OCR GCSE GATEWAY CHEMISTRY A · J248

CHEMISTRY



MARK SCHEME

C5.2 CONTROLLING REACTIONS

SCORE	PERCENTAGE
/217	%

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Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	1	
2			A	1	
			Total	1	

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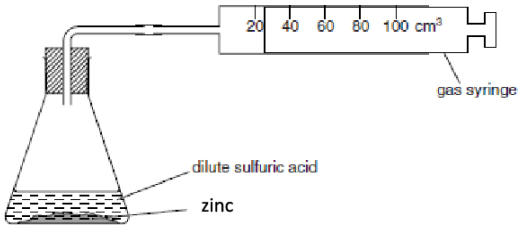
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Question			Answer/Indicative content	Marks	Guidance
3			* *Please refer to the marking instruction point 10 for guidance on how to mark this question.* Level 3 (5–6 marks) Describes the effect of changing the temperature and pressure on the percentage yield from the table and includes clear explanations on the effect of increasing the pressure on the rate of reaction. *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) Describes the effect of changing the temperature and pressure on the percentage yield from the table and either describes the effect of increasing the pressure on the rate of reaction or explains the effect increasing the pressure on the rate of reaction. *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) Describes the effect of changing the temperature and pressure on the percentage yield from the table or describes the effect of increasing the pressure on the rate of reaction. *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	AO1.1: Knowledge of pressure on rate of reaction • Increasing the pressure increases the rate of reaction. • Increasing the pressure means particles are closer together. • Increasing the pressure means more crowded particles / more particles in the same space. • Increasing the pressure means more collisions between particles. • More collisions the quicker the reaction. • More collisions more percentage yield. AO3.1a: Analyse information in the table to interpret percentage yield • As temperature increases the percentage yield decreases. • As pressure increases the percentage yield increases. • The highest yield is when the temperature is low and the pressure is high.
			Total	6	

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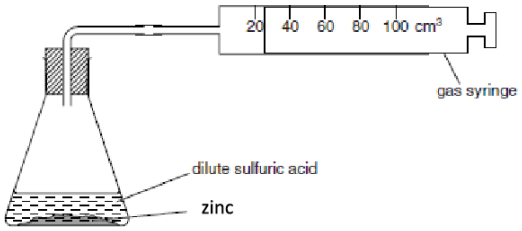
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Question			Answer/Indicative content	Marks	Guidance
4	a		Suitable container for the reactants e.g. flask, boiling tube or test tube (1) Use of a gas syringe / upturned burette with water in trough of water / upturned measuring cylinder with water in trough of water (1) The method actually works (1)	3	
	b	i	To allow a comparison between with and without the added substance (1)	1	
		ii	Idea that the rate of reaction will change if concentration is changed (1)	1	It is a fair test is not sufficient **ALLOW** if concentration is increased the rate of reaction is increased **ALLOW** to ensure there are the same number of acid particles present / same number of acid particles per unit volume
		iii	Copper Because the reaction is faster (1) There is no change in appearance (1)	2	**No** marks for copper on its own If substance other than copper given then 0 marks for the question
		iv	Measure mass of catalyst before and after (1)	1	
		v	(Relative rate) between above 1 and below 10 because of smaller surface area / less exposed particles / less collisions (2)	2	**No** marks for the prediction on its own **No** marks for whole question if prediction incorrect
			Total	**10**	
5			B	1	
			Total	**1**	
6			D	1	
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
7	a		Suitable container for the reactants, e.g. flask, boiling tube or test tube (1) Use of a gas syringe / upturned burette with water in trough of water / upturned measuring cylinder with water in trough of water (1) The method actually works (1)	3	
	b	i	To allow a comparison between with and without the added substance (1)	1	
		ii	Idea that the rate of reaction will change if concentration is changed (1)	1	It is a fair test is not sufficient **ALLOW** if concentration is increased the rate of reaction is increased **ALLOW** to ensure there are the same number of acid particles present / same number of acid particles per unit volume
		iii	Copper Because the reaction is faster (1) There is no change in appearance (1)	2	**No** marks for copper on its own If substance other than copper given then 0 marks for the question
		iv	Measure mass of catalyst before and after (1)	1	
		v	(Relative rate) between above 1 and below 10 because of smaller surface area / less exposed particles / less collisions (2)	2	**No** marks for the prediction on its own **No** marks for whole question if prediction incorrect
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
8		i	Rate increases More particles have energy above that of activation energy (1) More successful collisions (per second) (1)	2	**No** mark for rate increases but must be there to award two marks. Rate decreases give 0 marks for the question
		ii	Rate decreases Less particles per unit volume (1) Fewer collisions per second / decreased collision frequency (1)	2	**No** mark for rate decreases but must be there to award two marks. Rate increases give 0 marks for the question **ALLOW** less crowded particles **ALLOW** collisions less often
			Total	4	
9	a	i	50 (cm^3) (1)	1	
		ii	any value between 48 and 50 (seconds) (1)	1	
	b		idea that acid runs out or magnesium runs out (1)	1	**allow** idea that reactant(s) run(s) out (1) **ignore** no more gas given off **ignore** graph levels off **Examiner's Comments** Good responses described the idea that the magnesium or the acid runs out.
			Total	3	
10		i	(as temperature decreases so yield) increases (1)	1	**allow** ora if specified **Examiner's Comments** Were both usually correct.
		ii	25 – 40 (1)	1	**allow** anywhere in range **Examiner's Comments** Were both usually correct.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
11		i	75 (cm^3) (1)	1	**allow** any value between 74 – 76 cm^3 **Examiner's Comments** This question assessed aspects of quantitative chemistry in the context of the reaction between magnesium and sulfuric acid. Most candidates could interpret the graphs. A significant proportion of the candidates did not answer
		ii	any value between 50 and 52 (seconds) (1)	1	**Examiner's Comments** This question assessed aspects of quantitative chemistry in the context of the reaction between magnesium and sulfuric acid. Most candidates could interpret the graphs. A significant proportion of the candidates did not answer
		iii	line remains on or below original line and levels off at a lower volume (1) **BUT** line remains on or below original line and levels off at 48 ± 2 cm^3 (2)	2	line with a steeper gradient = 0 marks for the question **Examiner's Comments** This question assessed aspects of quantitative chemistry in the context of the reaction between magnesium and sulfuric acid. Those that did rarely obtained both marks. A common misconception was to give a volume just below the original. Candidates need to make certain that they draw sketch graphs carefully so that the line does not 'wobble' too much.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
12		i	LOOK FOR ANSWER FIRST OF ALL IF mass = 50 g AWARD 2 MARKS idea of 1 x 10 / 2 x 5 / 0.5 x 20 (1)	2	**allow** 10 x 10/2 or 10 x 5/1 or 10 x 2.5/0.5 **Examiner's Comments** This question assessed aspects of quantitative chemistry in the context of the reaction between magnesium and sulfuric acid. Candidates were often able to calculate the mass of magnesium sulfate made as 50 g and showed clearly how they got the marks. A small proportion of the candidates calculated out the mass for a different substance from the table but often their working out was sufficiently clear to be awarded a mark. Candidates found parts very demanding and often got both questions incorrect.
		ii	0.08 (moles) (1)	1	**Examiner's Comments** This question assessed aspects of quantitative chemistry in the context of the reaction between magnesium and sulfuric acid. Many candidates gave the answer as 0.16 moles rather than the correct answer of 0.08.
		iii	1920 (cm^3) (1)	1	**allow** ecf from part (ii) **Examiner's Comments** This question assessed aspects of quantitative chemistry in the context of the reaction between magnesium and sulfuric acid. An error carried forward mark was available but most candidates did not understand the concept of molar volume.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
13		i	zinc has a greater gradient / iron has a smaller gradient (1) less gas is made with zinc / more gas is made with iron (1)	2	**allow** reaction with zinc is faster / reaction with iron is slower / takes less time to react Examiner's Comments This question was about the reactions of zinc and iron with hydrochloric acid. Candidates in (i) had little difficulty interpreting the two graphs and could describe two differences focusing on the difference in the rate of reaction and the total volume of gas being made at the end of the reaction.
		ii	Powder has more surface area / more collisions (per second) / more exposed particles (1)	1	assume answers refer to powder unless lump is specified **allow** or a lump has less surface area / less collisions (per second) / less exposed particles Examiner's Comments This question was about the reactions of zinc and iron with hydrochloric acid. The idea that a powder has a larger surface area was well understood in (ii) and some candidates also referred to more collisions.
		iii	**any three from:** higher temperature / heat (1) greater concentration (1) add a catalyst (1) use a finer powder (1) shake or stir (1)	3	**ignore** increase pressure Examiner's Comments This question was about the reactions of zinc and iron with hydrochloric acid. In (iii) candidates often gave at least two ways of speeding up the reaction. The most common answers were adding a catalyst or having a higher temperature. Candidates sometimes explained the factor but there were no marks available in the mark scheme for explanations.
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
14			[Level 3] Extracts the correct conditions from the graph AND states at least two costs of making ammonia. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Extracts one correct condition from the graph and states at one cost of making ammonia. OR Extracts the correct conditions from the graph OR States at least two costs of making ammonia. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Extracts one correct condition from the graph OR States one cost of making ammonia. 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 C. Costs • cost of starting materials • labour costs • cost of the plant / apparatus or equipment • cost of catalyst • rent or rates • health and safety • pollution control ignore references to advertising / environment / transport / storage / packaging / energy / temperature and pressure Conditions • any temperature from 350oC or below • any pressure from 400 atmospheres or above Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This question was about the manufacture of ammonia by the Haber process. This was a six-mark question that involved date interpretation. Many candidates could interpret the information in the graphs and gave a possible temperature and a possible pressure to get the highest yield. Most candidates chose figures from the graphs although some gave lower temperatures and/or higher pressures instead. The other part of this question involved stating possible costs of making ammonia by the Haber process. Typically candidates were able to give one or two costs. Some candidates ignored the stem to the question and gave costs that were related to the energy e.g. maintaining the

