# Mark scheme – Controlling Reactions (F)

| Question | | | Answer/Indicative content | Marks | Guidance |
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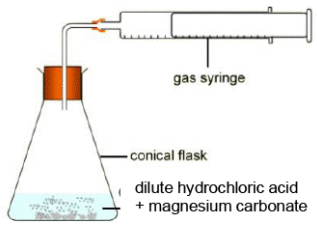
| 1 | | | **C** ✓ | 1 (AO2.2) | |
| | | | **Total** | **1** | |
| 2 | | | **A** ✓ | 1 (AO2.2) | |
| | | | **Total** | **1** | |
| 3 | | | **C** ✓ | 1(AO 1.2) | **Examiner's Comments**<br><br>Almost all candidates chose 'the rate increases'. However, only the higher ability candidates knew that there would be no change in mass, with the others thinking that mass would decrease. |
| | | | **Total** | **1** | |
| 4 | a | i | All points plotted correctly scores 2 marks<br>**BUT**<br>3 or 4 points plotted correctly scores 1 mark<br><br>Line of best fit through points ✓ | 3 (AO2×2.2)<br><br>(AO1.2) | **ALLOW** ± ½ square |
| | | ii | 42s ± 2s ✓ | 1 (AO2.2) | **ALLOW** answer ± 2s of graph |
| | | iii | (Rate of reaction) increases ✓ | 1 (AO3.1a) | |
| | | iv | **Any two from:**<br>Idea that particles move faster / particles have more energy ✓<br><br>Idea of increased collisions (frequency) between acid and thiosulfate ✓<br><br>Idea of more successful collisions / collisions between acid and thiosulfate are more energetic ✓ | 2 (AO2×2.2) | **IGNORE** references to 'faster' collisions |
| | b | | Labelled diagram showing gas syringe connected to conical flask ✓<br><br>  <br> | 4 (AO3.3a) | **NB** Apparatus must work |

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| | | | ✓ ✓<br><br>**And any three from:**<br>Measure known volume of acid ✓<br><br>Add known mass of magnesium carbonate ✓<br><br>Measure volume of gas every 30 seconds ✓<br><br>Repeat with different concentrations of acid ✓ | | |
| | | | **Total** | **11** | |
| 5 | a | | $Mg + 2HCl \rightarrow MgCl_2 + H_2$<br><br>Formulae ✓<br>Balancing ✓ | 2(AO 2.2) | **ALLOW** any correct multiple, including fractions<br>**DO NOT ALLOW** 'and/&' instead of '+'<br><br>balancing mark is dependent on the correct formulae but<br>**ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae<br>eg $Mg + 2HCL \rightarrow Mgcl_2 + H_2$<br><br>**Examiner's Comments**<br><br>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 $HCl_2$. |
| | b | | Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.<br><br>**Level 3 (5–6 marks)**<br>Analyses the results (in relation to both volume of acid & mass of magnesium) to show that they do not support the prediction.<br>**AND**<br>explains the results using the reacting particle model.<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* | 6(AO 3×2.2 3×2.2b) | **AO3.2b Analyse information and ideas to draw conclusions.**<br><br>• results show as volume decreases reaction time does not change so reaction time does not change<br>• results show that as mass of magnesium increases reaction time does not change<br>• reaction in experiment 3 is faster / has a shorter reaction time, than experiment 2<br><br>**AO2.2 Apply knowledge and understanding of scientific enquiry, techniques and procedures.** |

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| | | | **Level 2 (3–4 marks)**<br>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<br>**AND**<br>explains the results using the reacting particle mode Uses the reacting particle model in terms of more collisions rather than frequency of collisions.<br><br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>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.<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | | • concentration is higher in experiment 3<br>• 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<br>• more (successful) collisions per second / collisions more often / increased collision frequency / more chance of a collision<br><br>**IGNORE** references to 'faster' collisions<br><br>**<u>Examiner's Comments</u>**<br><br>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.<br><br>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. |
| | c | | **Any two from:**<br>**Cooling the acid:**<br><br>• idea that acid particles move slower / particles have less energy ✓<br>• idea of decreased collision frequency ✓<br>• idea of less successful collisions / collisions are less energetic ✓<br><br>**AND**<br>**Predicted reaction time** – Any time more than 30s ✓ | 3(AO 3 × 2.2) | **ALLOW** particles don't move as much<br>**ALLOW** 'less (unspecified) kinetic energy'<br>**IGNORE** 'less energy' unless linked to particles<br><br>**<u>Examiner's Comments</u>**<br><br>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.<br><br>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. |

