AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.5.1.1

Energy transfer during exothermic and endothermic reactions

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**20**
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.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

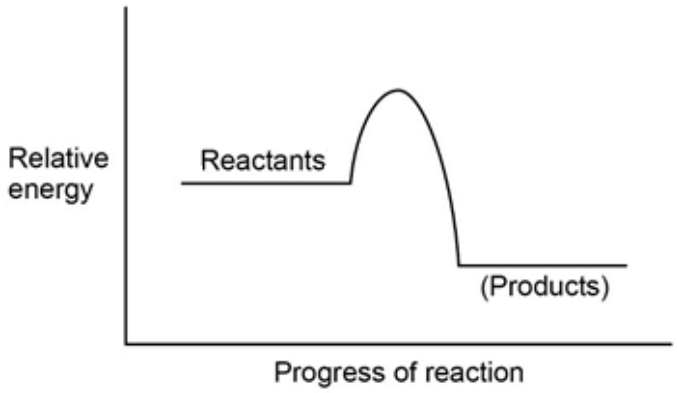
Answer 01 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	(difference) sodium has one and chlorine has seven electrons in outer level / shell **or** number of electrons	number of electrons must be correct if quoted	1	AO2 5.1.1.7 5.1.2.1
	(similarity) both have three / same number of levels / shells **or** have electrons in third level / shell **or** both have incomplete (outer) levels / shells	allow both have 2 electrons in inner shell **or** both have 8 electrons in second shell **or** both are one electron away from full outer level / shell	1	
02.2		allow marks from suitable diagram(s)		AO1 5.2.1.2
	sodium (atom) loses	allow moves / transfers for loses do **not** accept sodium ion loses	1	
	one (outer shell electron)		1	
	chlorine (atom) gains	do **not** accept chloride	1	
	one (electron)		1	
		transfer of 1 electron from chlorine to sodium **max 2** marks		
		reference to sharing **or** covalent bonding **max 3** marks		

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 01 · Mark scheme

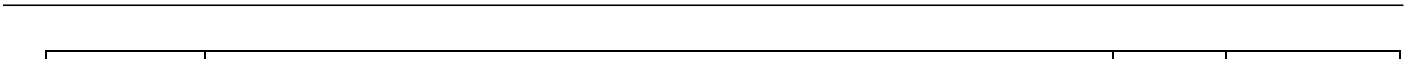
June 2018 | 8464/C/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3		ignore labels any curve / line going up and then down products line below reactants allow curve to start / finish anywhere along reactant / product lines	1 1	AO1 5.5.1.2
Total			**8**	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q2



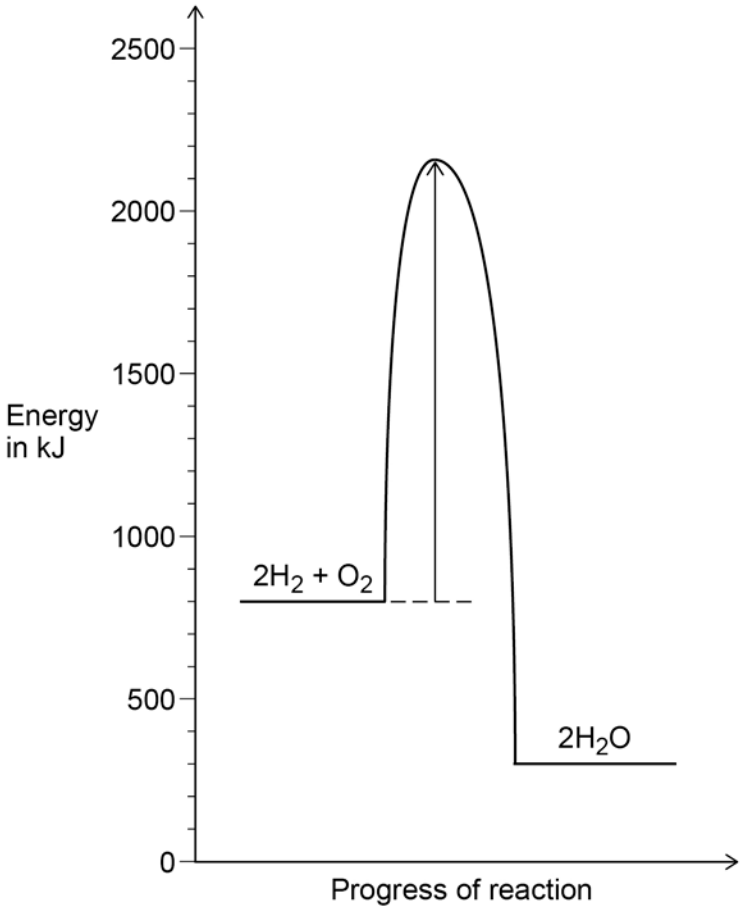
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 02 · Mark scheme June 2018 | 8464/C/2H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	<u>damp / moist</u> litmus paper	ignore colour of litmus paper	1	AO1 5.8.2.4
	bleaches / goes white		1	
06.2	forward and reverse rates equal		1	AO1 5.6.2.1 5.6.2.3
	because no escape of reactants or products	allow closed system allow particles for reactants or products	1	AO2 5.6.2.1 5.6.2.3
06.3	equilibrium shifts	allow no longer in equilibrium	1	AO3 5.6.2.3 5.6.2.4 5.6.2.5 5.6.2.7
	to right-hand side	allow in favour of forward reaction	1	
	to produce more of any products **or** to reduce any reactants	allow correct references to Le Chatelier's Principle	1	
	(new) equilibrium will be established		1	
06.4	amount of chlorine gas increases		1	AO2 5.6.2.4 5.6.2.6
	(because) system shifts to counteract the change	allow (because) system shifts to take in energy allow (because) system shifts in endothermic direction	1	AO1 5.6.2.4 5.6.2.6
06.5	no change		1	AO2 5.6.2.4 5.6.2.7
	because equal numbers of molecules **or** moles (of gas) on each side		1	AO1 5.6.2.4 5.6.2.7
Total			**12**	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

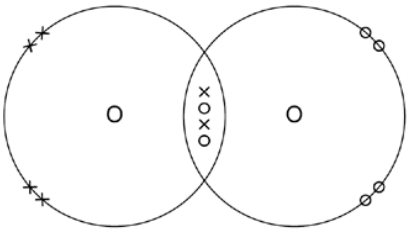
Answer 03 · Mark scheme June 2019 | 8464/C/1H | Original Q3

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	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 03 · Mark scheme

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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

