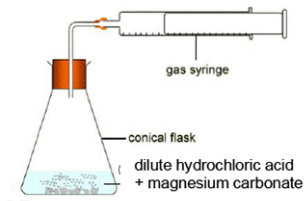
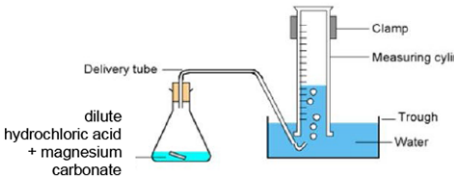
Mark scheme – Controlling Reactions (H)

Question			Answer/Indicative content	Marks	Guidance
1			**C** ✓	1 (AO2.2)	
			Total	**1**	
2			**A** ✓	1 (AO1.1)	
			Total	**1**	
3			**C** ✓	1 (AO2.2)	
			Total	**1**	
4			**C** ✓	1(AO 1.2)	
			Total	**1**	
5	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 ✓	5 (AO3.3 a)	**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

			Repeat using same temperature ✓		
	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 (AO3.1 a)	
		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**	
6	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**	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

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 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.

- 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

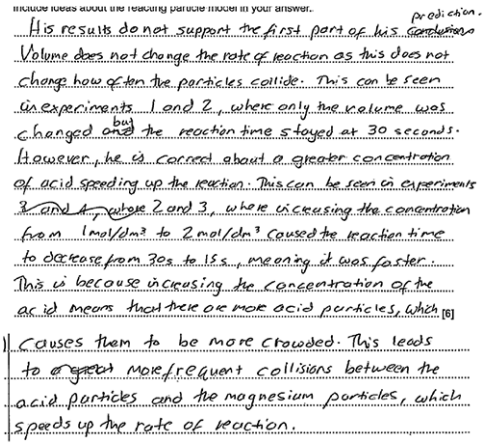
This 6-mark, Level of Response, question assessed AO2 and AO3. At Level 3 (5 - 6 marks) candidates needed to analyse the student's results to describe if the results supported the prediction with reference to experimental data **that includes fair testing**. At this level candidates also needed to explain 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

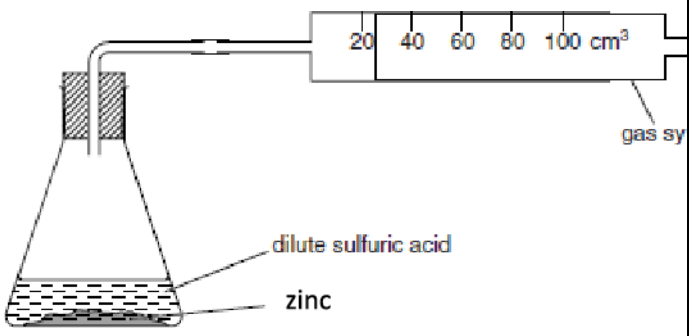


This is a Level 3 (6 mark) response, which has correctly identified that in experiments 1 & 2 only the volume of acid is changed and in experiments 2 & 3 only the concentration of the

					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 lower 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 collisions are expected. However, his results do not back this up. 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 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 ✓	3(AO 3 × 2.2)	**ALLOW** the reaction time will decrease / the reaction time will be less than 30 seconds

			AND **Predicted reaction time** – Any time less than 30s ✓		**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.
	c		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.67 × 10^{-3} (g / s) award 3 marks** 8.33 × 10^{-4} × 240 = 0.19992 = 0.2 or 100 × 2.00 × 10^{-3} = 0.2 or 50 × 4.00 × 10^{-3} = 0.2 ✓ 0.2 ÷ 120 = 0.00166666… or 0.2 ÷ 120 = 0.00167 ✓ = 1.67 × 10^{-3} (g / s) ✓ **OR** 8.33 × 10^{-4} × 2 ✓ = 0.001666 or 0.00167 ✓ = 1.67 × 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 **Examiner's Comments** 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	**12**	
7		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** 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.
		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**	
8			B	1	

			Total	**1**	
9			D	1	
			Total	**1**	
10		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**	
11	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**	