AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.6.1.1

Calculating rates of reactions

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**9**
Available paper years	**2018–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

5.6.1.1 Calculating rates of reactions

Answer 01 · Mark scheme June 2018 | 8464/C/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	$CaCl_2$ + CO_2 + H_2O	products in any order	1	AO2 5.1.1.1
	balancing: **2** (HCl)	dependent on correct formulae for products	1	5.6.1.2
05.2		values must be approximately correct		AO2 5.6.1.1
	value from graph used to show volume increase	must include a time or volume value	1	
	values from graph used to show the volume increases less rapidly	must include time interval or volume increment	1	
	volume **or** time stated when graph line levels off	allow levels off at 60 (cm^3) **or** 28 to 30 s allow descriptions in terms of rate of reaction	1	
05.3	draw tangent at 15 s	allow draw a straight line on the curve at 15 s	1	AO2 5.6.1.1
	calculate gradient	allow correct description of gradient calculation ignore calculations if given	1	
05.4	centimetres cubed per second	allow cm^3/s **or** cm^3 s^{-1} (all lower case) allow mixture of abbreviations and words, eg centimetres cubed/s do **not** accept non-SI abbreviations (eg sec for s)	1	AO1 5.6.1.1
05.5	(rate) increases as chips get smaller	allow converse	1	AO3 5.6.1.1 5.6.1.2

5.6.1.1 Calculating rates of reactions

Answer 01 · Mark scheme

June 2018 | 8464/C/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	same amount of acid **or** same number of moles of acid	allow same volume of acid allow same concentration of acid allow same mass of $CaCO_3$ / marble chips allow one reactant is the limiting factor	1	AO3 5.3.2.4 5.6.1.1
05.7	(surface area of each face = 2 × 2 =) 4 (6 × 4 =) 24 (cm^2)	an answer of 24 (cm^2) scores **2** marks allow 6 × student's value from step 1	1 1	AO2 5.6.1.2
05.8	small(er) chips have large(r) surface area (for the same volume) so more frequent collisions	allow converse allow more chance of collisions allow more likely to collide do **not** accept reference to speed of particles or energy of collisions ignore more collisions ignore more successful collisions	1 1	AO3 5.6.1.2 5.6.1.3 AO1 5.6.1.2 5.6.1.3

5.6.1.1 Calculating rates of reactions

Answer 01 · Mark scheme

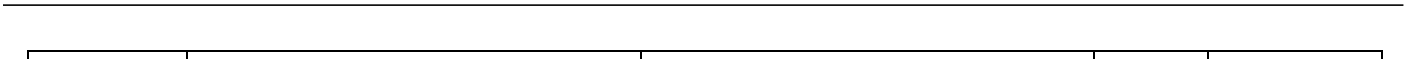
June 2018 | 8464/C/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.9	(sloping part is less steep because) reaction is slower	allow converse for more concentrated acid	1	AO2 5.6.1.2 5.6.1.3
	due to less frequent collisions	do **not** accept reference to speed of particles or energy of collisions ignore fewer collisions	1	
	fewer acid particles (in same volume)	ignore weaker acid	1	
	or (sloping part is less steep because) reaction is slower (1) there are fewer acid particles (in same volume) (1) (graph levels off lower) so less gas is produced (1)			
Total			**17**	

5.6.1.1 Calculating rates of reactions

Answer 01 · Mark scheme

June 2018 | 8464/C/2H | Original Q5



5.6.1.1 Calculating rates of reactions

Answer 02 · Mark scheme June 2019 | 8464/C/2H | Original Q5

05.1	$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$		1	AO2 5.6.1.2 5.1.1.1
05.2	electron transfer		1	AO2 5.11
05.3	all points correctly plotted	allow a tolerance of ± ½ a small square allow **1** mark for at least 4 points correctly plotted	2	AO2 5.6.1.1
	line of best fit		1	
05.4	(rate) decreases	allow (rate is) fastest at the beginning	1	AO3 5.6.1.1
	(rate decrease) more slowly as time increases (in rate)		1	AO3 5.6.1.1
	(rate) becomes zero at time read from graph	allow reaction stops at time read from graph	1	AO3 5.6.1.1
05.5		Incorrect reference to energy scores **max. 1**		AO2 5.6.1.3
	(rate decreases because) fewer particles (of acid / magnesium) as reaction progresses	allow (rate decreases because) concentration of acid decreases as reaction progresses	1	AO1 5.6.1.3
	(so) less frequent collisions	allow collisions less likely ignore less / fewer collisions	1	AO2 5.6.1.3
	reaction stops due to limiting factor / reagent	allow reaction stops because a reactant is used up	1	5.3.2.4
Total			**11**	

5.6.1.1 Calculating rates of reactions

Answer 02 · Mark scheme

June 2019 | 8464/C/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.6.1.1 Calculating rates of reactions

Answer 03 · Mark scheme

November 2020 | 8464/C/2H | Original Q2

Question	Answers	Mark	AO / Spec. Ref.
02.1	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO3 5.6.1.2
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content: • use a measuring cylinder / pipette / burette to measure 50 cm^3 of sodium thiosulfate • use a different measuring cylinder / pipette / burette to measure 10 cm^3 of hydrochloric acid • start the timer when the acid is added • record the temperature of the solution after the acid is added • stop the timer when the cross is no longer visible • record the temperature of the solution at the end of the reaction • calculate the mean temperature of the reaction • repeat the experiment at different temperatures • use the same concentration of sodium thiosulfate and same concentration of hydrochloric acid • use the same volume of sodium thiosulfate and the same volume of hydrochloric acid • describe how to heat the thiosulfate / acid solutions		