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**

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 04 · Mark scheme

November 2020 | 8464/C/1H | Original Q5

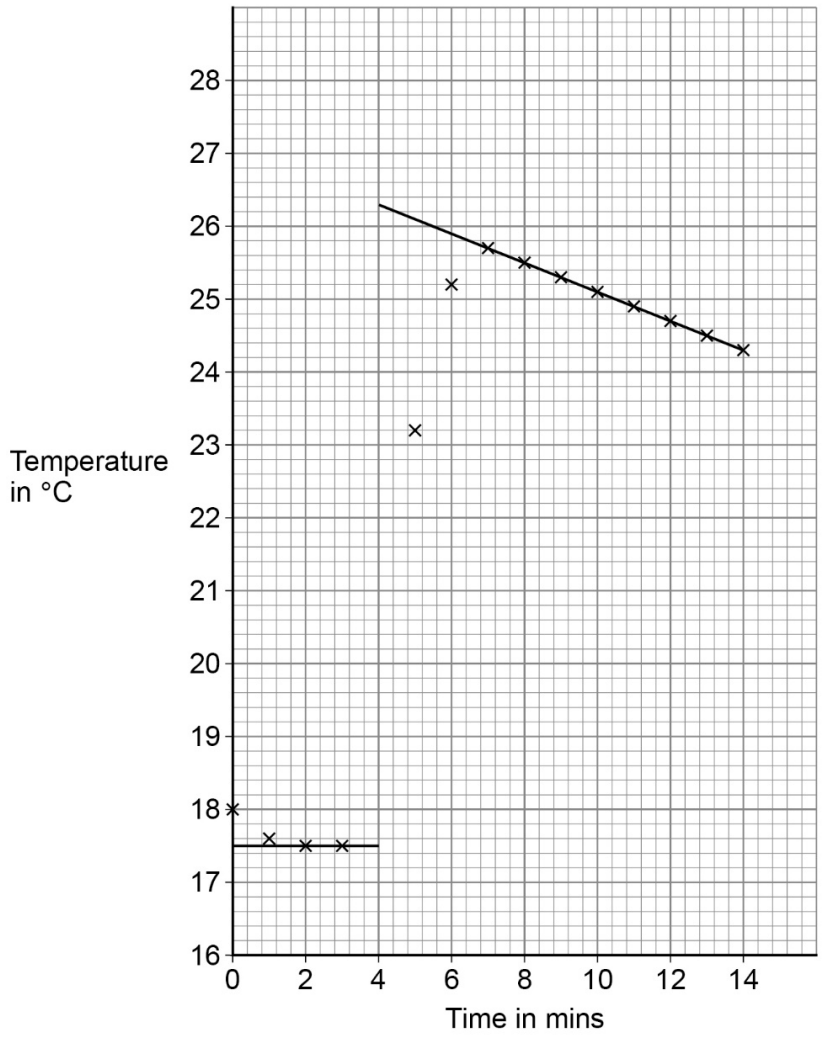
05.1	temperature (change)		1	AO2 5.4.1.2 5.5.1.1 RPA 10

05.2	to reach a constant temperature	allow to reach room temperature	1	AO3 5.4.1.2 5.5.1.1 RPA 10

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 04 · Mark scheme

November 2020 | 8464/C/1H | Original Q5

05.3	line of best fit after 7 minutes extends line back to 4 minutes	 ignore extension of line beyond 4 minutes	1 1	AO2 5.4.1.2 5.5.1.1 RPA 10
	the diagram below scores **2** marks  			

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 04 · Mark scheme

November 2020 | 8464/C/1H | Original Q5

05.4	(maximum **and** minimum values at 4 minutes) 26.3 (°C) **and** 17.5 (°C) (temperature change at 4 minutes) = 8.8 (°C)	allow ecf from **05.3**	1 1	AO3 5.4.1.2 5.5.1.1 RPA 10
05.5	the reaction finished / stopped (so) energy is lost to surroundings / atmosphere **or** (so the) solution cools (back to room temperature)	allow maximum temperature has been reached allow heat for energy	1 1	AO3 5.4.1.2 5.5.1.1 RPA 10
05.6	aluminium / zinc / iron / beryllium metal **Q** is less reactive (than magnesium) **or** metal **Q** is lower in reactivity series	allow Al / Zn / Fe / Be do **not** accept copper, silver MP2 dependent on a correct answer to MP1 allow converse	1 1	AO3 AO2 5.4.1.2 5.5.1.1 RPA 10

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 04 · Mark scheme

November 2020 | 8464/C/1H | Original Q5

05.7	(unit conversion) 30.0 cm^3 = 0.030 dm^3 **or** 0.500 dm^3 = 500 cm^3		1	AO2 5.3.2.1 5.4.1.2 5.5.1.1
	(moles = $\frac{30}{500}$ × 0.1 =) 0.006 **or** (moles = $\frac{0.030}{0.50}$ × 0.1 =) 0.006	allow correct use of incorrect / no unit conversion	1	
	mass = 0.006 × 159.5	allow correct use of incorrect value for number of moles	1	
	= 0.957 (g)	allow 0.96 (g)	1	

Total			**14**

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 04 · Mark scheme

November 2020 | 8464/C/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 05 · Mark scheme

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		

5.5.1.1 Energy transfer during exothermic and endothermic reactions

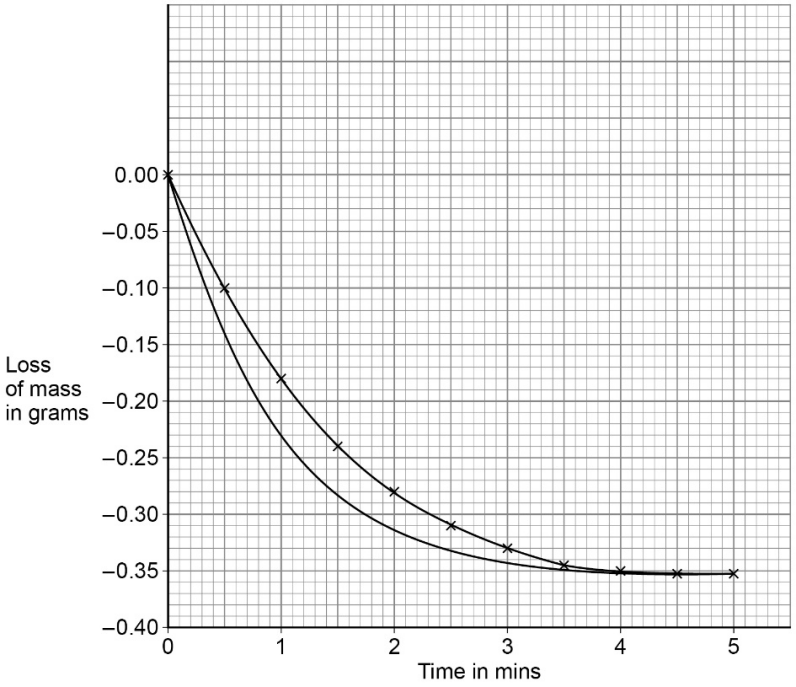
Answer 05 · Mark scheme

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

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	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 05 · 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**

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 05 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 06 · Mark scheme November 2020 | 8464/C/2H | Original Q7

07.1	when a reversible reaction occurs in apparatus which prevents the escape of reactants and products (equilibrium is reached) when the forward and reverse reactions occur at (exactly) the same rate	allow when a reversible reaction occurs in a sealed system	1 1	AO1 5.6.2.3
07.2	(as pressure increases) the equilibrium position shifts to the right hand side (because) there are less moles / molecules (of dinitrogen tetroxide) on right hand side	allow (as pressure increases) the percentage of product / dinitrogen tetroxide / N_2O_4 increases allow (because) there are more moles / molecules (of nitrogen dioxide) on left hand side	1 1	AO2 5.6.2.4, 5.6.2.6 5.6.2.7
07.3	(as temperature increases) equilibrium position shifts to left hand side (because the forward) reaction is exothermic **or** (because) the backward reaction is endothermic (so) the percentage of product / dinitrogen tetroxide / N_2O_4 decreases		1 1 1	AO2 AO2 AO3 5.6.2.4 5.6.2.6 5.6.2.7
Total			**7**	

