AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.6.1.3

Collision theory and activation energy

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**7**
Available paper years	**2018–2024**

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.

5.6.1.3 Collision theory and activation energy

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

5.6.1.3 Collision theory and activation energy

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		an answer of 24 (cm^2) scores **2** marks		AO2 5.6.1.2
	(surface area of each face = 2 × 2 =) 4		1	
	(6 × 4 =) 24 (cm^2)	allow 6 × student's value from step 1	1	
05.8	small(er) chips have large(r) surface area (for the same volume)	allow converse	1	AO3 5.6.1.2 5.6.1.3
	so more frequent collisions	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	AO1 5.6.1.2 5.6.1.3

5.6.1.3 Collision theory and activation energy

Answer 01 · Mark scheme

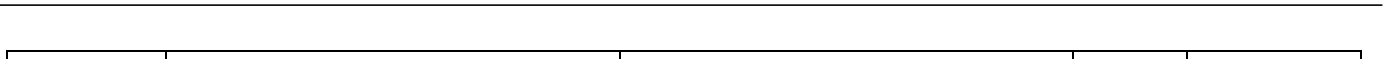
June 2018 | 8464/C/2H | Original Q5

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**	

5.6.1.3 Collision theory and activation energy

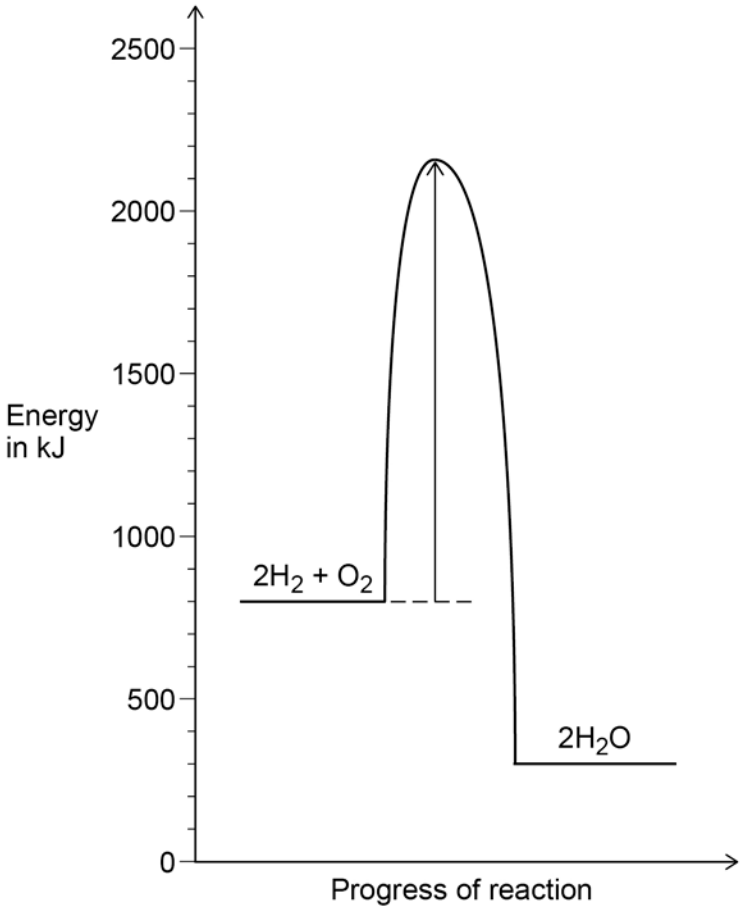
Answer 01 · Mark scheme

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



5.6.1.3 Collision theory and activation energy

Answer 02 · Mark scheme June 2019 | 8464/C/1H | Original Q3

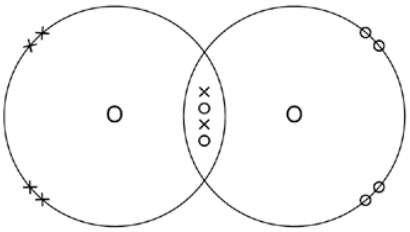
03.1	line from reactants to top of curve (i.e. from 800 to 2160)  ignore arrowheads	1	AO1 5.5.1.2