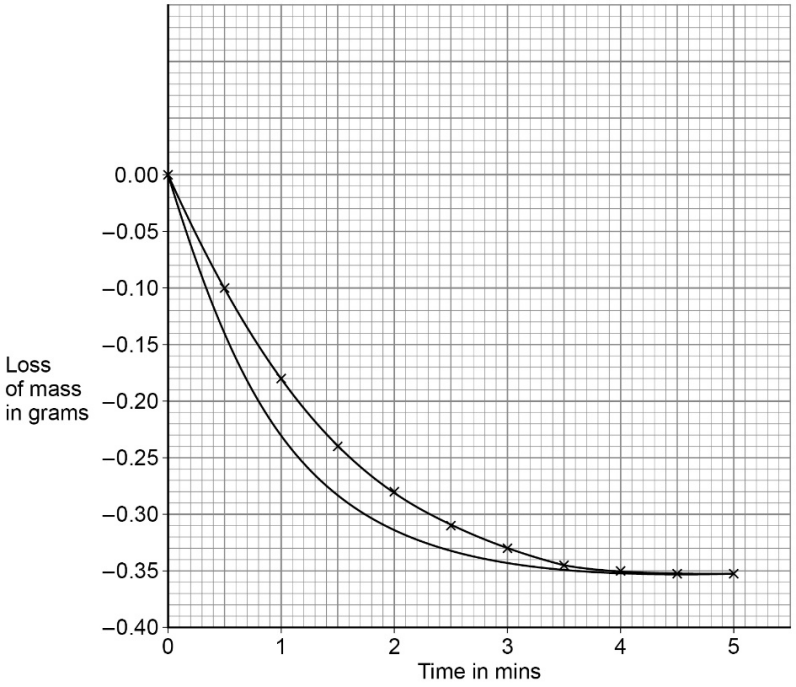
5.6.1.1 Calculating rates of reactions

Answer 03 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	(change in mass of gas =) 0.15 **and** (time =) 2	ignore signs	1	AO2 5.6.1.1 5.6.1.4
	(rate of reaction =) $\frac{0.15}{2}$	allow correct use of incorrectly determined values for mass and / or time	1	
	0.075 (g/min)		1	

5.6.1.1 Calculating rates of reactions

Answer 03 · Mark scheme

02.3	curve starts at same point, to the left and steeper line levels at −0.35 g the curve below can be awarded 2 marks  	1 1	AO2 5.6.1.1 5.6.1.2 5.6.1.4

Total			**11**

5.6.1.1 Calculating rates of reactions

Answer 03 · Mark scheme

November 2020 | 8464/C/2H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.6.1.1 Calculating rates of reactions

Answer 04 · Mark scheme November 2021 | 8464/C/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec.
01.1	**independent** concentration (of hydrochloric acid) **control** any **one** from: • temperature (of hydrochloric acid) • volume of (hydrochloric) acid • length of magnesium • surface area of magnesium	 allow same mass of magnesium allow same form of magnesium ignore amount	1 1	AO1 5.6.1 RPA11
01.2	all points correctly plotted line of best fit	allow a tolerance of ± ½ a small square allow 1 mark for 4 or 5 points correctly plotted must include 0,0	2 1	AO2 5.6.1 RPA11
01.3	the rate decreases		1	AO3 5.6.1 RPA11
01.4	the magnesium reacted more quickly		1	AO3 5.6.1.2

5.6.1.1 Calculating rates of reactions

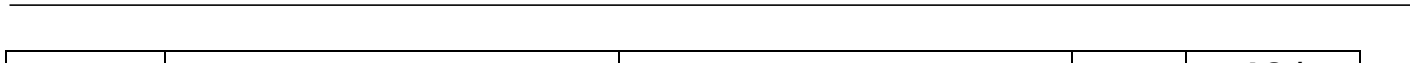
Answer 04 · Mark scheme

01.5	rate increases (because) particles have more energy (so) more frequent collisions	allow reaction happens faster allow (because) particles move faster allow (because) more particles have energy greater than the activation energy	1 1 1	AO1 5.6.1.2 5.6.1.3
Total			**10**	

5.6.1.1 Calculating rates of reactions

Answer 04 · Mark scheme

November 2021 | 8464/C/2H | Original Q1



5.6.1.1 Calculating rates of reactions

Answer 05 · Mark scheme

June 2022 | 8464/C/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	sulfur dioxide produced (which) escapes from the (conical) flask	allow a gas is produced	1 1	AO3 AO2 5.2.2.2 RPA11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	dependent		1	AO2 5.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	all points correctly plotted line of best fit	allow **1** mark for 3, 4 or 5 points correctly plotted allow a tolerance of ± ½ a small square	2 1	AO2 AO3 5.6.1.1

5.6.1.1 Calculating rates of reactions

Answer 05 · Mark scheme

June 2022 | 8464/C/2H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	correct values for *x* step **and** *y* step from tangent		1	AO2 5.6.1.1 RPA11
	(rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$	allow correct use of an incorrectly determined value from tangent for *x* step and/or *y* step	1	
	correct calculation of rate		1	
	s dm^3/mol		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	(as reaction proceeds) fewer (sodium thiosulfate) particles per unit volume	allow (as reaction proceeds) concentration (of sodium thiosulfate) decreases	1	AO2 5.6.1.2 5.6.1.3 RPA11
	(so) frequency of (particle) collisions decreases	allow (so) probability of collision decreases	1	