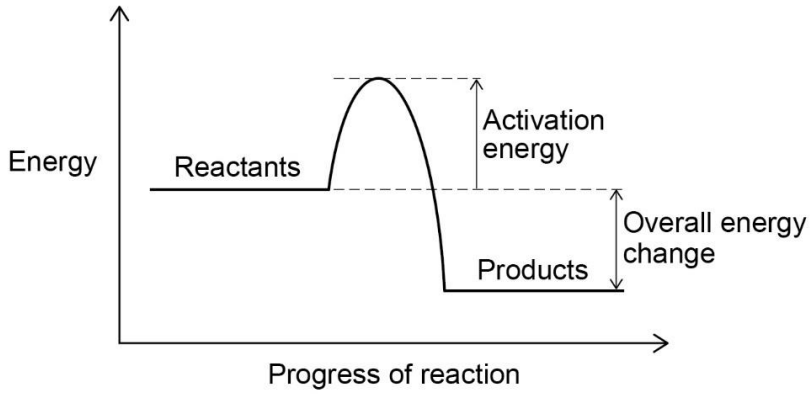
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 07 · 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

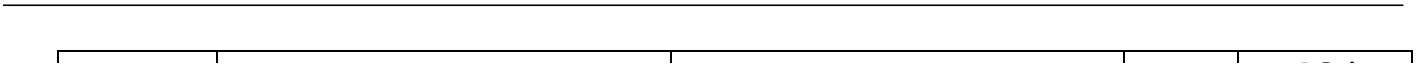
5.5.1.1 Energy transfer during exothermic and endothermic reactions

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**	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 07 · Mark scheme

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



5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 08 · Mark scheme

November 2021 | 8464/C/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	particles collide (but at room temperature) particles have insufficient energy **or** (but) have energy less than the activation energy (so collisions are not successful)		1 1	AO3 5.5.1.2
07.2	2120 (kJ/mol)		1	AO3 5.5.1.2 5.5.1.3
07.3	(bonds broken = (8 × 410) + 2 **X** + (5 × 500) = 5780 + 2 **X** (bonds formed = (6 × 740) + (8 × 460) = 8120 (bonds broken – bonds formed = energy released) (5780 + 2 **X**) – 8120 = – 1640 (2 **X** =) 700 (**X** =) 350 (kJ/mol)	allow C–C for **X** allow (bonds broken = (8 × 410) + (5 × 500) = 5780 allow correct use of incorrect values from step 1 and/or step 2 allow correct use of incorrect value from step 3	 1 1 1 1 1	AO2 5.5.1.3
Total			**8**	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 09 · 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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

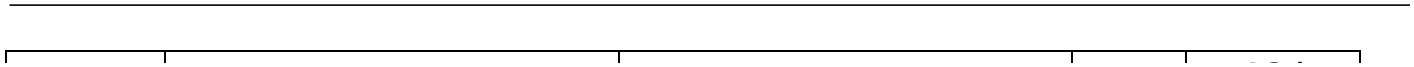
Answer 09 · Mark scheme

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**	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 09 · Mark scheme

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



5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 10 · Mark scheme

November 2021 | 8464/C/2H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	use limewater **or** use calcium hydroxide solution (which) does not turn milky / cloudy	 allow (which) stays colourless	1 1	AO2 5.8.2.3
06.2	provides an alternative pathway (which has) a lower activation energy		1 1	AO1 5.6.1.4
06.3	(when) the apparatus prevents the escape of reactants and products (and the) forward and reverse reactions occur at same rate	allow (in a) closed system	1 1	AO1 5.6.2.3
06.4	equilibrium position stays the same increases the rate of the forward and the reverse reaction by the same amount	allow no effect	1 1	AO3 5.6.1.4 5.6.2.3
06.5	the yield of ammonia increases		1	AO2 5.6.2.4 5.6.2.7

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 10 · Mark scheme

November 2021 | 8464/C/2H | Original Q6

06.6	yield of ammonia decreases (because) system shifts in endothermic direction	 allow (because) system shifts to counteract the change allow (because) system shifts to transfer in energy (from the surroundings)	1 1	AO2 5.6.2.4 5.6.2.6
Total			**11**	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 11 · Mark scheme

June 2022 | 8464/C/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	any **three** from: • green solid / powder • colourless solution • blue solution formed • copper carbonate disappears • fizzing / effervescence **or** bubbles (of gas) • stops fizzing • solid / powder left at the end **or** copper carbonate left at the end	 ignore green copper carbonate allow colour (of solution) changes allow solid disappears ignore gas allow fizzing slows down allow (container) gets hot **or** allow temperature increases	3	AO2 AO3 5.4.2.2 5.4.2.3 RPA8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	filtration **or** filter		1	AO1 5.4.2.3 RPA8

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 11 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	7		1	AO1 5.4.2.3 5.4.2.4 RPA8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	neutralisation	allow exothermic	1	AO1 5.4.2.2 5.4.2.4 RPA8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	83 (g at 80 °C)	allow a value in range 82–84 (g at 80 °C)	1	AO2
	32 (g at 20 °C)	allow a value in range 32–33 (g at 20 °C)	1	AO2
	(83–32 =) 51 (g)	allow a correct calculation using incorrectly read values for mass at 80 °C and/or 20 °C	1	AO3 5.4.2.3

Total Question 1		**9**	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 12 · Mark scheme

June 2022 | 8464/C/1H | Original Q3

Question 3

Question	Answers	Mark	AO / Spec. Ref.
03	**Level 3:** The method would lead to the production of a valid outcome. All 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	AO1
	No relevant content.	0	
	Indicative Content • measure volume of (hydrochloric) acid • into a suitable container eg polystyrene cup • measure the initial temperature (of hydrochloric acid) • with a thermometer • add stated mass of one metal • stir • measure the highest temperature reached of the solution **or** measure temperature reached after a set time period • determine the temperature difference • repeat • repeat for each metal • with same mass • in same physical state (powder, lump, etc) • with the same volume and / or concentration of (hydrochloric) acid • use results to arrange metals in order of reactivity • most reactive metal has the largest temperature change to access level 3 there must be an indication of how the temperature change is determined with the same mass of the 3 different metals reacted with the same volume of (hydrochloric) acid		5.1.4.2 RPA2

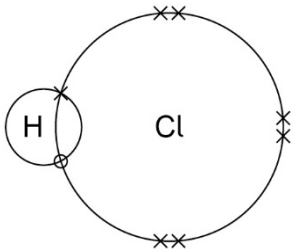
Total Question 3		**6**

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 13 · Mark scheme

June 2022 | 8464/C/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	one shared pair in overlap	allow any combination of circles, dots, crosses or $e^{(-)}$	1	AO1 5.1.2.6 5.2.1.4
	6 non-bonding electrons in outer shell of chlorine	do **not** accept extra electron(s) on outer shell of hydrogen ignore any inner shell electrons	1	
		an answer of  scores **2** marks		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	completely ionises in aqueous solution	allow completely dissociates in aqueous solution	1	AO1 5.4.2.5

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 13 · Mark scheme

June 2022 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	fizzing / effervescence **or** magnesium disappears		1	AO3 5.4.2.5
	at a greater rate with a strong acid	allow converse with weak acid allow for **2** marks strong acid has a greater temperature increase	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(pH) decreases	allow pH is lower	1	AO1
	by (a unit of) 2		1	AO2 5.4.2.5

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 13 · Mark scheme

June 2022 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	(bonds broken = (4 × 413) + C=C + 431 =) 2083 + **C=C**		1	AO2 5.5.1.3
	(bonds made = (346 + 339 + (5 × 413) =) 2750		1	
	(energy released = bonds made – bonds broken =) 56 = 2750 – [2083 + C=C]	allow correct use of incorrect value(s) from step 1 and / or step 2	1	
	(C=C) = 611 (kJ/mol)		1	

