewer side reactions, less waste, less purification needed Level 2 • [damage] ? **nature** of damage [enzyme denatured] • [damage] ? **consequence** [needs more tightly controlled conditions / enzyme doesn't last as long / needs to be replaced more often] • [warm] ? lower energy / costs **Ignore** more risky / **Ignore** more easily made • [enzyme speeds up this reaction only] ? realises this is an advantage • [cost] ? justified by greater productivity Level 1 • [speed] – enzyme very fast • [damage] ? enzyme easily damaged • Enzyme warm conditions • etc If one correct L3 and one incorrect L3, QWC impeded If one correct L3 and then L1 responses only, level 2 **incorrect** L1&2 responses, ignore, only mark the correct material Accept reverse arguments for sodium hydroxide Conclusion must be present to gain the higher mark in any level. Use the L1, L2, L3 annotations in Scoris; do not use ticks.

Question			Answer/Indicative content	Marks	Guidance
					Examiner's Comments Candidates answered this question at a range of levels. Those who quoted information from the table without taking that information any further were able to score some credit. Those who commented on that information were obviously able to able to score much more. Many candidates realised that the ability to coat the enzyme onto a solid surface would be an advantage. Answers which then explained *why* this might be an advantage were the hallmark of the most able. Suggestions that this was an advantage because it would obviate the need for a 'mixing in' stage were a common misunderstanding. Fewer candidates understood why it would be an advantage for an enzyme to speed up the one reaction only. Many suggested that the sodium hydroxide would be more versatile because it catalysed a range of reactions.
			Total	6	

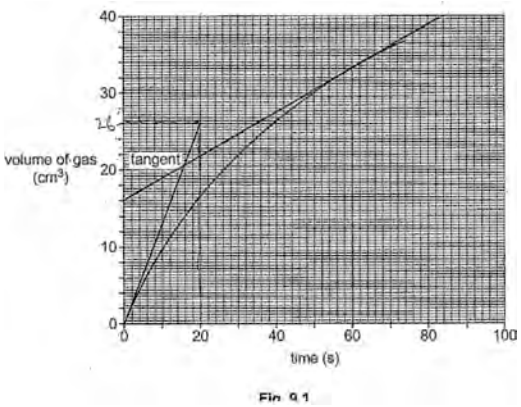
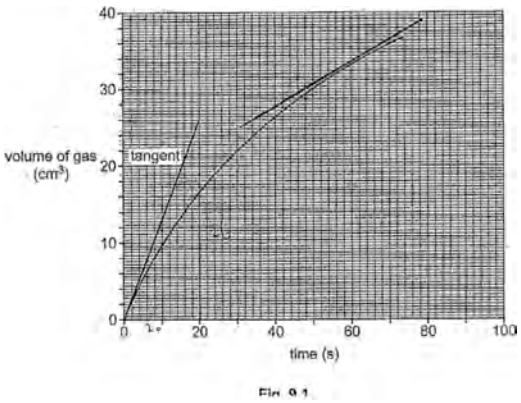
Question			Answer/Indicative content	Marks	Guidance
5			**Joe's idea**: Gp1 and Gp2 do not work **Eve's idea**: depends on + ion **Jay's idea**: depends on ? ion **[Level 3]** Correctly states that the ideas of Joe and Eve are correct and Jay is incorrect **and** gives reasons for two people **and** identifies control for Joe Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** Correctly states that the ideas of Joe and Eve are correct and Jay is incorrect **and** gives a reasons for one person. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** Correctly states that the ideas of Joe and Eve are correct and Jay is incorrect OR correctly states whether one person is correct **and** gives a reason. 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*** **Indicative scientific points may include:** **Level 3: Control** • Joe: compares group 1 and group 2 to no catalyst / times or rate the same as no catalyst **Ideas and reasons (Level 1, level 2, level 3)** **Joe:** • Joe's idea is correct / don't work at catalysts • Group 1 and group 2 reaction times all the same / take 45s / gives same rate / does not speed up • Na^+ / K^+ and Mg^{2+} all the same / take 45/46s (accept that Mg^{2+} is slower at 46s idea). **Eve** • Eve's idea is correct / iron acts as a catalyst • Using Fe^{2+} reduces reaction time / gives faster reaction **Jay** • Jay's idea is incorrect / chloride and nitrate don't work as catalysts • chlorides the same as nitrates **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** ?This was a complex level of response question, targeted at grades up to A*. Candidates were asked to make judgements about the interpretations of data by three people. In this type of question it is important that candidates give their views about who is right (and who is not) and then clearly present the evidence