Total Question 3		**12**

5.6.1.1 Calculating rates of reactions

Answer 06 · Mark scheme

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(test) glowing splint	MP2 is dependent upon MP1 being awarded do **not** accept burning / lit splint	1	AO2 AO1
	(result) relights	allow glows more brightly	1	5.8.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	smaller volume of gas produced (per unit time) (so) error in reading is a larger percentage of the total volume		1 1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	any **one** from: • measuring vessel (for hydrogen peroxide or gas) wrongly calibrated • balance wrongly calibrated • timer slow / fast		1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	all points plotted correctly line of best fit	allow a tolerance of ± ½ a small square allow at least 4 points plotted correctly for **1** mark	2 1	AO2 AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	manganese dioxide (because manganese dioxide) has the steepest gradient	allow ecf from question **06.4** allow (because manganese dioxide) produces the most gas per unit time	1 1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6	same number of particles per unit volume (so) same frequency of collisions (with catalyst)	allow same concentration (of hydrogen peroxide solution)	1 1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.7	tangent drawn at 20 s value for *x* step **and** *y* step from tangent (rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$ correctly calculated to 3 significant figures	 allow evidence of use of two points on tangent either on the graph or in the text allow correct use of incorrectly determined value(s) for *x* step and/or *y* step from a drawn tangent allow a correctly calculated answer to 3 significant figures from an incorrect calculation which uses values determined from the graph	1 1 1 1 1	AO2 5.6.1.1

Total Question 6	17

5.6.1.1 Calculating rates of reactions

Answer 07 · Mark scheme

June 2024 | 8464/C/2H | Original Q2

Question 2

Question	Answers	Mark	AO / Spec. Ref.
02.1	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	AO3
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	AO2
	No relevant content	0	
	Indicative content • measure volume of (hydrochloric) acid • using a measuring cylinder • measure mass of calcium carbonate • using a balance • **add (hydrochloric) acid to calcium carbonate in conical flask** • **put stopper and delivery tube into conical flask** • **start a timer** • **record volume of gas collected at set time intervals or time how long it takes for a fixed volume of gas to be collected** • **repeat using different sized pieces of calcium carbonate** • use same mass of calcium carbonate • use same volume of (hydrochloric) acid • use same concentration of (hydrochloric) acid • use same temperature of (hydrochloric) acid • repeat each experiment		5.6.1.2

5.6.1.1 Calculating rates of reactions

Answer 07 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	(increasing the temperature) increases the rate of reaction		1	AO1 5.6.1.2 5.6.1.3
	(because) particles have more energy	allow (because) particles move faster	1	
	(so) the frequency of collisions increases	allow (so) a greater proportion of collisions have enough energy to react	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	(a substance that) increases the rate of reaction	allow (a catalyst) increases / changes the rate of reaction	1	AO1 5.6.1.4
	and is not used up during the reaction	ignore does not take part in the reaction	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	enzymes		1	AO1 5.6.1.4

Total Question 2	12

5.6.1.1 Calculating rates of reactions

Answer 08 · Mark scheme

June 2024 | 8464/C/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	= 198 kJ/mol		1	AO2 5.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	equilibrium position shifts to the right		1	AO2 5.6.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	equilibrium position shifts to the left		1	AO2 5.6.2.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	equilibrium position shifts to the left		1	AO2 5.6.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(effect) (equilibrium position) does not change (reason) increases the rate of the forward reaction and reverse reaction equally		1 1	AO3 5.6.1.4 5.6.2.3

5.6.1.1 Calculating rates of reactions

Answer 08 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	210 (s)	allow a value in the range 205 to 210 (s)	1	AO3 5.6.2.3
	lines become level / horizontal		1	
	(because) the rates of the forward reaction and reverse reaction are equal **or** (because) the number of moles (of all three gases) remain constant		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.7	tangent drawn at 60 s		1	AO2 5.6.1.1
	correct values for *y* step **and** *x* step from tangent	allow correct use of an incorrectly drawn tangent allow a tolerance of ± ½ a small square for each coordinate	1	
	(rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$	allow correct use of incorrectly determined value(s) from the tangent for *y* step and/or *x* step	1	
	correct calculation of rate (mol/s)		1	

Total Question 5	13

5.6.1.1 Calculating rates of reactions

Answer 09 · Mark scheme

June 2025 | 8464/C/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	time taken (for the cross to be no longer visible)		1	AO1 5.6.1.2 RPA11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	sulfur (is produced)		1	AO2 5.2.2.2 5.6.1.2
	(which is a) solid	allow (which is) insoluble allow (which is) a precipitate	1	RPA11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3		allow converse throughout		AO1 5.6.1.2 5.6.1.3
	increasing the concentration increases the rate of reaction		1	
	(because) there are more particles in the same volume (of solution)	allow (because) the particles are closer together do **not** accept the particles have more energy	1	
	(so) there are more frequent collisions		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	to reduce loss of gas	allow to reduce loss of hydrogen do **not** accept to stop loss of gas / hydrogen	1	AO3 5.6.1.2 RPA11

5.6.1.1 Calculating rates of reactions

Answer 09 · Mark scheme

June 2025 | 8464/C/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(test) add a burning splint (result) (hydrogen burns with) a pop sound	do **not** accept glowing splint MP2 is dependent upon MP1 being awarded	1 1	AO1 5.8.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	tangent drawn at 75 s value of *x*-step **and** *y*-step from tangent $(\text{rate}=)\ \frac{\text{value for y-step}}{\text{value for x-step}}$ correct calculation of rate	 allow evidence of use of two points on tangent either on the graph or in the text allow a tolerance of ± ½ a small square allow correct use of incorrectly determined value(s) for *x*-step and/or *y*-step from a drawn tangent 	1 1 1 1	AO2 5.6.1.1 RPA11