Total Question 6		11

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 14 · 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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 14 · 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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 15 · Mark scheme

June 2022 | 8464/C/2H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	enzyme		1	AO1 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	provides a different reaction pathway (which) has a lower activation energy		1 1	AO1 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	the effects of changing conditions on the position of an equilibrium (in a closed system)	allow the effects of changing conditions on the yield of an equilibrium reaction (in a closed system)	1	AO1 5.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(when) the forward and reverse reactions have the same rate in apparatus which prevents the escape of reactants and products	 allow in a closed system	1 1	AO1 5.6.2.3

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 15 · Mark scheme

June 2022 | 8464/C/2H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	yield increases (because) there are more moles (of gas) on the left hand side	 allow (because) there are fewer moles (of gas) on the right hand side	1 1	AO2 5.6.2.1 5.6.2.2 5.6.2.3 5.6.2.4 5.6.2.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6	yield decreases (because) the system shifts in the endothermic direction		1 1	AO2 5.6.2.1 5.6.2.2 5.6.2.3 5.6.2.4 5.6.2.6

Total Question 6		10

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 16 · Mark scheme

June 2023 | 8464/C/2H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	heat the evaporating basin and contents to constant mass	allow heat until all of the water has evaporated	1	AO3 5.10.1.2 RPA13

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	(mass **X** =) [0.29 × 3] – [0.30 + 0.26] = 0.31 (g)	allow 0.87 – 0.56 allow $\frac{0.3 + \mathbf{X} + 0.26}{3} = 0.29$	1 1	AO2 5.10.1.2 RPA13

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	(test) determine the boiling point (result) (pure water) boils at 100 °C **OR** (test) determine the freezing point (1) (result) (pure water) freezes at 0 °C (1)		1 1	AO2 5.8.1.1 5.9.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	reversible reaction	allow a reaction that can go both ways	1	AO1 5.6.2.1

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 16 · Mark scheme

June 2023 | 8464/C/2H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	shifts towards the left hand side		1	AO3 5.6.2.3 5.6.2.4 5.6.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	(test) damp litmus paper (result) litmus paper bleached	 allow litmus paper turns white ignore litmus paper turns red	 1 1	AO2 AO1 5.8.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	the dissolved solids pass through filter paper (because) the dissolved solid (particles) are very small		1 1	AO2 5.10.1.2 RPA13

Total Question 4	**11**

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 17 · 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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 17 · 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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 18 · 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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 18 · Mark scheme

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

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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 19 · Mark scheme June 2025 | 8464/C/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	(a reaction) which transfers energy to the surroundings	allow heat for energy allow (a reaction) which releases energy (to the surroundings)	1	AO1 5.5.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	(mass of oxygen = 2 × 16 =) 32		1	AO2 5.3.1.2
	(percentage =) $\frac{32}{74}$ × 100	allow correct use of an incorrectly determined mass of oxygen	1	
	= 43.2 (%)	allow 43.2432 (%) correctly rounded to at least 2 significant figures	1	

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 19 · Mark scheme

June 2025 | 8464/C/1H | Original Q2

Question	Answers	Mark	AO / Spec. Ref.
02.3	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO1 5.5.1.1 RPA10
	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	
	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
	• measure volume of water
	  ○ using a measuring cylinder
	  ○ pour into a suitable container eg insulated cup
	• measure initial temperature of water
	  ○ using a thermometer
	• add known mass of calcium oxide
	  ○ measured with a balance
	  ○ stir
	• measure the highest temperature reached by the mixture
	or
	measure temperature reached after set time period
	  ○ determine the temperature change
	• repeat with different masses of calcium oxide
	or
	add successive masses to the same mixture
	• use the same volume of water
	  ○ use the same initial temperature of water
	
	for **Level 3** all key steps should be described and the control variable the same volume of water must be given		

Total Question 2	**10**

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 20 · Mark scheme

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	a mixture that has been designed as a useful product		1	AO1 5.8.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	91 kJ/mol		1	AO2 5.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	Le Chatelier		1	AO1 5.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	the proportion of methanol decreases		1	AO2 5.6.2.4 5.6.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	the proportion of methanol stays the same		1	AO3 5.6.1.4 5.6.2.4

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 20 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	(increasing the pressure) increases the proportion of methanol		1	AO2 5.6.2.4 5.6.2.7
	(because) there are more molecules / moles of reactant (than product)		1	
	(so) the equilibrium (position) shifts to the side with fewer molecules / moles		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	(the catalyst) increases the rate of the reaction		1	AO1 5.6.1.4
	(by) providing an alternative pathway (for the reaction)		1	
	(with) a lower activation energy		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.8	reduces the costs		1	AO2 5.6.1.4 5.9.2.2
	(because) less energy is used		1	5.9.2.4
	OR			
	less fuels burned (1)			
	(so) less contribution to global warming (1)	allow (so) less carbon dioxide produced		

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.9	$CO_2 + 3\,H_2 \rightarrow CH_3OH + H_2O$	allow multiples allow **1** mark for $CO_2 + H_2 \rightarrow CH_3OH + H_2O$ with no / incorrect balancing numbers	2	AO2 5.3.1.1

Total Question 4	**15**

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q2

Question 2 (standard demand)

02.1 73% of students achieved at least a mark on this question. Many could clearly see the most obvious difference and similarity in the electronic structures of sodium and chlorine. These correct answers were described in a variety ways eg different number of electrons or by stating the correct number of electrons in the outer shell. Examples of similarities related to the number of shells or completed inner energy levels.

Students often used the periodic table shown in the stem of the question to answer the question, but most of these referred to periods and groups and failed to gain marks. Students should note that there is only one 'outer' shell or level.

02.2 This question was well answered with 63% of students achieving all four marks, often with concise statements.

Some students contradicted their description by mentioning covalent, the incorrect type of bonding, or the sharing of electrons, which restricted the number of marks they could attain.

Students need to use scientific terminology accurately. Ionic bonding occurs when a metal transfers its electron(s) to a non-metal (loss and gain of electrons). Whereas covalent bonding involves non-metals sharing electrons, which results in the formation of covalent bonds.

02.3 67% of students achieved both marks, although it was common for students to have incomplete diagrams, by failing to include a horizontal for the products side. Some students confused the two types of energy changes (endothermic and exothermic), while others provided a wide range of incorrect diagrams.

Question 6 (standard & high demand)

06.1 53% of students achieved credit on this question. The majority of those in their response omitted to write ‘damp or moist’ when describing the litmus paper test. Limewater was a popular incorrect answer.

06.2 34% of students achieved any credit on this question; with 5% of responses achieving both marks. The idea of a ‘closed system’ was the most popular creditworthy answer.

Students described a reversible reaction, explained that the reactants changed into the products and vice versa but rarely indicated that it was the rate of these reactions that was equal. Some students gave the confused answer that ‘the rate that reactants are used up is equal to the rate that the products are formed'.

06.3 In this question and in questions **06.4** and **06.5**, it was apparent that, although many students could recall Le Chatelier’s Principle, few were able to apply it.

23% of students achieved more than one mark on this question, with 2% of students achieving all four marks. Students (34% that achieved one mark) were able to suggest a shift in the equilibrium but often in the wrong direction: ‘The equilibrium shifts to the left so that more NaClO can be formed to react with the HCl’.

Some students gave responses that discussed changes in terms of the exothermic or endothermic direction though this was not given in the stem of the question.