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Question			Answer/Indicative content	Marks	Guidance
					pressure or temperature, these answers were not given any credit.
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Question			Answer/Indicative content	Marks	Guidance
15	a		Zn + 2HC*l* ? ZnCl_2 + H_2 (1)	1	**allow** correct multiples **allow** = or ? instead of ?. **not** 'and' or & instead of + **all** subscripts and case **must** be correct Examiner's Comments This question focused on rates of reaction. Most candidates correctly constructed the balanced symbol equation.
	b	i	1.47 (1)	1	**allow** 1.46 / 1.5 (1) **unit not needed** Examiner's Comments This question focused on rates of reaction. Many candidates correctly calculated the rate of reaction in part (i). 30 ÷ 44 was a common error, as was misreading the volume of hydrogen as 42 cm_3.
		ii	60 (1)	1	**unit not needed** Examiner's Comments This question focused on rates of reaction. In part (ii) the most common incorrect response was 120 cm_3.

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Question			Answer/Indicative content	Marks	Guidance
	c		particles more crowded / particles closer together / more particles in the same volume / more particles per unit volume (1) more collisions (1)	2	**allow** particles more concentrated / more particles in the same area **not** just more particles **not** particles have more energy / move faster / more energetic collisions **allow** higher level answers e.g. more frequent collisions / more collisions per second / collisions more often / more chance of collisions (1) Examiner's Comments This question focused on rates of reaction. Good responses explained the increase in the rate of reaction in terms of particles being more crowded / more particles in the same volume, hence more collisions. Candidates who did not score both marks often simply stated that there were more particles, but failed to describe within the same volume.
			Total	5	

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Question			Answer/Indicative content	Marks	Guidance
16			[Level 3] Extracts the correct conditions from the graph AND explains why both the temperature and the pressure giving the highest yield are not used. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Extracts the correct conditions from the graph AND explains why the temperature or the pressure giving the highest yield is not used. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Extracts the correct conditions from the graph OR explains why the temperature or the pressure giving the highest yield is not used. 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: Conditions • any temperature from 350°C or below • any pressure from 400 atmospheres or above Explanations ◦ 400 atm / high pressure is expensive to maintain / generate ◦ cost of equipment / plant for high pressure is expensive ◦ safety risks increase as pressure increases • at 350°C the rate of reaction is too slow • 450°C gives a lower yield at a higher rate • higher temperature means higher energy costs Simply extracting the correct conditions from the graph restricts the answer to L1 Use the L1, L2, L3 annotations in RM Assessor; do not use ticks. <u>Examiner's Comments</u> This question was about the conditions used in the Haber process to make ammonia. This 6 mark question was targeted up to grade A* and required candidates to interpret information from the graph and to explain why the conditions giving the highest yield of ammonia are not used in the Haber process. Candidates who gave good responses extracted the conditions