Total Question 5	13

5.6.1.1 Calculating rates of reactions

Answer 01 · Examiner comments

June 2018 | 8464/C/2H | Original Q5

Question 5 (standard, standard / high & high demand)

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05.1 9% of students managed to correctly complete and balance the equation. Many different errors were seen. Students found it difficult to write the correct formulae of the products, for example, calcium chloride (CaCl), carbon dioxide (CO_3) and hydrogen (H_2) instead of water, but H_2 was probably written to balance the extra oxygen attributed to carbon dioxide.

Some students wrote down random products including ones with none of the elements present in the reactants. A sizeable minority of students simply repeated the reactants on the products side. Those students who did get the formulae of the products correct were usually able to balance the equation.

05.2 This question discriminated well with only 6% of students failing to achieve any marks for their answer. Most students quoted values (times and / or volumes) when describing the trend shown in the graph. Usually for the volume increase and the point at which the reaction stopped; as a result 53% of the students achieved two marks.

Many students failed to include in their answer that the rate slowed down. Three marks were awarded to 26% of students. Lower-attaining students simply described the shape of the graph without reference to any values.

05.3 Many students described drawing a line up from the *x*-axis to the curve and then another line across to the *y*-axis to read off the value which was not creditworthy. Several students mistakenly described how to calculate average rate of reaction.

24% of students correctly drew a tangent and explained how to work out the gradient. However, a few students incorrectly quoted y/x rather than $\Delta y/\Delta x$.

05.4 69% of students gave the correct answer of cm^3/s on this question. Nearly all other incorrect variations, for example cm/s, s/cm^3 and cm/sec were seen.

05.5 67% of students gained credit for a correct response. Although, many responses were confused; students stated that ‘a larger chip would have a faster rate of reaction because its surface area is bigger’. Some responses referred to how size of the marble chip affected the amount of gas produced, rather than the rate of its production.

05.6 29% of students achieved credit on this question. Many responses incorrectly stated that ’60 cm^3 was the maximum amount of gas that was in the chips’ or ‘it’s the maximum volume the syringe can hold’. Some students thought that both reactants had ‘been used up’. However, ‘a limiting factor’ was often seen as was ‘same mass of $CaCO_3$ used’.

5.6.1.1 Calculating rates of reactions

Answer 01 · Examiner comments

June 2018 | 8464/C/2H | Original Q5

05.7 54% of students achieved both marks for this question. Most students successfully calculated the surface area of one side of the large cube and then multiplied the answer by six (sides). An answer of 48 was regularly seen (volume of large cube × number of sides).

05.8 13% of students achieved both marks for this question. Many students were unable to correctly link the surface area to the size of the marble chips. Students often answered in terms of 'more collisions' with no reference to the frequency of those collisions.

A sizable number of students seem to think it was the marble chips colliding. Or they answered in terms of number of chips available (smaller the chips – more available to react) rather than considering the size the chips relative to their surface area.

05.9 In this question 82% of students achieved some credit for their response. 14% of students achieved all three marks. Both marking pathways were equally represented. However, very often students would start to answer in terms of one concentration then repeat information in the converse form for the other concentration but gaining no further marks.

Volume of gas evolved, or rate of reaction were the most common points addressed in student responses. Responses that stated 'fewer acid particles' or as highlighted in question **05.8**, their effect on the 'frequency of collisions', were seen less often.

5.6.1.1 Calculating rates of reactions

Answer 02 · Examiner comments — June 2019 | 8464/C/2H | Original Q5

Question 5 (standard/high demand)

05.1 Around 6% of students gained this mark. The third option was the most popular incorrect response.

Answer 02 · Examiner comments — June 2019 | 8464/C/2H | Original Q5

05.2 About 65% of students gained this mark. Most students gave the correct symbol equation rather than the ionic equation.

05.3 This question produced a good spread of marks, with only 2.5% of students failing to gain any credit for their answer. Around 27% of students gained all three marks. Most students gained 2 marks and just below a third gained one mark.

Common errors included:

- failing to plot the point at the origin
- incorrectly plotting the points (particularly 35, 36.0 and 95, 59.0), lines of best fit that were sketched
- drawing a straight line of best fit rather than a curved line of best fit
- lines of best fit that extended too far above the plateau
- ‘double lines’ drawn as part of the curve.

Points plotted as ‘crosses’ are easier to see and mark as opposed to those points plotted as ‘dots’, though large, heavy crosses make it difficult for examiners to determine whether the plotted points are within tolerance and risk losing credit.

05.4 Few students gained any credit on this question. Many responses incorrectly described the change in volume of gas evolved rather than the change in the rate of the reaction. Those students who gained one mark usually did so by identifying the point at which the rate of reaction became zero (read from their graph). However, some students used the figure from Table 2 (120 seconds) to identify when the reaction stopped, which did not reflect the time indicated by their graph, so consequently gained no credit.

05.5 In this question more than a third of students gained some credit for their response, however, only about 1% of students obtained all 3 marks. Very often students would answer in terms of the reaction getting faster (rather than slower), ‘the particles gain more energy and move about faster causing more frequent collisions’ or would give a detailed answer covering all aspects of the collision theory rather than explaining the rate changes for the reaction given in the question.