Question			Answer/Indicative content	Marks	Guidance
					from the data to show who is (and who is not) supported. The question referred candidates to the 'results in the table'. Answers gaining 6 marks referred to the results of the experiment, relating these to whether or not each person had made a valid conclusion. Very good answers compared the times for the reactions with the control, experiment 1. Answers which only said 'works as a catalyst' or 'does not work' did not clearly relate to the data, only to the opinions of the people. Commonly, answers at levels 1 and 2 did not use the data in the table to justify whether or not the people's ideas were correct.
			Total	6	
6			more surface area; idea that more collisions occur (between particles of acid and calcium hydroxide); (collisions are….) more frequent / more per unit time / (collide) more often;	3	**Allow** 'more chance of collisions' for MP2 only **Ignore** 'faster collisions' **Do not allow** collisions between incorrect particles e.g. atoms / collisions between the same reactant alone 'more frequent collisions' OWTTE (2) Examiner's Comments ?Almost all candidates knew that the size of the pieces of solid affect its surface area, but some thought that the surface area becomes smaller in a powder form. The idea of 'more collisions' was well known. Some very good answers discussed collision frequency.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
7	a		**[Level 3]** Makes statements about the trend on the graph and explains the trend in terms of collision theory. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** Makes statements about the trend on the graph and makes a statement about collision theory **OR** makes one statement about the trend with a level 3 explanation in terms of collision theory. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** Makes statements about the trend on the graph. 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** **Explains trend in terms of collision theory (level 3)** • Concentration of acid decreases / acid is used up therefore fewer collisions • acid particles are further apart therefore fewer collisions • surface area of zinc decreases as zinc is used up so fewer collisions • Less frequent (rate of) collisions leads to lower rate of reaction **Collision theory (level 2)** • particles must collide to react • more (chance of successful) collisions = faster reaction • idea that when collisions stop reaction stops. • More concentrated acid contains more particles (per unit volume) • Higher surface area leads to more collisions **Trend on the graph (levels 1, 2 and 3)** • reaction is fastest at the start (at A) • reaction slows down (at B) • then stops / fully reacted / reaction over idea (at C) • The mass falls / flask gets lighter If answer includes incorrect or irrelevant points (e.g. rate increases at start / discussion of effect of energy or temperature / rate at C is steady) then consider quality of communication to be impeded at levels 2 and 3 only. **Indicative scientific points may include:** **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This level of response question again caused difficulties for candidates who did

Question			Answer/Indicative content	Marks	Guidance
					not fully answer all aspects of the question. Candidates were asked about the rate of reaction at A, B and C and to explain their answer in terms of ideas about collisions. Firstly, many candidates did not mention rate, but rather discussed answers only in terms of mass change. Such answers were limited to level 1. A second common problem was that candidates discussed collisions between reactants rather than between particles or between named particles, for example saying 'the acid is colliding with the zinc'. Where collisions were discussed, they often were only mentioned in terms of *number* of collisions rather than in terms of *frequency* of collisions or of number *per unit time*. The most common mark for this question was four, with less than a quarter of candidates gaining a level 3. Some candidates made errors which limited the marks. For example, some thought that initially the rate of reaction is steadily increasing. Others said that energy increases as particles collide. These answers were considered to have some communication impeded and scored the lower mark of each level.
	b		Repeat (same) experiment; (1) add copper / catalyst; (1) look for a faster reaction / higher rate; (1)	3	**Allow** 'do it again' **Allow** shorter time **Examiner's Comments** This question was well answered, with most stating that copper should be added to lead to a faster reaction. Some omitted to say that this should be compared with a reaction without copper. A common error was to change other conditions, for example heating the reaction.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
8	a	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.3 (cm^3/s) award 3 marks Uses 20 (s) in working ✓ Uses 26 (cm^3) in working ✓ 26 ÷ 20 = 1.3 (cm^3/s) ✓	3 (AO 3× 2.2)	Allow values correctly read not at 20s e.g. at 10s giving 13 cm^3 M3 Allow ECF for volume ÷ time ALLOW Δy/Δx for (1)
		ii	Ruler drawn straight tangent, both sides of line above curve, centre touches curve at 60s ✓	1 (AO 2.2)	Examiner's Comments In (a) (i), although most candidates knew how to calculate the gradient (and did so correctly), not all used the largest values of y and x possible from the line given (26 and 20). Some took readings at 10 or even 5s. In this case, these calculations usually still gave the correct answer, but candidates may consider for the future that the most accurate gradient will be calculated from the largest available values of y and x. In (a) (ii) most knew what a tangent should look like, but the lines drawn did not always touch the curve at 60s and did not always appear to be tangential. Commonly, lines were drawn which appeared to be tangential at a lower time value and were away from the line at 60s.