A simple response that ‘reaction would do the opposite’ because of Le Chatelier was frequently given. Very few students concluded their explanation with ‘a new equilibrium would be established’.

06.4 Many students answered incorrectly by explaining the effect of temperature on the rate of reaction rather than on the equilibrium. 8% of students achieved both marks. And a further 28% achieved a single mark, predominately for identifying that the amount of chlorine gas increased. 14% of students made no attempt at this question.

06.5 This was a challenging question whereby 7% of students achieved any marks. Many students answered incorrectly by explaining the effect of pressure on the rate of reaction rather than on the equilibrium. Those that answered with reference to the number of molecules on each side of the equation seemed to think that 2HCl was one molecule and consequently talked of the equilibrium shifting to the left, the side with fewer molecules. Approximately 12% of students made no attempt at this question.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 02 · Examiner comments

June 2018 | 8464/C/2H | Original Q6

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 03 · 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 03 · 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.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 07 · 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 08 · Examiner comments November 2021 | 8464/C/1H | Original Q7

Question 7 (standard / high and high demand)

07.1 One mark was gained by approximately one fifth of students, usually for stating that particles collide. Very few appreciated that at room temperature the particles had insufficient energy to react.

07.2 Approximately two thirds of students gained this mark. They were able to deduce the trend in increase of energy released as the number of carbon atoms increased.

Answer 08 · Examiner comments

07.3 Approximately one third of students were able to score at least one mark but only a small number scored all five marks. Students had to calculate the energy required to break all bonds and also the energy released when all bonds are formed. However, many made mistakes in these calculations. Few then were able to subsequently evaluate the difference in bonds broken (including the two C-C bonds), bonds made, and the energy released (1640 kJ/mol).

Concluding Remarks

The demand of this paper was similar to those previously set for this specification. Students should note that two-mark questions, for example, require two answer points.

15% of marks are based upon the required practical activities; students should question 'what and why' is happening in each step of these procedures. Answers should be chemically accurate, e.g. crystals are produced from salt solutions when the solution is heated (partially evaporated to produce a more concentrated solution) and then left to crystallise, rather than implying that 'all the water was evaporated'.

In chemistry 20% are marks are for questions assessing mathematical skills. In these questions, students should show their working for each step. If an error is made, such as an incorrect evaluation of values in the question, credit is awarded for each correct step shown. In **01.5** not all students used all the data provided to evaluate the relative atomic mass, a weighted mean of the mass numbers. In **04.4** most students calculated the percentage and mass of the other elements. Fewer were able to use the ratio of percentages to evaluate the mass of iron. In **06.4** students found difficulty in converting moles to a formula or to simple whole number ratios in equations. In **07.3** the displayed formula was provided to help students calculate the energy required to break all the bonds and the energy released when all the bonds are formed. Many failed to link the energy released as the difference in bonds broken (including the two C-C bonds) and bonds made.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Mark Ranges and Award of Grades

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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 09 · 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 10 · Examiner comments

November 2021 | 8464/C/2H | Original Q6

Question 6 (standard / high and high demand)

Students have a good understanding of what catalysts are and what they do, but they failed to explain how they work and instead gave a list of features of catalysts. Some students recognised that the activation energy was lowered but that this was achieved by following an alternative pathway was rarely seen.

Likewise, students were able to successfully apply Le Chatelier's Principle to an equilibrium but were unable to explain those changes.

A common misconception is that the quantities of reactants and products are equal rather than the rates of the forward and the backward reactions. That catalysts speed up both of these rates equally was rarely seen. Students tended to describe the action of a catalyst but then failed to address the question of their effect upon the equilibrium position, for which they gained no credit.

Concluding Remarks

The demand of this paper was similar to that of papers set for this specification in previous series.

Students scored well on questions involving the use of data and knowledge of atmospheric pollution. They are advised to look at the number of marks allocated. If the question is asking to describe a trend in a graph, comments are not only required for the general trend but also the rate of change.

A range of methods were used to answer the mathematical questions. Students are always advised to show working - credit can be gained for correct working in the event that the final answer given is not correct. They should also take careful note of any additional instructions. In question 04.6, the final mark was often not gained as the answer was not given to 3 significant figures.

Practical work is at the heart of the specification. The importance of the use of variables in experiments is paramount. In question 02.1, when identifying control variables, students should refer back to the method provided where in this instance the volume of hydrochloric acid was given. Many answers referred to the "amount" of acid or metal which is insufficient to gain credit, likewise, adding a "piece" of magnesium which does not indicate that either the length or mass has been controlled. Reading through the method will also reveal what is being changed in subsequent repeats as the independent variable.

In questions, such as 02.3, where comparisons are to be made from given data, students should be encouraged to answer accordingly using a comparative and not rewrite the information that is provided without elaboration - this does not gain any credit as the student has not added any value to their answer. Some excellent answers were seen where the students expanded upon the data, for example, to explain why the molecules had different melting and boiling points or to explain how the length of the hydrocarbon chain was linked to a trend in physical properties, such as flammability.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 10 · Examiner comments

November 2021 | 8464/C/2H | Original Q6

Mark Ranges and Award of Grades

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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 11 · Examiner comments June 2022 | 8464/C/1H | Original Q1

Question 1 (Standard demand)

01.1 Students were asked to state observations when copper carbonate is added to sulfuric acid. 30% of students gave at least two correct observations. The most common responses were ‘colour changes’ or ‘fizzing’. Many students appeared to misunderstand what an observation is and instead either wrote instructions on how to carry out the preparation of copper sulfate or gave vague comments such as ‘there was a reaction’, or ‘it stopped reacting’, along with describing the reaction with comments such as carbon dioxide gas was given off. Some students referred to copper carbonate as either copper or copper oxide which are different chemicals.

01.2 Nearly three quarters of students knew that filtration is used to separate unreacted copper carbonate after a reaction between sulfuric acid and excess copper carbonate.

01.3 Just under half the students knew the pH of the solution at the end of the reaction between sulfuric acid and excess copper carbonate.

01.4 Just over a third of students knew that the reaction between sulfuric acid and copper carbonate was neutralisation.

Answer 11 · Examiner comments June 2022 | 8464/C/1H | Original Q1

01.5 The question required students to read the masses of ammonium nitrate that dissolve at 80 °C and 20 °C from a graph and to then carry out a subtraction to determine the mass of solid that crystallises on cooling. Just over 40% of students were able to gain all 3 marks. There were a minority of students who failed to show any working except for small crosses on the graph.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 12 · Examiner comments June 2022 | 8464/C/1H | Original Q3

Question 3 (Standard demand)

03 This question discriminated well with nearly 60% of students achieving level two or above. It was based upon Required Practical Activity 10. Students needed to plan an investigation to find the order of reactivity of three metals using the temperature change recorded when each metal reacts with hydrochloric acid.

To access level 3, the method would lead to a valid outcome. This required students controlling variables such as the mass of metal and the volume of acid reacting, determining a temperature change having recorded the initial and final temperatures and repeating the method for each metal.

To access level 2 the method would not necessarily lead to a valid outcome. Students were generally good at providing practical details. The main oversights that prevented a valid outcome were the measurement of starting temperature and/or controlling the mass of metal. Students should be encouraged to state volumes and masses as most creditworthy

Answer 12 · Examiner comments June 2022 | 8464/C/1H | Original Q3

responses regarding the control of volume and mass did so by stating a value and then repeating with the other metals. Weaker responses gained credit for either correctly identifying apparatus or for explaining the link between expected results and the reactivity of the metal.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 13 · Examiner comments

June 2022 | 8464/C/1H | Original Q6

Question 6 (Standard, standard/high and high demand)

06.1 Two third of students correctly drew a dot and cross diagram for hydrogen chloride. The most common mark was for the two shared electrons in the overlap between the atoms. Many did not show that there are six unshared electrons.