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Question			Answer/Indicative content	Marks	Guidance
					that give the highest yield of ammonia from the graph. They then explained that high pressures are expensive to maintain or require expensive equipment and that the rate of reaction at 350°C would be too slow. Candidates were required to discuss both the conditions of temperature and pressure to gain credit at Level 3.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
17			[Level 3] Applies reacting particle model, including mention of collisions frequency and / or successful collisions, to explain the effect of temperature **AND** pressure on the rate of reaction. Quality of written communication does not impede communication of science at this level. **(5–6 marks)** [Level 2] Applies reacting particle theory, including mention of collisions, to explain the effect of temperature **OR** pressure on the rate of reaction. Quality of written communication partly impedes communication of science at this level. **(3–4 marks)** [Level 1] Applies reacting particle theory to explain the effect of temperature **OR** pressure on the rate of reaction. Quality of written communication impedes communication of science at this level. **(1–2 marks)** [Level 0] Insufficient or irrelevant science such as repeating the question. Answer not worthy of credit. **(0 marks)**	6	This question is targeted at grades up to A. Indicative scientific points may include: • Increasing pressure gives more crowded nitrogen and oxygen molecules / molecules are closer together / more nitrogen and oxygen molecules in the same volume so there is an increased number of collisions per second / collisions more often • Increasing temperature has nitrogen or oxygen molecules moving faster / molecules have more energy so more successful collisions per second / more energetic collisions. Use the L1, L2, L3 annotations in scoris. Do not use ticks. Examiner's Comments Many candidates gave detailed answers and gave answers in terms of either more frequent collisions for Level 3 or more collisions for Level 2. A common misconception was that pressure increases the speed of the nitrogen and oxygen molecules.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
18	a	i	increases / gets bigger / AW (1)	1	Examiner's Comments This question was about the manufacture of ethanol by the hydration of ethene. Most candidates could interpret the data in the table.
		ii	decreases / gets less / AW (1)	1	Examiner's Comments Most candidates could interpret the data in the table.
	b		idea of catalyst used to speed up the reaction or increase the rate of reaction (1) 70 atm used as is cheaper to generate than higher pressures (1) 300 °C is used to increase the rate of reaction but sacrifice percentage yield / it is a compromise or optimum temperature (1)	3	**allow** catalyst does not affect percentage yield (1) **allow** answer relating to the risks associated with high pressure (1) Examiner's Comments Was a challenging question and only a small proportion of candidates were able to explain why the temperature chosen was a compromise. Candidates were most likely to be awarded a mark for stating that the catalyst increased the rate of reaction or for the idea that a higher pressure will cost more money.
	c		idea of **reduction** of wage bill / idea of **reduction** of number of workers (1)	1	**ignore** rule out human error **ignore** to make the process work faster **ignore** references to safety **ignore** it is a continuous process **not** no labour costs Examiner's Comments Many candidates appreciated that fewer workers would be employed. However some stated that no workers would be needed, which was not allowed on the mark scheme.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
19			**Level 3 (5–6 marks)** Identification of at least three ways of making the reaction go faster **AND** applies reacting particle model correctly, including mention of collisions, to explain one way. Quality of written communication does not impede communication of science at this level. **Level 2 (3–4 marks)** Identification of at least two ways of making the reaction go faster **AND** makes an attempt to apply reacting particle theory to one of the ways (theory only partly correct). Quality of written communication partly impedes communication of science at this level. **Level 1 (1–2 marks)** Identification of two ways of making the reaction go faster. Quality of written communication impedes communication of science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science such as repeating the question. Answer not worthy of credit.	6	This question is targeted at grades up to C. Relevant points include: Reacting particle theory • increasing concentration or pressure gives more crowded nitrogen and oxygen molecules / molecules are closer together / more nitrogen and oxygen molecules in the same volume so there is an increased number of collisions (per second) / more collisions • increasing temperature has nitrogen or oxygen molecules moving faster / molecules have more energy so more (successful) collisions (per second) • adding a catalyst means there are more successful collisions (per second). **allow** one correct way of making the reaction go faster and a complete explanation level 2 (4 marks) Ways of making reaction faster • increase temperature • increase pressure • increase concentration • add a catalyst. Examiner's Comments This level of response question differentiated well. At the simplest level a candidate who gave two correct ways to speed up this reaction, with no attempt to use the reacting particle model, scored Level 1. Use of a catalyst and heating the gases were common correct responses. To gain Level 2, an incomplete explanation was required in addition to the ways of speeding up the reaction. To gain Level 3, a full and correct particle level explanation and a range of methods of speeding up the reaction were required. Just over 10% of candidates omitted the question.

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Question			Answer/Indicative content	Marks	Guidance
			Total	6	
20	a		remove food or blood stains (1)	1	**allow** remove biological stains / remove named foods / remove protein stains (1) **allow** digest or break down food or blood stains (1) **ignore** remove dirt **ignore** just 'remove stains' Examiner's Comments The role of enzymes in removing food and/or blood stains was not well understood. 'To remove stains' was insufficient to score. Another common incorrect answer was 'to remove dirt'.
	b		**any two from**: idea of less energy used / cheaper energy costs (1) idea of able to wash more fragile clothes (1) does not shrink or damage clothes (1)	2	**not** just 'cheaper' **allow** less carbon dioxide produced (1) **allow** prevent dye from running (1) **allow** enzymes only work effectively at low temperatures or enzymes do not denature (1) Examiner's Comments About two thirds of candidates scored 1 or 2 marks on this question usually for the idea of less energy or electricity used and the idea that the clothes don't shrink. Answers such as 'cheaper' were insufficient to score.
			Total	3	

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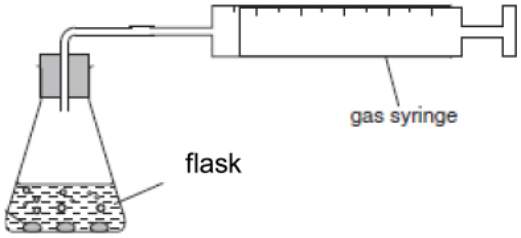
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Question			Answer/Indicative content	Marks	Guidance
21			No idea that graph shows that percentage yield goes up with increasing pressure (1) idea that graph shows that percentage yield goes down as temperature increases (1)	2	**No marks** for no on its own. **allow** yes for pressure graph and no for temperature graph – but no marks **allow** graph shows a positive correlation (1) **allow** graph shows a negative correlation (1) Examiner's Comments In order to gain the marks on this question, candidates needed to clearly state the relationship between increasing the pressure and percentage yield and increasing the temperature and percentage yield. Merely stating that Paul was right about pressure but wrong about temperature was insufficient.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
22		i	**any two from**: correct piece of apparatus to collect and measure gas e.g. (gas) syringe, upturned measuring cylinder with water or upturned burette with water (1) workable and gas tight (1)	2	 The measuring apparatus must be graduated and does not need to be assembled. The apparatus does not need to be named if there is no ambiguity from the diagram **allow** even if the syringe / measuring cylinder is not graduated **allow** the tube can be a single line **ignore** if tube does not appear to go through the stopper **not** the delivery tube must not go in the reaction mixture <u>Examiner's Comments</u> significant numbers of candidates thought that the method needed was a titration and drew burettes and pipettes. Credit was given for a diagram resembling a gas syringe provided it was clear that it was graduated even when the apparatus was drawn disassembled.
		ii	**Level 3** **Explains why the volume of gas produced is the same** **AND** **Explains the different shapes of the graph in terms of simple reacting particle model** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **Level 2** **Explains why the volume of gas produced is the same AND explains that nitric acid is**	6	**This question is targeted at grades up to C.** **Indicative scientific points may include:** **Volume of gas** • both use same amount of calcium carbonate • both use same amount of acid • both use same amount of reactants • acid and / or calcium carbonate are the limiting reactants **Shapes of graph**