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 10  Fig. 9.1 This tangent is well drawn with the centre of the line clearly in contact with the curve at 60s. 1 mark. Exemplar 11  Fig. 9.1 Although this candidate clearly understands what to do, this tangent does not touch the curve. 0 marks.

Question			Answer/Indicative content	Marks	Guidance
		iii	Rate of reaction has slowed down ✓ Tangent at 0 is steeper / tangent at 60s is less steep / gradient is less ✓	2 (AO 3.1a) (AO 2.2)	IGNORE it levels out Examiner's Comments Candidates understood that the tangents represented rate and were able to justify the reduction in rate at 60s by reference to the tangents.
	b	i	yes because) **Any 2 from:** rate is proportional to concentration ✓ straight line with a positive gradient / straight line through the origin ✓ as concentration doubles, rate doubles ORA ✓	2 (AO 1.1) (AO 2.2)	ALLOW MP1 rate = k × concentration (1) IGNORE 'correlation' ALLOW answers which use values from the graph to show that the ratio of rate:concentration is constant Examiner's Comments There were several routes to gaining the two marks here. Some candidates clearly stated that they understood the meaning of the equation by stating 'the rate is proportional to the concentration', gaining a mark. Some went on to say that the graph shows a straight line which goes through the origin. Other used values from the graph to demonstrate the idea of direct proportionality. Any two of these points gained both marks. Some candidates mentioned that the graph was a straight line, but this in itself is not enough to describe direct proportion without clear mention of the line passing through the origin.

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 3.6 (cm^3/s) award 2 marks Quotes rate and concentration values from graph e.g. 1.2 at 1.0 or 1.8 at 1.5 or 2.4 at 2.0 ✓ = 3.6 (cm^3/s) ✓	2 (AO 2× 2.2)	ALLOW +/-0.05 ALLOW 3.4-3.8 <u>Examiner's Comments</u> In common with (a) (i) some candidates used very small values of y and x from the graph to judge the proportion of the two. Higher ability candidates gave better answers by working out a ratio of y to x at concentrations of either 1.0 or 2.0 mol/dm^3.
			Total	10	

Question			Answer/Indicative content	Marks	Guidance
9	a		FIRST CHECK ANSWER ON ANSWER LINE If answer = 0.08 ± 1 (cm^3 / s) award 2 marks Change in volume = 8 ± 1 (cm^3)✓ rate = 8 / 100 = 0.08 (cm^3 / s) ✓	2 (AO 2.2 × 2)	ALLOW use of any number 7- 9 anywhere in calculation (1) ALLOW ECF for 2nd mark: rate = change in volume / 100 ALLOW 0.07 - 0.09 (2) Examiner's Comments Most candidates correctly read the graph to state the volume of gas given off in 100s. Most, but not all, used their value to correctly calculate rate by dividing by 100.
	b		"Particle size" of carbonate / AW✓ Temperature ✓	2 (AO 3.3a × 2)	ALLOW take readings every 200s or less/ same time interval IGNORE 'the same time' Examiner's Comments Most candidates gained a single mark for identifying one control variable. Others restated controls already identified in the question, such as 'mass of calcium carbonate' or 'concentration'.
	c		Particles closer/have less space / more particles in same volume / more (densely) packed ✓ Collide more frequently / higher rate of collisions / more collisions per unit time/per second ✓	2 (AO 2.1 × 2)	ALLOW molecules for particles ALLOW more chance of collisions IGNORE more particles / more collisions / faster collisions / energy arguments / more successful collisions / Examiner's Comments Approximately half of the candidates gained at least one mark; candidates found this part question challenging. Some answers discussed 'particles colliding' without referring either to particle density or to collision frequency. Others discussed particles moving faster or having more energy, which does not relate to a change

Question			Answer/Indicative content	Marks	Guidance
					in concentration but rather a change in energy. AfL For raised concentration, the important points are that particles are *closer together* so collide *more frequently*. When discussing particle collisions, candidates need to discuss *frequency* of collisions rather than only 'more collisions'. Also, candidates need to exclude points about changes in energy (which relates to temperature) when talking about changes in concentration. So candidates should avoid discussing particles moving faster, or having more energy, as these are not relevant to concentration. Key: AfL Guidance to offer for future teaching and learning practice.
			Total	6	