06.2 Less than 10% were able to state what is meant by the term strong acid. Many omitted 'in aqueous solution'.

06.3 40% of students gained 1 mark usually for referring to an observation when magnesium reacts with a strong acid and a weak acid. The second mark was for a comparison of the rates of reaction between magnesium and the two acids, with few students being able to develop their response to give this.

06.4 Nearly 40% of students gained 1 mark usually for stating that the pH decreases when the concentration was increased. However very few recognised that pH was related to the power of 10, so when the concentration of hydrochloric acid is increased by a factor of 100 then the pH will decrease by 2.

06.5 Many students were good at calculating the energy changes for bonds broken and bonds made, however then went on to simply subtract these two numbers without taking into account the C=C bond energy. Many students kept their working to a minimum which often did not help them score. This question discriminated well with better responses showing clear working where the energy released was equated to the difference between the bonds made and the bonds broken.

Answer 14 · 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.

Answer 14 · 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 15 · Examiner comments June 2022 | 8464/C/2H | Original Q6

Question 6

Students struggled to identitify which parts of this question were about rates and which were about equilibria.

06.1 Students found this recall question fairly straightforward with around 85% recognising that a biological catalyst was an enzyme.

06.2 About half of students could describe that catalysts lower the activation energy, however, fewer than 20% could link that to an alternative reaction pathway. There were lots of references to energy and frequency of collisions, but the responses lacked context.

06.3 Only 5% of students were able to make the link between conditions changing and the way that the equilibrium moves accordingly.

06.4 About a third of students gained at least one mark for this item. The closed system and equal rates in the forward and reverse directions were both seen, however, fewer than 10% of students mentioned both conditions.

06.5 Just under a third of students identified the increase in yield, which scored one mark. An explanation in terms of number of moles on each side of the equation was seen on very few occasions.

06.6 Many students answered this question in terms of rates of reaction, and gave an increase in yield because ammonia is made quicker, which did not score.
An explanation in terms of movement in the endothermic direction was seen on very few occasions.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

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

Answer 16 · Examiner comments

June 2023 | 8464/C/2H | Original Q4

Question 4

04.1 Only one in ten students could give the improvement in the method. Common insufficient responses included heat for longer, whilst giving no reasoning, heat for shorter time, or put a lid on.

04.2 An alternative approach to a mean calculation proved to be straightforward as nearly four in five students gained both marks.

04.3 Fewer than a quarter of students gained at least one mark for this question. It relied on students recognising that pure substances boil (or melt) at a fixed temperature. Some students realised this but did not go on to measure and quote the boiling point. A few students did approach it from the melting / freezing point but still did not refer to measuring the value.

04.4 Over four in five recognised that the symbol was for a reversible reaction or for a description of a reversible reaction. The most common insufficient response was for saying that the reaction was at equilibrium, which it may be but in industry often is not.

04.5 Around half of students correctly identified the correct direction of movement. The opposite change was most often given as the incorrect response.

04.6 Fewer than a quarter of students identified the correct gas test for chlorine for both marks. It was essential for the award of both marks that the litmus paper was damp.

Answer 16 · Examiner comments

June 2023 | 8464/C/2H | Original Q4

However, if just litmus paper was given, one mark could be credited for being bleached or turning white.

04.7 Just over one in ten students gained both marks for the idea that dissolved particles are too small and pass through the filter paper. One in five gained one mark, with similar numbers achieving both marking points.

Answer 17 · 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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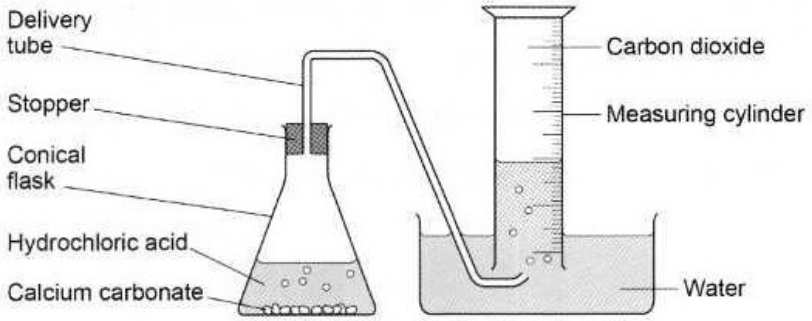
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 17 · 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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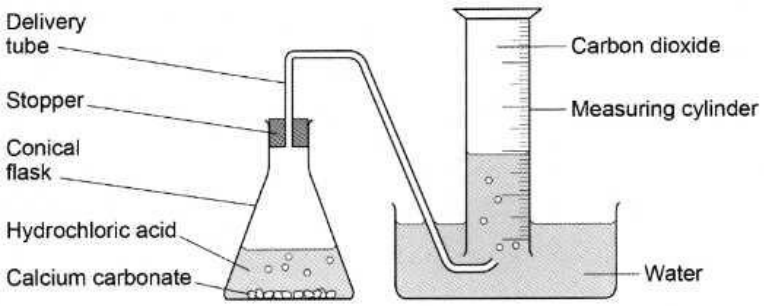
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 17 · 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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5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 17 · 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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5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 17 · 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 18 · 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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5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 18 · 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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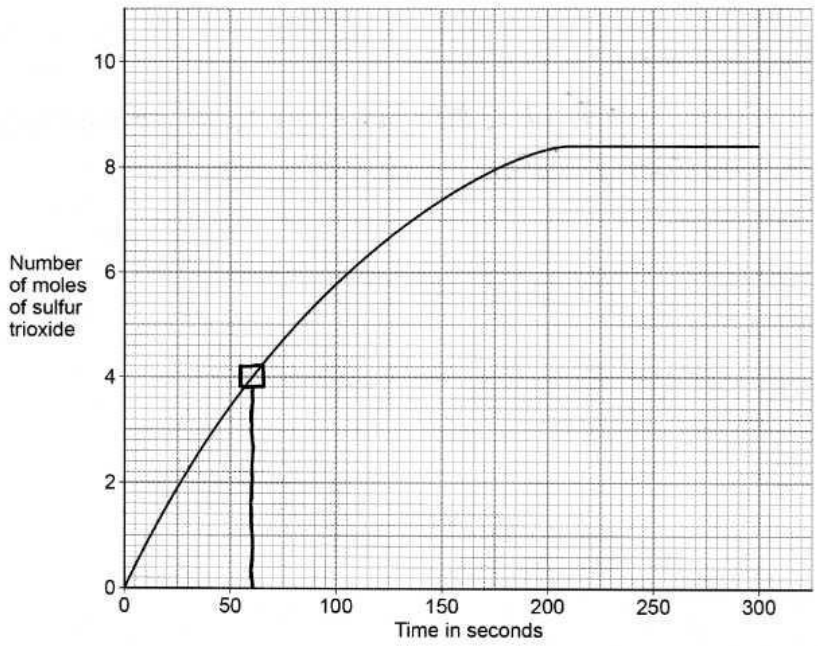
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 18 · 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]