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Question			Answer/Indicative content	Marks	Guidance
			faster than propanoic acid OR Explains why the volume of gas produced is the same AND recognises that nitric acid is a strong acid and / or propanoic acid is a weak acid OR explains that nitric acid is faster than propanoic acid AND recognises that nitric acid is a strong acid and / or propanoic acid is a weak acid OR Explains the different shapes of the graph in terms of simple reacting particle model Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 Explains why the volume of gas produced is the same OR Explains that nitric acid is faster than propanoic acid OR recognises that nitric acid is a strong acid and / or propanoic acid is a weak acid 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)		• nitric acid faster than propanoic acid • nitric acid is strong acid and propanoic acid is a weak acid Reacting particle model • nitric acid has more hydrogen ions / greater concentration of hydrogen ions • nitric acid has more collisions (per second) • nitric acid has particles closer together ignore nitric acid is more reactive (than propanoic acid) allow ora for propanoic acid Use the L1, L2, L3 annotations in Scoris; do not use ticks. To access level 3 answer must include a particle model explanation? Examiner's Comments few candidates accessed level 3 (5–6 marks) as their answer did not include a particle model explanation. Many candidates gained level 2 (3–4 marks) often by stating that nitric acid reacted more quickly as it was a strong acid. Only better candidates could adequately explain why the gas volumes were the same at the end of the reaction.
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
23			C (1) it removes blood / food stains (1)	2	 **allow** it removes organic materials **not** any reference to removing paint **ignore** reference to grease **Examiner's Comments** Many candidates were able to evaluate the data and suggest that detergent C contained an enzyme. The best answers referred to the removal of blood or food stains.
			Total	2	
24		i	any value between 12 and 13 (cm^3) (1)	1	**Examiner's Comments** Candidates had little difficulty interpreting the graph and often quoted values between 12 and 13 cm^3.
		ii	44°C (1) idea of highest point on the curve / where most carbon dioxide is made (1)	2	**allow** 42-45 (°C) (1) **second mark is dependent on the correct temperature** **allow** optimum temperature (1) **Examiner's Comments** Candidates often quoted a temperature between the accepted values of 42 to 45°C. The normal reason given was that the temperature gave the greatest volume of carbon dioxide. A small proportion of the candidates explained that the temperature quoted was the optimum temperature for the enzymes which was allowed in the mark scheme. Candidates that gave other temperature values often looked at the gradient of the graph rather than the actual volume of carbon dioxide produced.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
25		i	5 (cm^3)(1)	1	**allow** any value between 5 and 6 **Examiner's Comments** The vast majority of candidates could correctly read 5cm3 off the graph in part (i).
		ii	44°C (1) idea of highest point on the curve / where most carbon dioxide is made (1)	2	**allow** 42-45 (°C) (1) **second mark is dependent on the correct temperature** **allow** optimum temperature (1) **Examiner's Comments** About half of candidates scored 2 marks in part (ii) for correctly identifying 44°C and stating that this temperature produces the greatest volume of carbon dioxide after 10 minutes. A common misconception was to identify the steepest part of the curve i.e. around 30°C
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
26	a		[Level 3] Explanation that the results (in relation to both volume of acid & mass of magnesium) do not support the prediction with reference to experimental data AND an explanation *using collision frequency* that reaction in experiment 4 is faster, or has a shorter reaction time, than experiment 3. Quality of communication does not impede communication of science at this level. (5–6 marks) [Level 2] Explanation that the results (in relation to both volume of acid & mass of magnesium) do not support the prediction with reference to experimental data AND an explanation that the reaction in experiment 4 is faster, or has a shorter reaction time, than experiment 3 using idea of more collisions rather than collision frequency OR an explanation *using collision frequency* that reaction in experiment 4 is faster or has a shorter reaction time than experiment 3. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) [Level 1] Explanation that the results (in relation to either volume of acid or mass of magnesium) do not support the prediction with reference to experimental data OR an explanation that the reaction in experiment 4 is faster or has a shorter reaction time than experiment 3 *using idea of more collisions rather than collision frequency*. Quality of communication impedes communication of the science at this level	6	This question is targeted at grades up to A* Indicative scientific points for explanation may include: • results show as volume increases reaction time does not change • results show that as mass increases reaction time does not change Indicative scientific points for experiments 3 and 4 may include: • concentration is higher in experiment 4 • acid particles are more crowded in experiment 4 / acid particles are closer together / more acid particles per unit volume / more acid particles per cm^3 / more acid particles in the same space • more (successful) collisions per second / collisions more often / increased collision frequency / more chance of a collision Use the L1, L2, L3 annotations in Scoris; do not use ticks Examiner's Comments This 6 mark question was targeted up to grade A* and required candidates to draw conclusions based on evidence and to explain a scientific process using the reacting particle model. Candidates who gave good responses supported their answers with clear reference to the experimental data and could explain why experiment 4 was faster than experiment 3 using ideas about collision frequency. When candidates did not gain credit it was usually because they did not refer to experimental evidence. Some candidates compared experiments 2 and 3, where both the mass of magnesium and volume of acid changed.

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Question			Answer/Indicative content	Marks	Guidance
			(1–2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)		
	b		(acid) particles have more energy / (acid) particles are moving faster / more collisions per second (1) more successful collisions / more energetic collisions / more collisions above the activation energy / more effective collisions (1)	2	**ignore** particles vibrate more or vibrate faster **ignore** particles move more **allow** more successful collisions per second / more frequent energetic collisions for two marks **ignore** harder collisions / faster collisions **allow** more collisions (1), if no other mark awarded **allow** rate increases / reaction is faster (1), if no other mark awarded Examiner's Comments Most candidates scored 1 mark for explaining that at higher temperature the particles would have more energy or move faster. Good responses also explained that this resulted in more *successful* collisions.
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
27	a		**B** (1)	1	**allow** correct answer ticked, circled or underlined in list if the answer line is blank **Examiner's Comments** Most candidates identified the conditions that give the highest percentage of ethanol.
	b		**any two from:** the temperature or pressure chosen is a compromise (1) the high temperature gives a high rate of reaction (1) high pressure increases the percentage yield of ethanol (1) at higher temperatures the percentage yield is lower (1) higher pressures are expensive to maintain or generate (1)	2	**allow** answer relating to the risks associated with high pressure (1) **Examiner's Comments** This was a challenging question and only a small proportion of candidates were able to suggest why these conditions are used, even though they do not give the highest percentage yield. Candidates were most likely to be awarded a mark for suggesting that the high temperature gives a high rate of reaction or that higher pressures are expensive to generate.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
28	a		Level 3 Complete evaluation including some use of data from graph AND Explanation using reacting-particle model that must mention the idea of collisions Quality of communication does not impede communication of science at this level. (5–6 marks) Level 2 EITHER Partial evaluation including some use of data from graph AND partial explanation using reacting particle model OR Explanation using reacting-particle model that must mention the idea of collisions OR Complete evaluation including some use of data from graph Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 EITHER Partial evaluation including some use of data from graph OR Partial explanation using reacting-particle model Quality of 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 C Indicative scientific points may include: Evaluation • results support the conclusion • a reference to the data in the graph to justify the answer e.g. at low concentration high reaction time which is smaller as you go the right of the graph, or the graph has a negative slope Reacting particle model • idea that as reaction time decreases the rate of reaction increases • idea that the rate of reaction increases with concentration • as acid is more concentrated particles (of acid) are more crowded • as acid is more concentrated particles (of acid) are closer together • as acid is more concentrated there are more collisions (per second) allow ora i.e. as the concentration gets lower Use the L1, L2, L3 annotations in Scoris, do not use ticks Examiner's Comments This question focused on the rate of reaction between sodium hydrogencarbonate and hydrochloric acid. This question assessed both quality of written communication and evaluation. Almost all candidates realised that the data supported the conclusion made, however a smaller proportion of candidates quoted data from the graph to support their answer. The most common data quoted