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| | | | | | 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. |
| | d | | (As reactants are used up) concentration of reactants decreases / particles of reactants become less crowded / less reactant particles per unit volume ✓<br><br>(so) collision frequency is less / less collisions per second ✓ | 2(AO 1.2) | Must have idea of concentration<br><br>**IGNORE** references to fewer particles/collisions, only mark credit-worthy responses<br><br>**Examiner's Comments**<br><br>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<br><br>**Exemplar 4**<br><br>because once the reactants are used up there is no more product to react so particles slow down [2] |
| | | | **Total** | **13** | |
| 6 | | i | **FIRST CHECK THE ANSWER ON ANSWER LINE**<br>**If answer = 100 award 3 marks**<br><br>Round each number to 1 significant figure:<br>Silicon dioxide nanoparticle 20 nm ✓<br>Silicon atom 0.2 nm ✓<br><br>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<br>**ALLOW** (18 ÷ 0.2 =) 90 for 2 marks if no other mark awarded<br><br>**Examiner's Comments**<br><br>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.<br><br>A few candidates assumed this was a much |

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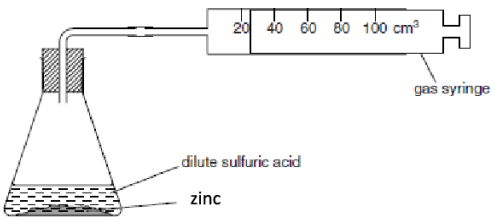
| | | | | | more complicated problem than it was and calculated the areas of circles of the two diameters given. |
| | | ii | (Silicon dioxide) nanoparticles have a greater surface area (to volume ratio than powder) / ORA ✓<br><br>Idea that chemical reactions take place on the surface of a catalyst ✓<br><br>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<br><br>**IGNORE** idea that there is more area of catalyst to react with<br><br>**Examiner's Comments**<br><br>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.<br><br>**Exemplar 5**<br><br>Because it has more surface area to volume ratio. This means the more surface area it has, the faster the reaction will take place - speeding it up. [3]<br><br>This response gained two of the three marks available. |
| | | | **Total** | **6** | |
| 7 | a | | Suitable container for the reactants e.g. flask, boiling tube or test tube (1)<br><br>Use of a gas syringe / upturned burette with water in trough of water / upturned measuring cylinder with water in trough of water (1)<br><br>The method actually works (1) | 3 |  |
| | b | i | To allow a comparison between with and without the added substance (1) | 1 | |

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| | | ii | Idea that the rate of reaction will change if concentration is changed (1) | 1 | It is a fair test is not sufficient<br><br>**ALLOW** if concentration is increased the rate of reaction is increased<br><br>**ALLOW** to ensure there are the same number of acid particles present / same number of acid particles per unit volume |
| | | iii | Copper<br><br>Because the reaction is faster (1)<br><br>There is no change in appearance (1) | 2 | **No** marks for copper on its own<br>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<br>because of smaller surface area / less exposed particles / less collisions (2) | 2 | **No** marks for the prediction on its own<br><br>**No** marks for whole question if prediction incorrect |
| | | | **Total** | **10** | |
| 8 | | | ** Please refer to the marking instruction point 10 for guidance on how to mark this question.*<br><br>**Level 3 (5–6 marks)**<br>**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.**<br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>**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.**<br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>**Describes the effect of changing the temperature and pressure on the percentage yield from the table or** | 6 | **AO1.1: Knowledge of pressure on rate of reaction**<br><br>• Increasing the pressure increases the rate of reaction.<br>• Increasing the pressure means particles are closer together.<br>• Increasing the pressure means more crowded particles / more particles in the same space.<br>• Increasing the pressure means more collisions between particles.<br>• More collisions the quicker the reaction.<br>• More collisions more percentage yield.<br><br>**AO3.1a: Analyse information in the table to interpret percentage yield**<br><br>• As temperature increases the percentage yield decreases.<br>• As pressure increases the percentage yield increases.<br>• The highest yield is when the temperature is low and the pressure is high. |

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| | | | **describes the effect of increasing the pressure on the rate of reaction.**<br>*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.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | | |
| | | | **Total** | **6** | |
| 9 | | | C | 1 | |
| | | | **Total** | **1** | |
| 10 | | | A | 1 | |
| | | | **Total** | **1** | |