Some students did not gain the last marking point because they referred to both reactants being ‘used up’ at the end of the reaction rather than just one reactant or it being a limiting factor.

5.6.1.1 Calculating rates of reactions

Answer 04 · Examiner comments November 2021 | 8464/C/2H | Original Q1

Question 1 (standard demand)

The variables were rarely correctly identified. Well over half of the students did not score any marks. No credit was given for the use of “amount” in place of volume or mass or for simply stating magnesium or hydrochloric acid unqualified.

The graphs were accurately plotted and a reasonable line of best fit drawn which needed to include the given plot at (0.0)

The effect of temperature upon the rate of reaction was well known, and many scored highly on this question. When explaining how the rate of reaction is affected credit is given for the frequency of particle collisions not simply more collisions.

Answer 05 · Examiner comments June 2022 | 8464/C/2H | Original Q3

Question 3

The most accessible item in this question was the graph, however students found interpretation of the practical results difficult.

03.1 About 2 in 5 students scored at least 1 mark for this item. The most common answer was that sulfur dioxide or a gas was produced. There needed to be some recognition that sulfur dioxide was a product in the reaction, it was not enough to say that sulfur dioxide took part. Just over 15% of students then went on to say that the gas escaped from the flask.

03.2 Two thirds of students were able to identify time as the dependent variable.

03.3 Over 90% of students plotted the points correctly on the graph. Only 1 in 5 were able to then go onto drawing a curve of best fit whilst missing out the anomalous point.

5.6.1.1 Calculating rates of reactions

Answer 05 · Examiner comments June 2022 | 8464/C/2H | Original Q3

03.4 About a third of students were able to correctly calculate the gradient and clearly show their working. Students should be encouraged to annotate the line that the gradient is calculated from, as marks cannot be awarded for numbers whose provenenance cannot be determined. Very few students were able to correctly determine the units.

03.5 About a quarter of students were able to score at least 1 mark on this question. This is an application of a standard explanation; however, many students still appear to think that concentration changes are related to the energy of the particles.

Answer 06 · Examiner comments June 2023 | 8464/C/2H | Original Q6

Question 6

06.1 Fewer than half of the students were able to identify oxygen from the equation then recall the test for oxygen gas and its result. Frequently, a description of a glowing splint was inadequate, such as a blown out splint or just a splint.

06.2 Practical errors are not well known by students and fewer than one in ten gained any marks on this question, usually for the idea that a smaller volume of hydrogen peroxide would lead to a smaller volume of gas. Students did not then make the link to a greater percentage reading error.

06.3 Understanding what a systematic error is was not well known by students with fewer than one in twenty five gaining this mark. There is significant confusion with a zero error, which could be systematic, but there was little realisation that the error has to be the same for every reading taken.

06.4 Three quarters of students were able to correctly plot the points on the graph. However, with the anomaly (which was not flagged in the question) and the curve, only about a quarter actually scored all three marks. It did appear that many thought the line had to be straight because the two already on the graph were. However, there was no realisation that these would also slow as the maximum volume of oxygen had been produced.

06.5 Nearly half of students correctly identified manganese oxide (not magnesium oxide) as the catalyst that gave the fastest rate of reaction with the reason. Since the question asked for the fastest rate, the superlative was required in the answer, which many students missed, so a quarter gained one mark, most frequently for this.

5.6.1.1 Calculating rates of reactions

Answer 06 · Examiner comments June 2023 | 8464/C/2H | Original Q6

06.6 Most students did not answer the question, preferring to talk about what the reaction was dependent on. Some talked about concentration, temperature, or surface area affecting rate without linking it to this specific question so failed to gain any credit.

06.7 Nearly a quarter of students gained full marks on this question. It appeared that if a student knew to draw a tangent, they could often work it through to an answer. The most common way of not gaining marks when a tangent was drawn was for misreading the scales, or not giving an answer to three significant figures. If a tangent was not drawn, then the mark was limited to a maximum of one for a correct calculation of an expression given to three significant figures.

5.6.1.1 Calculating rates of reactions

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

5.6.1.1 Calculating rates of reactions

Answer 07 · Examiner comments

Question 2 (standard demand)

02.1 This question was well attempted overall with very few blank responses. Many students were able to list some of the key points necessary for a valid result.

To reach Level 2, three key steps, or two with control variables, were required. To achieve Level 3 marks, all key steps and control variables were needed.

The two most common steps identified were adding the hydrochloric acid to the calcium carbonate in the conical flask and attaching the stopper and delivery tube. Many students could not then access Level 3 as they often referred to 'counting the bubbles of gas' or to 'reading the volume when the reaction had finished', both of which would not allow a valid result to be obtained. Another common response was to 'repeat the experiment changing the mass of calcium carbonate' instead of using different-sized pieces with the same mass. This once again limited the response to Level 2, even if control variables were identified.

A significant number of students did identify one or more control variables, but only listed one or two key steps, again limiting their responses to Level 2. Only a minority of students were able to obtain 6 marks.