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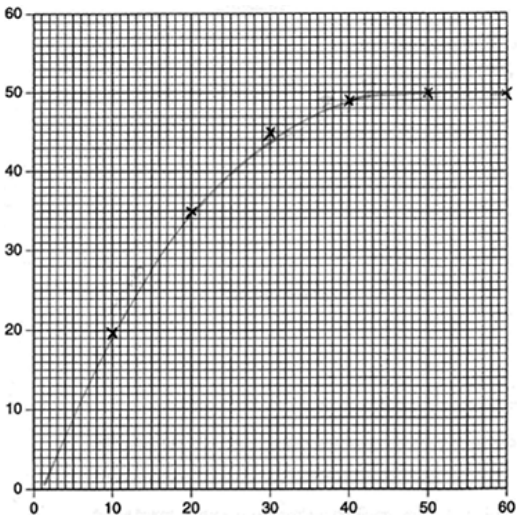
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Question			Answer/Indicative content	Marks	Guidance
					were reaction times from two different acid concentrations. Candidates rarely explained their answers in terms of collision theory.
	b	i	As temperature increases the reaction time decreases.	1	**allow** ORA **allow** reaction time is shorter as reaction gets hotter **not** faster, quicker or slower times Examiner's Comments Candidates often appreciated that the rate of reaction increased as the temperature of acid got higher but this did not address the question set which referred to reaction time. The best answers were that the reaction time decreases as the temperature increases. A common misconception was to refer to the reaction time being faster or quicker.
		ii	Any time between 100 and 160 seconds	1	Examiner's Comments Some candidates could make a correct prediction the most common answer being 136 seconds.
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
29	a	i	 all points plotted correctly (1) correct best fit line (1)	2	**allow** error of half a square **allow** curve half a square either side of points **not** dot to dot instead of curve **Examiner's Comments** The points were well plotted but many candidates tried to draw a best fit straight through the points rather than a curve.
		ii	**any one from:** magnesium used up (1) hydrochloric acid used up (1) reactant(s) used up (1)	1	no more gas given off on its own scores 0
	b		smaller surface area of magnesium (1) less collisions between acid and magnesium (1)	2	**allow** higher level answers less frequent / less often / less chance of collision **Examiner's Comments** Many candidates assumed a reaction had finished because no more gas is given off, rather than one or other of the reactants had been used up.
			Total	**5**	

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Question			Answer/Indicative content	Marks	Guidance
30		i	38 – 41 (seconds) (1)	1	Examiner's Comments Many candidates correctly indicated when the reaction had stopped. The only common mistake was “37”.
		ii	acid or magnesium runs out (1)	1	**allow** reactant(s) run out / used up **ignore** magnesium dissolved Examiner's Comments Many candidates could explain why the reaction had stopped. Common errors were to describe that magnesium dissolved or to comment that the hydrogen had run out.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
31			Level 3 Complete evaluation including some information from the graph AND explanation using reacting particle model that must mention the idea of collision frequency Quality of communication does not impede communication of science at this level. (5 – 6 marks) Level 2 Complete evaluation including some information from the graph AND explanation using reacting particle model that must mention the idea of collisions OR explanation using reacting particle model that must mention the idea of collision frequency Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 Complete evaluation including some information from the graph OR explanation using reacting particle model that must mention the idea of collisions Quality of 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: Evaluation • results support the analysis • idea that as concentration increases reaction time decreases and the rate of reaction increases Reacting particle model • as acid is more concentrated particles (of acid) are more crowded • as acid is more concentrated particles (of acid) are closer together • as acid is more concentrated more particles (of acid) per unit volume • as acid is more concentrated there are more collisions • as acid is more concentrated there are more collisions per second **allow** collisions more often, more chance of collision, increases collision frequency for more collisions per second **allow** reverse argument with as acid gets less concentrated Use the L1, L2, L3 annotations in Scoris. Do not use ticks. <u>Examiner's Comments</u> This 6 mark question was targeted up to grade A and required candidates to draw conclusions based on evidence and to explain a scientific process using the reacting particle model. Candidates who gave good responses supported their answers with clear reference to the experimental results and could explain why the results supported Fatimah's conclusion using ideas about collision frequency. Answers that did not refer to experimental evidence or only mentioned the idea of collisions, rather than collision frequency,

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Question			Answer/Indicative content	Marks	Guidance
					did not gain credit beyond Level 2.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
32	a		[Level 3] Explanation that the results do not support the prediction with reference to experimental data AND an explanation using reacting particle model that reaction in experiment 4 is faster or the reaction time is shorter than experiment 3. Quality of communication does not impede communication of science at this level. (5–6 marks) [Level 2] Explanation that the results do not support the prediction with reference to experimental data AND an explanation that the reaction in experiment 4 is faster or the reaction time is shorter than experiment 3 because acid is more concentrated OR an explanation using reacting particle model that reaction in experiment 4 is faster or the reaction time is shorter than experiment 3. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) [Level 1] Explanation that the results do not support the prediction with reference to experimental data OR An explanation that the reaction in experiment 4 is faster or reaction time is shorter than experiment 3 because the acid is more concentrated. Quality of communication impedes communication of the science at this level (1–2 marks) [Level O] Insufficient or irrelevant science. Answer	6	This question is targeted at grades up to C Indicative scientific points for evaluation could include: • identification that experiments 1 and 3 must be compared • results show as volume increases reaction time does not change Indicative scientific points for experiments 3 and 4 could include: • concentration is higher in experiment 4 • acid particles are more crowded in experiment 4 / acid particles are closer together / more acid particles per unit volume / more acid particles per cm^3 / more acid particles in the same space • more (successful) collisions (per second) Use the L1, L2, L3 annotations in Scoris, do not use ticks Examiner's Comments This question assessed quality of written communication, evaluation and the ability to apply collision theory. Although candidates often appreciated that the conclusion was not supported by the results they did not refer to the experiment numbers to help their explanation. The best answers referred to experiments 1 and 3 where the volume changed but the reaction time did not. Candidates often appreciated that the difference in reaction times in experiments 3 and 4 was because the concentration of the acid had been changed. Only the best answers related this to collision theory and described an increased collision frequency or more crowded particles in the more concentrated acid.