03.2		an answer of (–) 500 (kJ) scores **2** marks ignore sign		AO2 AO3 5.5.1.2
	reads levels of reactants (800 kJ) and products (300 kJ)		1	
	(800 – 300) = 500 (kJ)	allow correct subtraction of one incorrect value determined for the energy change	1	

5.6.1.3 Collision theory and activation energy

Answer 02 · Mark scheme

June 2019 | 8464/C/1H | Original Q3

03.3	two shared pairs in overlap all non-bonding electrons in outer shell (4 electrons on each O atom)	allow combination of circles, dots, crosses or e(–) ignore any inner shell electrons  diagram scores 2 marks	 1 1	AO2 5.2.1.4

03.4	(bonds broken) ((4×463) + (2×138) =) **2128** (bonds made) ((4×463) + (496) =) **2348** (energy change = bonds broken – bonds made) (2128 – 2348 =) (–) **220** (kJ) **alternative approach:** (bonds broken) (2× (O–O) = (2×138) =) **276** (1) (bonds made) (1× (O=O) =) **496** (1) (energy change = bonds broken – bonds made) (276 – 496 =) (–) **220** (kJ) (1)	an answer of (–) 220 (kJ) scores **3** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps ignore energy change sign allow correct calculation using incorrect values from step 1 and/or step 2	1 1 1	AO2 5.1.1.1 5.5.1.1 5.5.1.3

Total			**8**

5.6.1.3 Collision theory and activation energy

Answer 02 · Mark scheme

June 2019 | 8464/C/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.6.1.3 Collision theory and activation energy

Answer 03 · Mark scheme

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**

5.6.1.3 Collision theory and activation energy

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.6.1.3 Collision theory and activation energy

Answer 04 · Mark scheme

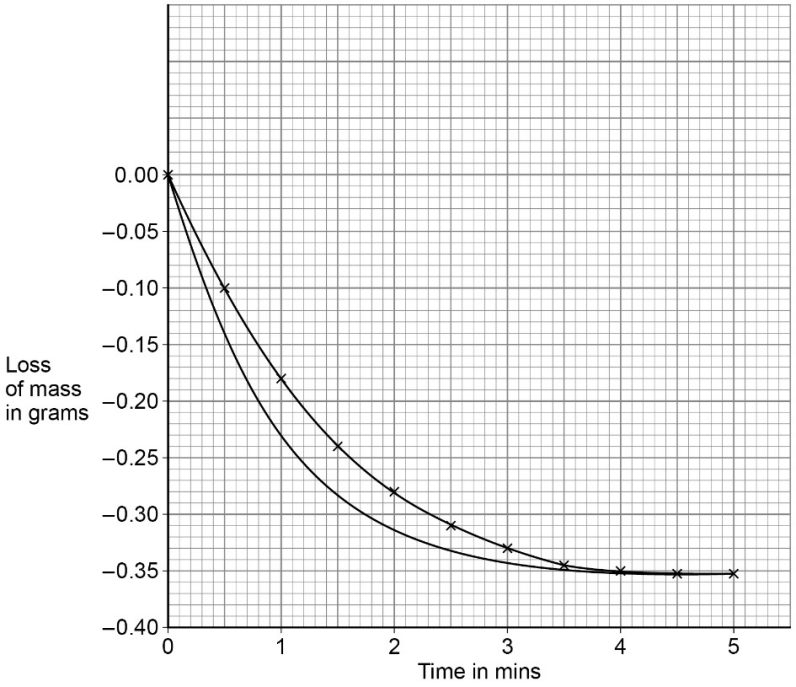
November 2020 | 8464/C/2H | Original Q2

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		

5.6.1.3 Collision theory and activation energy

Answer 04 · 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	

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**

5.6.1.3 Collision theory and activation energy

Answer 04 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.6.1.3 Collision theory and activation energy