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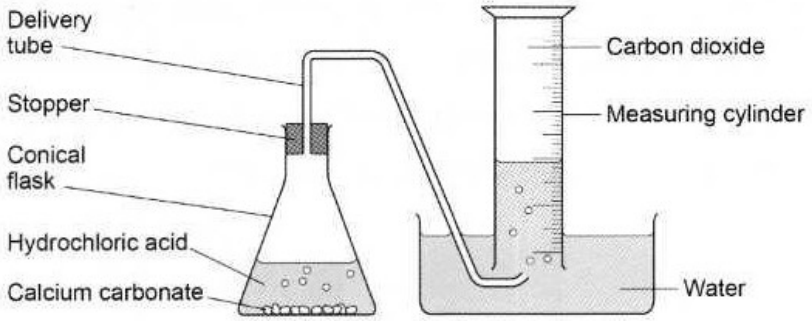
5.6.1.1 Calculating rates of reactions

Answer 07 · Examiner comments June 2024 | 8464/C/2H | Original Q2

0 7 . 1 A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

Figure 6 shows the apparatus.

Figure 6



Describe a method the student could use to produce valid results.

[6 marks]

1.) Measure the mass of the calcium carbonate

2.) Add 50 cm^3 of hydrochloric acid into the conical flask and put the ~~delivery~~ stopper over to trap the gasses in.

3.) connect the delivery tube to the water so that the gasses can enter it.

4.) Measure the ~~amount of tar potato bit~~ amount of carbon dioxide.

5.) ~~Also measure the amount of~~ ~~Repeat the experi~~ Record the results of carbon dioxide and how much calcium carbonate was used.

6.) Repeat steps 1-5 ~~but~~ with different masses of calcium

Turn over ▶

This student (from a Foundation tier paper) has achieved the first two key steps; however, they have not described what they are going to measure or change in the repeats to achieve the other key steps. The student has specified 50 cm^3 of hydrochloric acid and done repeats (of something) so that they have given a control variable. This would therefore just place this script into Level 2 and 3 marks are awarded.

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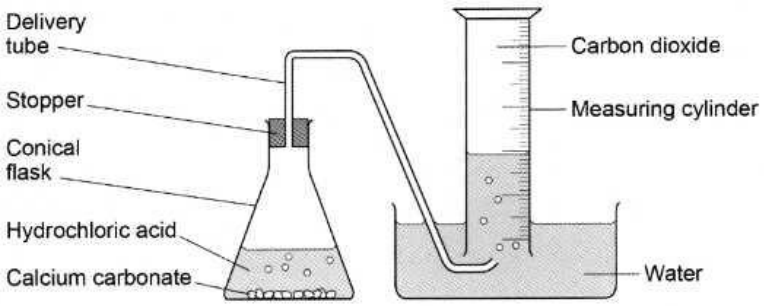
5.6.1.1 Calculating rates of reactions

Answer 07 · Examiner comments June 2024 | 8464/C/2H | Original Q2

0 2 . 1 A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

Figure 3 shows the apparatus.

Figure 3



Describe a method the student could use to produce valid results. **[6 marks]**

- Use a balance to ~~find out the M~~ make sure your using the correct mass of calcium carbonate
- then place the calcium carbonate into the hydrochloric acid and place the stopper with the delivery tube on very quickly.
- record the amount of carbon dioxide in the measuring cylinder every 30 seconds ~~repeat this~~ until the calcium carbonate stops bubbling.
- repeat this method but with bigger particle size of calcium carbonate but they have to be the same mass as the smaller particles.

In this response from a Higher tier paper the student has suggested that the 'correct mass' of calcium carbonate should be used in the first bullet point. This is insufficient for a control variable, but in the final bullet point the 'same mass' has been identified, so there is one control variable here. The first two key steps are identified in the second bullet point. Key steps 3 and 4 are given in the third bullet point. 'Amount' would not be acceptable in a points-based mark scheme, but this response should be marked holistically as it is an extended response. There is no explicit mention of starting a stopwatch; however, it is implied in the statement 'every 30 seconds.' The final bullet point gives the repeats with a different particle size and one control variable.

Therefore, there are all five key steps, and one control variable so this is a Level 3 response and is awarded 5 marks. An additional control variable is needed for 6 marks.

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5.6.1.1 Calculating rates of reactions

Answer 07 · Examiner comments June 2024 | 8464/C/2H | Original Q2

02.2 The vast majority of students on this tier scored some marks for this question, with marking points 1 and 2 being more commonly awarded.

A significant number of students still confuse 'number of collisions' with 'frequency of collisions' and there were many responses that simply stated 'there would be more collisions between particles' which was not creditworthy for marking point 3.

0 2 . 2 The student investigated the effect of increasing the temperature on the rate of a reaction.

Explain the effect of increasing the temperature on the rate of a reaction.

Refer to particles and collisions in your answer.

[3 marks]

Increasing the temprature will increase the rate of reaction because an increased temprature will give the particles more energy meaning they will be moving faster meaning more colisions occuring.

0 2 . 2 The student investigated the effect of increasing the temperature on the rate of a reaction.

Explain the effect of increasing the temperature on the rate of a reaction.

Refer to particles and collisions in your answer.

[3 marks]

When the temperature increases the particles have more energy and move around. Because of this the particles collide more frequently with each other, resulting in the rate of reaction increasing

The first student clearly gains marking points 1 and 2 in the first two lines. However, they only write about more collisions rather than more frequent collisions, so the response is insufficient for marking point 3.

The second answer is not structured as in the mark scheme; however, it covers each of the marking points clearly and gains all 3 marks.

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5.6.1.1 Calculating rates of reactions

Answer 07 · Examiner comments June 2024 | 8464/C/2H | Original Q2

02.3 A large majority of students gained marking point 1; however, fewer than a third gained the second mark. Many students spent time explaining how a catalyst worked rather than answering the question that was asked. It is important that students understand command words so that they do not waste time in examinations with unnecessary working.