$2 \div 50 = 0.04$ 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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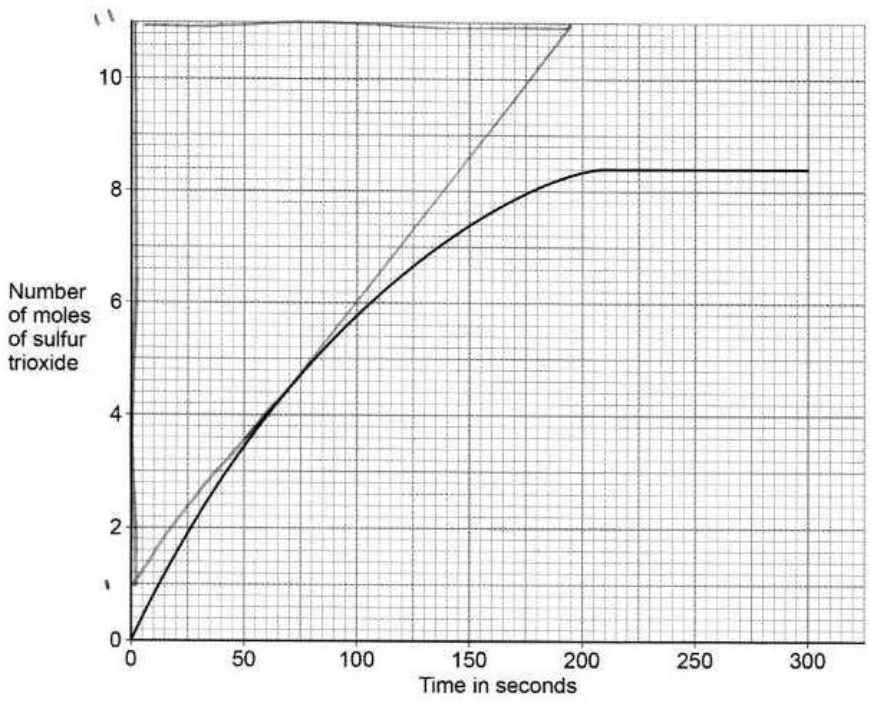
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 18 · 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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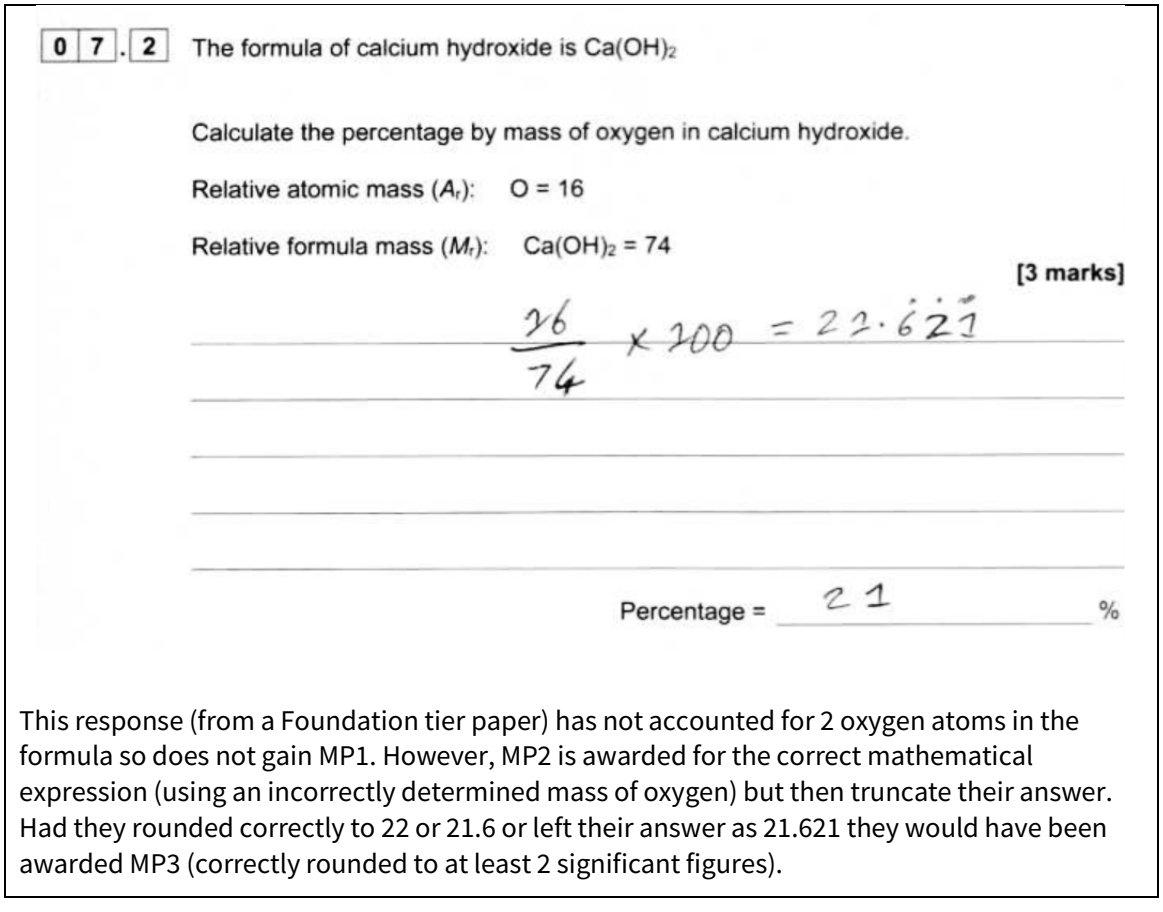
Answer 19 · Examiner comments

June 2025 | 8464/C/1H | Original Q2

Question 2 (Standard demand)

02.1 The specification definition for an 'exothermic' reaction was not well known as students rarely stated that energy or heat was released or transferred '*to the surroundings*'. However, more than three-quarters of students gained this mark. Answers were mostly general explanations, describing how energy or heat were 'given off' or 'released'. Common non-creditworthy responses referred to energy or heat being 'produced', the idea of heat or energy being 'lost' or references to an increase in temperature. Some answers stated that 'oxygen' or 'a gas' was given off by the reaction.

02.2 This question was well answered. The majority of students understood the use of brackets in a formula and used the subscript 2 correctly so evidence of 32 was common. There were some different variations on the use of 16 and 74 such as 74+16, 74-16 or 74÷16.



0 7 . 2 The formula of calcium hydroxide is $Ca(OH)_2$

Calculate the percentage by mass of oxygen in calcium hydroxide.

Relative atomic mass (A_r): O = 16

Relative formula mass (M_r): $Ca(OH)_2$ = 74

[3 marks]

$\frac{16}{74} \times 100 = 22.6\dot{2}\dot{1}$

Percentage = 21 %

This response (from a Foundation tier paper) has not accounted for 2 oxygen atoms in the formula so does not gain MP1. However, MP2 is awarded for the correct mathematical expression (using an incorrectly determined mass of oxygen) but then truncate their answer. Had they rounded correctly to 22 or 21.6 or left their answer as 21.621 they would have been awarded MP3 (correctly rounded to at least 2 significant figures).

02.3 This was an 'extended response' style of question. Such questions are marked holistically. There are overall generic descriptions for the three levels of response at the top of the mark scheme, giving a hierarchy of response. Within each level there are 2 marks.

Students were asked to plan a method to investigate how changing the mass of calcium oxide affects the temperature change of the reaction when calcium oxide is added to water. The indicative content includes 5 key steps and the control variable, along with some additional information.