Answer 05 · Mark scheme

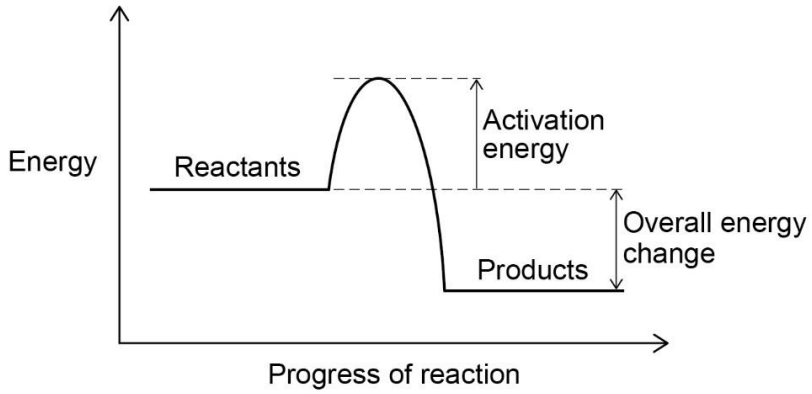
November 2021 | 8464/C/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	temperature (of solution)	allow temperature change	1	AO1 5.5.1.1
03.2	any **three** from: • insulate the beaker **or** use polystyrene cup • add a lid • stir more (times) • repeat the experiment **and** calculate the mean (ignoring anomalous results) • use smaller volume (of water) • use larger mass of ammonium nitrate • more accurate balance • use digital thermometer **or** use a more accurate thermometer		3	AO3 5.5.1.1
03.3	(from 0 to 1.5 minutes the) temperature decreases (because) ammonium nitrate dissolving is endothermic (then) after 1.5 minutes the temperature increases (because) energy transfers to the solution from the surroundings	allow the temperature decreases (from 21.4 ºC to 15.4 ºC) (then) after 15.4 ºC the temperature increases	1 1 1 1	AO3 5.5.1.1

5.6.1.3 Collision theory and activation energy

Answer 05 · Mark scheme

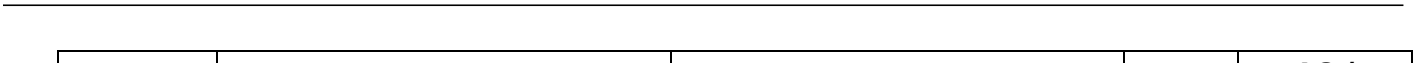
November 2021 | 8464/C/1H | Original Q3

03.4	labelled horizontal lines for reactants and products, with the product line below the level of the reactant line		1	AO1 5.5.1.2
	reaction pathway	allow curve to start / finish anywhere along reactant / product lines	1	
	line from reactants to maximum labelled activation energy		1	
	line from reactants to products labelled overall energy change		1	
	the diagram below scores 4 marks  			
Total			**12**	

5.6.1.3 Collision theory and activation energy

Answer 05 · Mark scheme

November 2021 | 8464/C/1H | Original Q3



5.6.1.3 Collision theory and activation energy

Answer 06 · 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

5.6.1.3 Collision theory and activation energy

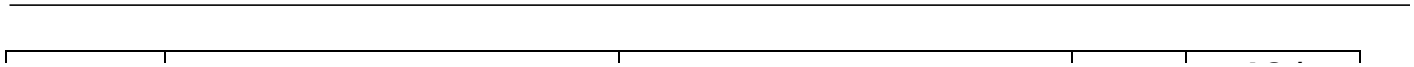
Answer 06 · Mark scheme

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**	

5.6.1.3 Collision theory and activation energy

Answer 06 · Mark scheme

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



Answer 07 · Mark scheme

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

5.6.1.3 Collision theory and activation energy

Answer 07 · Mark scheme

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

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

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’.

5.6.1.3 Collision theory and activation energy

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.

5.6.1.3 Collision theory and activation energy

Answer 02 · Examiner comments — June 2019 | 8464/C/1H | Original Q3

Question 3

This was the first question not common with the Foundation tier. There was a ramping of demand through the question from standard demand (03.1) to standard/high demand (03.2) then to high demand (03.3 and 03.4).

03.1 A good proportion of students correctly identified the activation energy. Common errors included arrows pointing to the maximum of the energy diagram or to a section of the line leading to the peak.