02.4 The majority of students answered this question correctly. The most common incorrect response was simply 'biological catalyst'.

Answer 08 · Examiner comments

Question 5 (standard/high & high demand)

05.1 Three-quarters of students correctly responded that the energy change in the backwards reaction was equal to the energy change in the forward reaction.

05.2 Half of students identified the correct equilibrium shift.

05.3 The multiple-choice questions at the beginning of question 5 become progressively harder, testing the students' understanding of Le Châtelier's principle. Fewer than half of all students correctly answered this question on the effect of pressure on the equilibrium.

05.4 Making the link from the stem that energy is released to the reaction being exothermic, and consequently the effect that a temperature change would have made on the position of this equilibrium, made this the most difficult of these multiple-choice questions. Fewer than 40% of students selected the correct answer.

05.5 Fewer than a third of students correctly gave the effect of a catalyst on equilibrium position for 1 mark. This was a high demand question and the small number of students who gained the second mark reflected this.

Many students had the same misconception that a catalyst only speeds up the forwards reaction. There were two common answers following this misconception: either that this meant the equilibrium would shift right as the forwards reaction had been sped up or that the equilibrium would therefore shift to the left to oppose this.

05.6 Most students were able to gain 1 mark, for the correct time. Common incorrect responses were 200 and 82.5 (seconds). If students put 82.5 then they had the misconception that the equilibrium was reached when the lines crossed and so were prevented from getting any further marks. Students often referred to equilibrium being where the moles were equal at 82.5 seconds.

The mark scheme identified where equilibrium was reached, how the graph showed this and what the graph meant in terms of moles of the three gases.

For the second marking point, a clear description of the line flattening out, not just straightening, was required as 'straightening' could be vertical.

The third marking point is for the number of *moles* not changing. Some students stated that the reaction had stopped, meaning that they could not be awarded the third marking point. Equally, if a student stated that the number of moles was equal, the mark could not be given.

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5.6.1.1 Calculating rates of reactions

Answer 08 · Examiner comments June 2024 | 8464/C/2H | Original Q5

0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

Explanation All the lines go straight to show that the ~~mole~~ number of moles is not changing, ~~and the reaction is ready~~ meaning the reaction has reached equilibrium.

0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

Explanation This is where the line flattens out on the graph. The reaction has taken place and reached equilibrium because the number of moles of each gas is not changing, so therefore the reaction is no longer occuring.

In the first response the student gains the mark for the time, but the 'lines go straight' is insufficient for marking point 2. Marking point 3 is given for the number of moles not changing.

The second response gains marking point 1 for a correct time. Marking point 2 is also given for the '… line flattens out …'. The student would have been given the third marking point for '… the number of moles of each gas is not changing …'; however, this mark cannot be awarded as the student goes on to state that the '… reaction is no longer occurring'.

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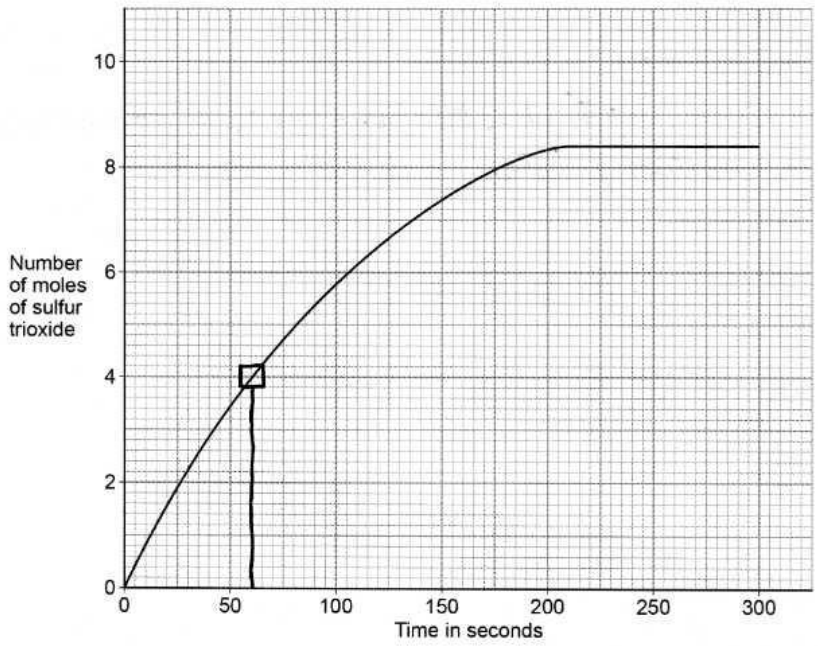
5.6.1.1 Calculating rates of reactions

Answer 08 · Examiner comments June 2024 | 8464/C/2H | Original Q5

05.7 It is evident that students are becoming more familiar with drawing gradients to calculate rates, with a third of students gaining full marks on this high-demand calculation. It should be noted that students who do not draw a tangent cannot gain any marks since the fundamental chemical idea is not known and understood.

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

2÷50 = 0.04 mol/s

Rate = 0.04 mol/s

The student needs to first draw a tangent at 60 s in order to be able to calculate the rate. Here, no tangent has been drawn, so no marks are awarded.