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Question			Answer/Indicative content	Marks	Guidance
			not worthy of credit. (0 marks)		
	b		any time less that 30 seconds (1) the reaction will be faster (1)	2	**allow** higher level answers such as particles have more energy / particles move faster / there are more collisions between particles Examiner's Comments Many candidates could predict a reaction time of less than 30 seconds but they did not always explain why. It was sufficient to state that the reaction was faster to be awarded the explanation mark. Some candidates gave explanations involving collision theory.
			Total	8	
33			C ✓	1(AO 1.2)	Examiner's Comments Almost all candidates chose 'the rate increases'. However, only the higher ability candidates knew that there would be no change in mass, with the others thinking that mass would decrease.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
34		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 100 award 3 marks Round each number to 1 significant figure: Silicon dioxide nanoparticle 20 nm ✓ Silicon atom 0.2 nm ✓ Number of times larger ≅ 20/0.2 = 100 ✓	3(AO 2.2)	ALLOW (18 ÷ 0.22 =) 81.8 / 82 / 80 for 1 mark if no other mark awarded ALLOW (18 ÷ 0.2 =) 90 for 2 marks if no other mark awarded Examiner's Comments The many candidates who calculated the exact answer rather than estimating it were still able to gain some credit, but examiners were looking for the ability to estimate as it is one of the mathematical requirements. A few candidates assumed this was a much more complicated problem than it was and calculated the areas of circles of the two diameters given.

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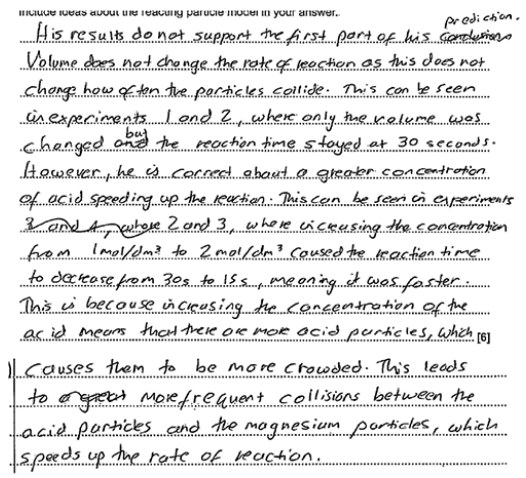
Question			Answer/Indicative content	Marks	Guidance
		ii	(Silicon dioxide) nanoparticles have a greater surface area (to volume ratio than powder) / ORA ✓ Idea that chemical reactions take place on the surface of a catalyst ✓ Idea that there will be more (frequent) collisions / the rate of reaction will be faster ✓	3(AO 1 × 2.1 2 × 1.1)	ALLOW more active sites / idea that there are more places for the reaction to occur on IGNORE idea that there is more area of catalyst to react with Examiner's Comments A few candidates understood that nanoparticles might be more effective as catalysts because of their surface area, even though they had problems in expressing that relationship, as in exemplar 5. Most, but not all, realised that nanoparticles are smaller than the particles of powder, although it was not uncommon to see 'nanoparticles have larger diameter so larger surface area'. It was rare for candidates to explain why surface area affected rate of reaction, and there was no discussion of reaction sites. Exemplar 5 Because it has more surface area to volume ratio. This means the more surface area it has, the faster the reaction will take place - speeds up. [3] This response gained two of the three marks available.
			Total	6	
35			C ✓	1(AO 1.2)	
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
36	a		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) Analyses the results to describe that the results in relation to the volume of acid DO NOT support the prediction but that the results in relation to the concentration of the acid DO support the prediction with reference to experimental data (that includes fair testing) AND explains the results in detail using the reacting particle model, using the idea of collision frequency, that the greater the concentration the faster the reaction rate. *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) Analyses the results to describe that the results in relation to the volume of acid DO NOT support the prediction AND that the results in relation to the concentration of the acid DO support the prediction with reference to experimental data AND explains the results using the reacting particle model, using idea of more collisions (rather than collision frequency) that the greater the concentration the faster the reaction rate. *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) Analyses the results to describe that the results in relation to the volume of acid DO NOT support the prediction OR analyses the results to describe that the results in relation to the concentration of	6(AO 3 × 3.2b 3 × 2.2)	AO3.2b Analyse information and ideas to draw conclusions. VOLUME To include fair testing, candidates should compare EXPERIMENTS 1 & 2 CONCENTRATION To include fair testing, candidates should compare EXPERIMENTS 2 & 3 • results (in experiments 1 & 2) show as volume decreases reaction time does not change so reaction rate does not change • results show that as concentration increases reaction time gets less so reaction rate gets faster • the reaction in experiment 3 is faster, or has a shorter reaction time, than experiment 2 AO2.2 Apply knowledge and understanding of scientific enquiry, techniques and procedures. • concentration is higher in experiment 3 (than experiment 2) • acid particles are more crowded in experiment 3 / acid particles are closer together / more acid particles per unit volume / more acid particles per cm^3 / more acid particles in the same space • more (successful) collisions per second / collisions more often / increased collision frequency / more chance of a collision IGNORE references to 'faster' collisions NB Correct points may be credited from annotation on the results table Examiner's Comments This 6-mark, Level of Response, question assessed AO2 and AO3. At Level 3 (5 - 6 marks) candidates needed to analyse the student's results to describe if the results

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Question	Answer/Indicative content	Marks	Guidance
	the acid DO support the prediction **OR** **explains using the reacting particle model, using idea of more collisions (rather than collision frequency) that the greater the concentration the faster the reaction rate.** *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		supported the prediction with reference to experimental data **that includes fair testing**. At this level candidates also needed to explain the results using the idea of the reacting particle model and **collision frequency.** Some of the responses were excellent, showing a clear understanding of fair testing and rates of reaction. The answers of lower ability candidates often • did not treat the predictions for volume and concentration independently of one another; they looked for experiments where the volume was low and the concentration was high and / or vice versa • chose experiments where the mass of magnesium was also varied • looked for experiments where the reaction time was lowest (experiments 3 & 5) and drew the conclusion that the volume had to be high (as well as the concentration) to get a faster reaction rate • criticised that data for not having an experiment where the smaller volume (25cm³) and higher concentration (2.0 mol / dm³) were used together. **Exemplar 3**  Include ideas about the reacting particle model in your answer. His results do not support the first part of his prediction. Volume does not change the rate of reaction as this does not change how often the particles collide. This can be seen in experiments 1 and 2, where only the volume was changed but the reaction time stayed at 30 seconds. However, he is correct about a greater concentration of acid speeding up the reaction. This can be seen in experiments 3 and 4, where 2 and 3, where increasing the concentration from 1mol/dm³ to 2mol/dm³ caused the reaction time to decrease from 30s to 15s, meaning it was faster. This is because increasing the concentration of the acid means that there are more acid particles, which [6] causes them to be more crowded. This leads to a more frequent collisions between the acid particles and the magnesium particles, which speeds up the rate of reaction.