03.2 Students were very good at determining the overall energy change; nearly three-quarters of all students gained full marks. Those students who selected one value of either the reactants or products from the graph gained credit for a correct subtraction of their values.

03.3 Students provided a wide range of responses for the dot-and-cross diagram of oxygen. Half of all students appreciated the number of electrons involved in bonding and non-bonding. A number of students did not appreciate that oxygen always has two sharing pairs of electrons; in this case a double bond results between the two atoms. Others who added 4 electrons for a double bond often still added 3 other non-bonding pairs on each O atom.

03.4 This question discriminated very well where two-fifths of students gained all three marks for an answer of (–) 220 kJ.

Many students presented their working clearly. This allowed examiners to identify where any errors had been made which allowed access to the final marking point (MP3); a subtraction of bonds made (their MP2) from bonds broken (their MP1).

Answer 02 · Examiner comments — June 2019 | 8464/C/1H | Original Q3

Common mistakes centred on using an O-O value when an O=O bond strength should have been used and not taking into account the stoichiometry of the equation.

Answer 03 · 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 03 · 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.

5.6.1.3 Collision theory and activation energy

Answer 05 · Examiner comments November 2021 | 8464/C/1H | Original Q3

Question 3 (standard and standard / high demand)

03.1 In this investigation the temperature of the solution is measured (the independent variable is changed and the dependent variable measured). Just under two fifths of students gained the mark.

03.2 This question was based on the required practical activity of investigating the variables that affect temperature changes. Students had difficulty in identifying more than one improvement from the method or from the diagram of the apparatus.

03.3 Students were good at describing the trends in the graph, although a few misread the minimum point (1.5, 15.4); approximately half of students gained two marks. However, students struggled to explain the trends. The temperature of the solution decreased because the dissolving process is endothermic. Then when the energy change due to dissolving finishes, the temperature of the solution increases from the minimum back to room temperature as energy transfers to the solution from the surroundings.

03.4 More than two thirds of students scored at least one mark with approximately one sixth of students gaining all four marks. A small number incorrectly drew the reaction profile for an endothermic reaction and some labels were not clearly drawn.

Answer 06 · 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.

5.6.1.3 Collision theory and activation energy

Answer 07 · Examiner comments

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

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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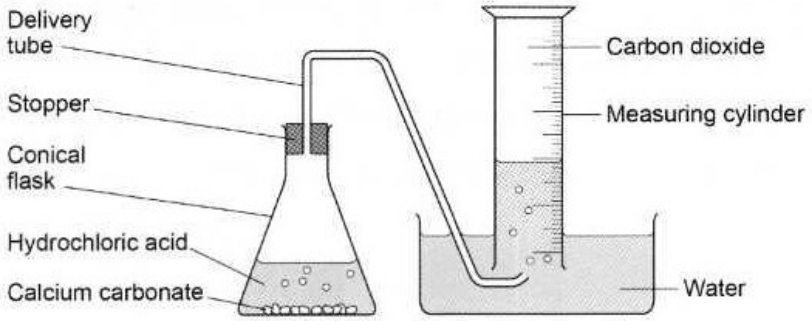
5.6.1.3 Collision theory and activation energy

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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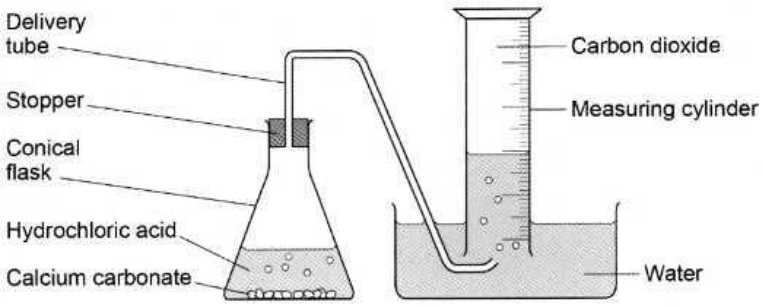
5.6.1.3 Collision theory and activation energy

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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5.6.1.3 Collision theory and activation energy

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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5.6.1.3 Collision theory and activation energy

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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'.