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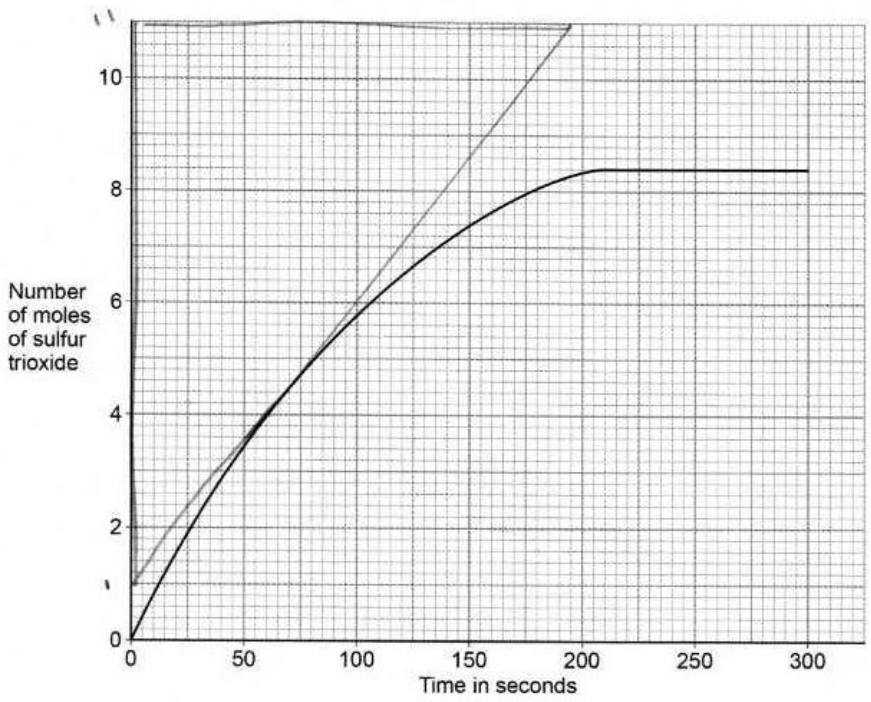
5.6.1.1 Calculating rates of reactions

Answer 08 · Examiner comments June 2024 | 8464/C/2H | Original Q5

The most common errors were misreading the *x*-step and/or the *y*-step. Progress could still be made in the calculation if it was clear that the values had come from a tangent and had been used correctly. Substitution into the equation upside down meant that neither marking point 3 nor marking point 4 could be given.

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

11 − 1 = 10 $\frac{10}{195}$ = 0.051282

195 − 0 = 195

Rate = 0.051282 mol/s

This student has made a good attempt at drawing the tangent at 60 s, so marking point 1 can be awarded. They have drawn a triangle on the graph and substituted correct values for the *y*-step and the *x*-step into the expression (10 ÷ 195), which they have then correctly evaluated. The recurring dots can be ignored as there was no significant figures mark for this question. All 4 marks are awarded.

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5.6.1.1 Calculating rates of reactions

Answer 09 · Examiner comments

June 2025 | 8464/C/2H | Original Q5

Question 5 (Standard, Standard/High and High demand)

05.1 This question was answered well by half of all students. The most common incorrect link to time taken was 'time taken for reaction to go cloudy'.

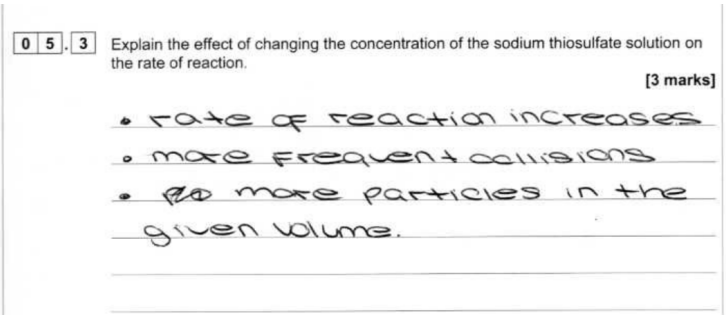
05.2 Although a significant number of students recognised that sulfur was formed and is a solid, they often then linked sulfur dioxide bubbling through the solution as a contributory factor causing the cross to become obscured thus not accessing full marks. Another common error was mistaking S for sodium rather than sulfur.

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5.6.1.1 Calculating rates of reactions

Answer 09 · Examiner comments June 2025 | 8464/C/2H | Original Q5

05.3 Several students misinterpreted this question and simply stated 'changing the concentration' without clarifying whether they meant 'increasing' or 'decreasing'. This resulted in them not having access to any of the marks.
Those who did achieve credit mainly did so by correctly linking the directional change in concentration to a directional change in rate of reaction and then linking this to an appropriate description of frequency of collisions. Descriptions of 'more particles per unit volume/ in the same volume' were rarely seen, with many students simply stating 'more particles'.


0 5 . 3 Explain the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

[3 marks]

- rate of reaction increases
- more frequent collisions
- more particles in the given volume.

The student has not stated how the concentration is changing and therefore what appears to be a good response scores 0 marks.

05.4 The majority of students did not recognise that the reaction would start immediately and that some gas would inevitably escape from the conical flask. They therefore answered in terms of an absolute such as 'to stop gas escaping' or 'to prevent the gas escaping' rather than expressing the fact that the insertion of the bung would 'minimise' or 'reduce' the volume of gas lost. Consequently, very few students gained this mark.

05.5 Over half of students answered this question well, however there was a significant number who mixed up the standard tests for hydrogen and oxygen giving perfect answers but for the wrong gas.

05.6 More students attempted this question than in previous years. Where a tangent was drawn further marks were nearly always achieved.
Common errors included misreading the scales to calculate the *x*-step or *y*-step, using these figures incorrectly (change in *x*/change in *y*), or simply trying to calculate the gradient from a single point (often 56,75).