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Question	Answer/Indicative content	Marks	Guidance
			This is a Level 3 (6 mark) response, which has correctly identified that in experiments 1 & 2 only the volume of acid is changed and in experiments 2 & 3 only the concentration of the acid is changed. The candidate has correctly described that the results in relation to the volume of acid do not support the prediction but that the prediction is supported in relation to concentration. The candidate explains the results clearly using the idea of collision frequency.
			Exemplar 4
			The students results don't support "The smaller the volume of acid" part because Experiment 1 and 4 used a smaller volume of acid (25cm³) than all the others which used 50cm³. The reason these two experiments don't back up his prediction is because they both have 30 second reaction times. Other experiments like 3 have higher volume of acid [50cm³] but a laer reaction time (15seconds). "The greater the concentration of acid" is backed up because experiments 3 and 5 have the highest concentration of acid (2.0 mol/dm³) and the fastest reaction time at 15 seconds. [6] His predictions are perfect to support the particle collision theory but his results do not back up his prediction. You would expect a higher concentration of acid in a smaller volume to have a higher rate of reaction. This is because more successful collision are expected. However, his results do not back this up. I would recommend him repeating each experiment 3 times to get more accurate results incase some on his results table are anomolys.
			This is a Level 2 (4 mark) response. While the candidate appreciates that the results in relation to the volume of acid do not

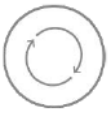
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Question			Answer/Indicative content	Marks	Guidance
					support the prediction but that the prediction is supported in relation to concentration, they have not shown an appreciation of fair testing. The candidate explains the results clearly using the idea of more collisions, rather than collision frequency.
	b		**Any two from:** **Heating the acid:** • idea that acid particles move faster / particles have more energy ✓ • idea of increased collision frequency ✓ • idea of more successful collisions / collisions are more energetic ✓ **AND** **Predicted reaction time** – Any time less than 30s ✓	3(AO 3 × 2.2)	**ALLOW** the reaction time will decrease / the reaction time will be less than 30 seconds **DO NOT ALLOW** reaction time increases **DO NOT ALLOW** faster reaction time Examiner's Comments Good responses to this question described that heating the acid would give the particles more energy and / or make the particles move faster, resulting in more frequent collisions. Credit was given for any reaction time less than 30 seconds.
			Total	9	

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Question			Answer/Indicative content	Marks	Guidance
37		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 100 award 3 marks Round each number to 1 significant figure: Silicon dioxide nanoparticle 20 nm ✓ Silicon atom 0.2 nm ✓ Number of times larger ≅ 20/0.2 = 100 ✓	3(AO 2.2)	ALLOW (18 ÷ 0.22 =) 81.8 / 82 / 80 for 1 mark if no other mark awarded ALLOW (18 ÷ 0.2 =) 90 for 2 marks if no other mark awarded <u>Examiner's Comments</u> Good responses to this question required candidates to use estimating skills and round the data in the question to 1 significant figure in order to work out the answer. Most candidates simply divided 18 by 0.22 and then rounded their answer to 1 significant figure to obtain an answer of 80, only gaining 1 mark.  AfL Appendix 5e of the specification lists the mathematical skills that will be assessed within the context of relevant chemistry. Skill M1d requires candidates to make estimates of the results of simple calculations.

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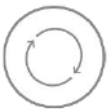
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Question			Answer/Indicative content	Marks	Guidance
		ii	(Silicon dioxide) nanoparticles have a greater surface area (to volume ratio than powder) / ORA ✓ Idea that chemical reactions take place on the surface of a catalyst ✓ Idea that there will be more (frequent) collisions / the rate of reaction will be faster ✓	3(AO 1 × 2.1 2 × 1.1)	ALLOW more active sites / idea that there are more places for the reaction to occur on IGNORE idea that there is more area of catalyst to react with Examiner's Comments High ability candidates were able to describe that nanoparticles have a greater surface area to volume ratio. They appreciated that chemical reactions take place on the surface of the catalyst and so the larger surface area would help more collisions between reactant particles. Lower ability candidates did not appreciate that this was heterogeneous catalyst activity. Misconception A common misconception is that the catalyst takes part in the reaction and reacts with the reactants.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
38			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.67×10^{-3} (g / s) award 3 marks $8.33 \times 10^{-4} \times 240 = 0.19992 = 0.2$ or $100 \times 2.00 \times 10^{-3} = 0.2$ or $50 \times 4.00 \times 10^{-3} = 0.2$ ✓ $0.2 \div 120 = 0.00166666\ldots$ or $0.2 \div 120 = 0.00167$ ✓ $= 1.67 \times 10^{-3}$ (g / s) ✓ <u>OR</u> $8.33 \times 10^{-4} \times 2$ ✓ = 0.001666 or 0.00167 ✓ $= 1.67 \times 10^{-3}$ (g / s) ✓	3(AO 2 × 2.2 1.2)	ALLOW 1.66×10^{-3} / 1.7×10^{-3} for 2 marks IGNORE 0.0016 / 1.6×10^{-3} ALLOW 1.66×10^{-3} / 1.7×10^{-3} for 2 marks IGNORE 0.0016 / 1.6×10^{-3} ALLOW ECF from incorrect calculation for 3 sig fig and standard form mark <u>Examiner's Comments</u> Many candidates gained 3 marks for a correct answer of 1.67×10^{-3}.  AfL Appendix 5e of the specification lists the mathematical skills that will be assessed within the context of relevant chemistry. Skill M2a requires candidates to use an appropriate number of significant figures. Incorrect rounding to 3 significant figures, giving 1.66×10^{-3}, was a common error.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
39	a		$Mg + 2HCl \rightarrow MgCl_2 + H_2$ Formulae ✓ Balancing ✓	2(AO 2.2)	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** 'and/&' instead of '+' balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae eg $Mg + 2HCL \rightarrow Mgcl_2 + H_2$ <u>Examiner's Comments</u> The task of writing an equation has two main components: writing the correct formulae, most of which were given, and then doing the balancing. In this case, higher ability candidates showed mastery of the formulae and went on to gain both marks. Most other candidates were uncertain of the formulae of hydrogen gas and used 'H' or '2H'. Some did not see the formula of the hydrochloric acid in the stem and wrote HCl_2.

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Question			Answer/Indicative content	Marks	Guidance
	b		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)** Analyses the results (in relation to <u>both</u> volume of acid & mass of magnesium) to show that they do not support the prediction. **AND** explains the results using the reacting particle model. *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)** Analyses the results (in relation to <u>both</u> volume of acid & mass of magnesium) to show that they do not support the prediction OR sees that (both) predictions are incorrect and uses the data to show that only concentration affects reaction time **AND** explains the results using the reacting particle mode Uses the reacting particle model in terms of more collisions rather than frequency of collisions. *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)** Analyses the results to show one of the predictions to be incorrect **OR** Uses the reacting particle model in terms of more collisions rather than frequency of collisions. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks**	6(AO 3×2.2 3×2.2b)	**AO3.2b Analyse information and ideas to draw conclusions.** • results show as volume decreases reaction time does not change so reaction time does not change • results show that as mass of magnesium increases reaction time does not change • reaction in experiment 3 is faster / has a shorter reaction time, than experiment 2 **AO2.2 Apply knowledge and understanding of scientific enquiry, techniques and procedures.** • concentration is higher in experiment 3 • acid particles are more crowded in experiment 3 / acid particles are closer together / more acid particles per unit volume / more acid particles per cm^3 / more acid particles in the same space • more (successful) collisions per second / collisions more often / increased collision frequency / more chance of a collision **IGNORE** references to 'faster' collisions <u>Examiner's Comments</u> While candidates often had trouble in describing what the table showed, many of them showed a clear intuitive understanding and pointed out that it was only changes in concentration that produced an effect. The higher ability candidates responded to both the command prompts and interpreted the table and also included ideas about the reacting particle model. A very large number of candidates did not respond to this second prompt, which limited the number of marks available to them.

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Question			Answer/Indicative content	Marks	Guidance
			No response or no response worthy of credit.		
	c		**Any two from:** **Cooling the acid:** • idea that acid particles move slower / particles have less energy ✓ • idea of decreased collision frequency ✓ • idea of less successful collisions / collisions are less energetic ✓ **AND** **Predicted reaction time** – Any time more than 30s ✓	3(AO 3 × 2.2)	**ALLOW** particles don't move as much **ALLOW** 'less (unspecified) kinetic energy' **IGNORE** 'less energy' unless linked to particles Examiner's Comments Higher ability candidates realised that the particles would move slower or have less energy and suggested a suitable reaction time. Occasionally they even went on to discuss collision frequency or the idea of successful collisions and so scored all three marks. Others showed much confusion over 'rate of reaction' and 'time for reaction'. Many said that when the rate is less the time is less, to the point where examiners could not give credit for statements such as 'the reaction is slower' because there was so much evidence of misunderstanding in that area. A significant number of candidates were able to explain what happens when temperature increases but had some difficulty in reversing their argument to explain what happens if temperature falls. Answers such as 'Less chance of more frequent successful collisions' and 'Fewer frequent successful collisions' were common. These candidates were still able to gain full marks, but centres should be aware of this as a potential problem.

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Question			Answer/Indicative content	Marks	Guidance
	d		(As reactants are used up) concentration of reactants decreases / particles of reactants become less crowded / less reactant particles per unit volume ✓ (so) collision frequency is less / less collisions per second ✓	2(AO 1.2)	Must have idea of concentration IGNORE references to fewer particles/collisions, only mark credit-worthy responses Examiner's Comments The reasons why reactions slow down as they progress was not well understood by candidates of all abilities. Many answers went no further than a re-wording of the stem, stating that the reactants are used up so the rate decreases. Most candidates who did give some form of explanation did so in terms of energy. 'Once the reactants are used up the particles slow down / have less energy', as in **exemplar 4**. There were also several references to enzymes and denaturing Exemplar 4 because once the reactants are used up there is no more product to react so particles slow down [2]
			Total	13	
40			A ✓	1 (AO2.2)	
			Total	1	
41			C ✓	1 (AO2.2)	
			Total	1	
42			C ✓	1 (AO2.2)	
			Total	1	
43			A ✓	1 (AO1.1)	
			Total	1	

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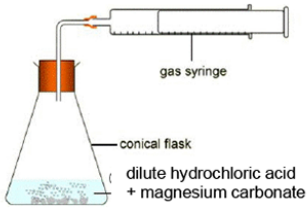
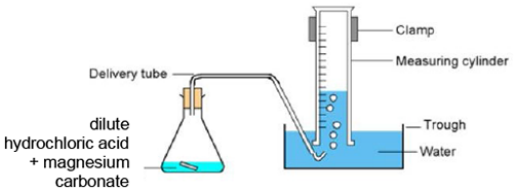
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Question			Answer/Indicative content	Marks	Guidance
44			C ✓	1 (AO2.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
45	a		Use of gas syringe / upturned measuring cylinder / burette to collect gas over water ✓ Apparatus will work ✓ eg  **OR**  **And any three from:** Measure known volume of acid ✓ Add known mass of magnesium carbonate ✓ Measure volume of gas every 30 seconds ✓ Repeat with different concentrations of acid ✓ Repeat using same temperature ✓	5 (AO3.3a)	**ALLOW** idea of same volume of acid in each experiment **ALLOW** idea of same mass of magnesium carbonate in each experiment **ALLOW** Measure volume of gas at any sensible time interval **ALLOW** just the idea of measuring the time taken for a fixed volume of gas to be produced or the volume of gas produced in a fixed time **IGNORE** measure the time taken for the reaction to finish
	b	i	Linear scale on both x and y axes ✓ All points plotted correctly scores 2 marks **BUT** 3 or 4 points plotted correctly scores 1 mark Line of best fit through points ✓	4 (AO3 × 2.2)	**ALLOW** ± ½ square **NB** Check that 7.0×10^{-3} is plotted as 0.7×10^{-2}
		ii	(Rate of reaction) increases ✓	1 (AO3.1a)	

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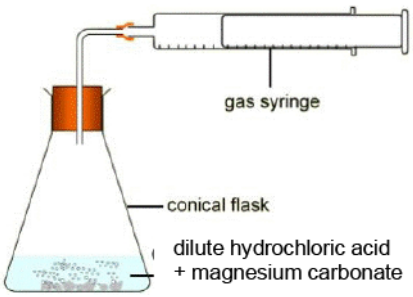
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Question			Answer/Indicative content	Marks	Guidance
		iii	Idea that acid particles move faster / particles have more energy ✓ Idea of increased collision frequency (between acid and thiosulfate) ✓ Idea of more successful collisions / collisions (between acid and thiosulfate) are more energetic / more particles have the activation energy ✓	3 (AO2.2)	IGNORE references to 'faster' collisions IGNORE just 'more collisions'
			Total	13	

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Question			Answer/Indicative content	Marks	Guidance
46	a		Labelled diagram showing gas syringe connected to conical flask ✓  ✓ ✓ **And any three from:** Measure known volume of acid ✓ Add known mass of magnesium carbonate ✓ Measure volume of gas every 30 seconds ✓ Repeat with different concentrations of acid ✓	4 (AO3.3a)	**NB** Apparatus must work
	b	i	All points plotted correctly scores 2 marks **BUT** 3 or 4 points plotted correctly scores 1 mark Line of best fit through points ✓	3 (AO2×2.2) (AO1.2)	**ALLOW** ± ½ square
		ii	42s ± 2s ✓	1 (AO2.2)	**ALLOW** answer ± 2s of graph
		iii	(Rate of reaction) increases ✓	1 (AO3.1a)	

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Question			Answer/Indicative content	Marks	Guidance
		iv	**Any two from:** Idea that particles move faster / particles have more energy ✓ Idea of increased collisions (frequency) between acid and thiosulfate ✓ Idea of more successful collisions / collisions between acid and thiosulfate are more energetic ✓	2 (AO2×2.2)	**IGNORE** references to 'faster' collisions
			Total	11	

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