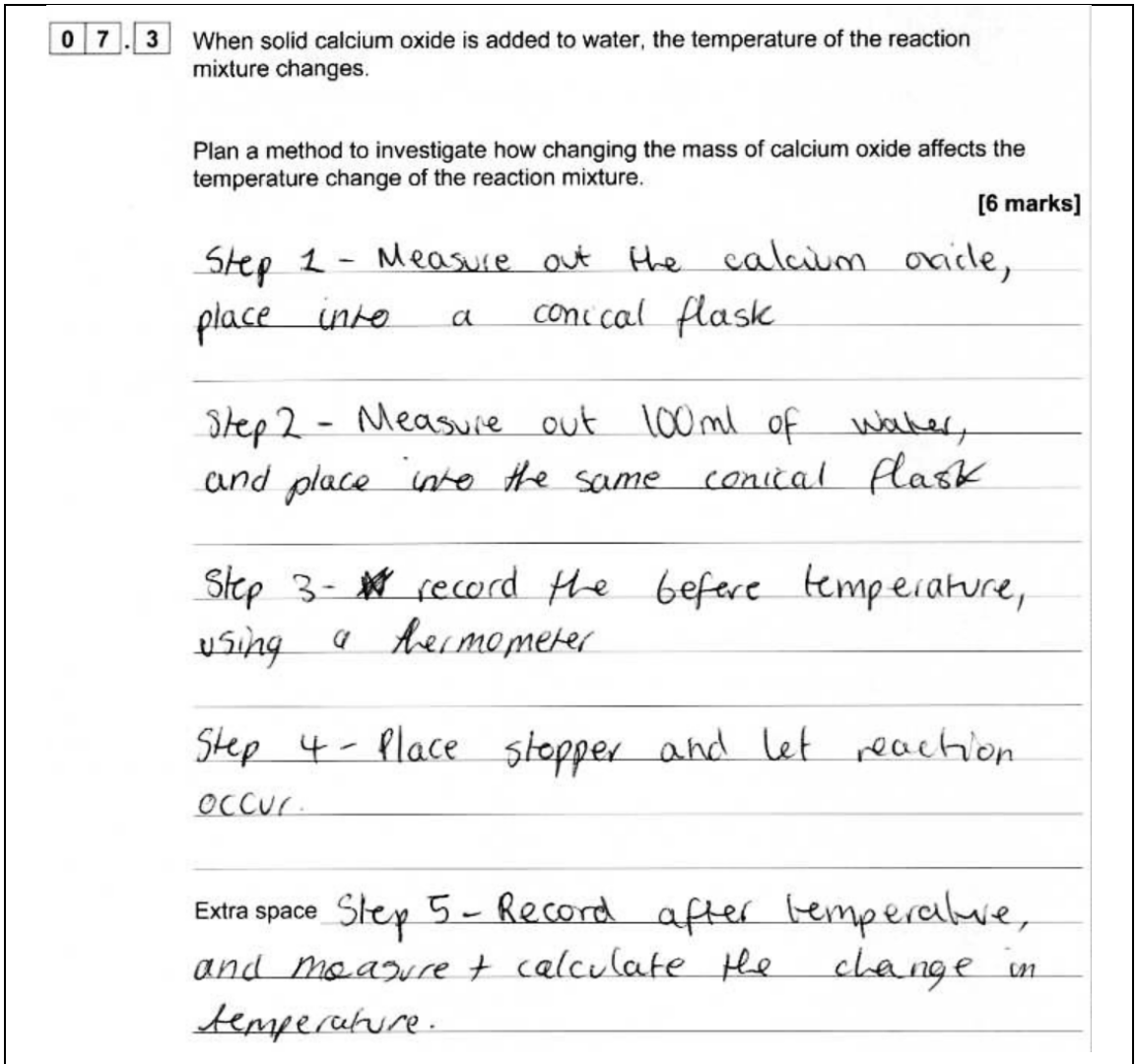
At Level 1, students needed to identify some relevant steps. To enter Level 2, three key steps, or two with the control variable, were required. To achieve marks in Level 3, all 5 key steps and the control variable were needed. Only a minority of students were able to obtain 6 marks.

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5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 19 · Examiner comments June 2025 | 8464/C/1H | Original Q2

Most students added calcium oxide to water but many omitted either volume (of water) or mass (of solid) although 'amount' was creditworthy for both here. Numerous students then took the 'initial' temperature (but this was often after they had added solid to water). Many were less clear on when and how the subsequent temperature or temperatures were to be taken. Too frequently it was stated that the 'temperature change' was to be measured which is not creditworthy, as this requires a calculation. The need for a control variable, whilst rarely stated as such, was often found in a Level 2 response due to the students realising that the volume of water needed to be fixed along with the experiment being repeated in some way. An indication of how the temperature change was to be determined was rarely seen.



0 7 . 3 When solid calcium oxide is added to water, the temperature of the reaction mixture changes.

Plan a method to investigate how changing the mass of calcium oxide affects the temperature change of the reaction mixture.

[6 marks]

Step 1 - Measure out the calcium oxide, place into a conical flask

Step 2 - Measure out 100ml of water, and place into the same conical flask

Step 3 - record the before temperature, using a thermometer

Step 4 - Place stopper and let reaction occur.

Extra space Step 5 - Record after temperature, and measure + calculate the change in temperature.

In this response (from a Foundation tier paper) the student has stated a valid volume of water but omitted 'mass' of calcium oxide. In step 3 they record the 'before' temperature but this is after both reactants have been added to the conical flask so is not credited with taking the initial temperature. They have not stated when the subsequent temperature is measured nor described how the temperature change is determined. Had the student 'repeated the experiment with different masses of calcium oxide' they would have been credited with the control variable as this would imply fixing the volume stated. The student uses a thermometer which is a valid point in the mark scheme.

Only one key step is stated with some additional information (correct use of a thermometer) so this is a Level 1 response and is awarded 1 mark.

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5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 19 · Examiner comments June 2025 | 8464/C/1H | Original Q2

0 7 . 3 When solid calcium oxide is added to water, the temperature of the reaction mixture changes.

Plan a method to investigate how changing the mass of calcium oxide affects the temperature change of the reaction mixture.

[6 marks]

- Place water in a polystegrene cup with a thermometer and lid
- ~~Add in~~ measure out different masses of calcium oxide
- add smallest mass to cup, place lid on top and measure maximum temperature and temperature change
- repeat with increasing masses of calcium oxide
- repeat previous steps to make sure investigation is accurate
- ~~measure~~ find the mean temperature of each reaction of increasing calcium oxide mass and water.

Extra space

In this response (from a Foundation tier paper) the student has omitted volume of water but stated mass of calcium oxide. The initial temperature is not recorded but the maximum temperature is. They repeat for accuracy and then repeat with different masses of calcium oxide. They have not stated how the temperature change is determined nor that they need to use the same volume of water when repeating. The student uses a suitable container (an insulated cup) and a thermometer which are valid ideas from the mark scheme.

There are three key steps with some additional information (thermometer and insulated cup) so this is a Level 2 response and is awarded 3 marks.

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5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 19 · Examiner comments June 2025 | 8464/C/1H | Original Q2

0 2 . 3 When solid calcium oxide is added to water, the temperature of the reaction mixture changes.

Plan a method to investigate how changing the mass of calcium oxide affects the temperature change of the reaction mixture.

[6 marks]

1. Measure 25cm^3 of water using a measuring cylinder and pour into a polystyrene cup.
2. Place the cup into a beaker and measure initial temperature using a thermometer
3. Measure 4g of calcium oxide using a balance
4. Add the calcium oxide and ~~put~~ put on a lid
5. Once the temperature has come to a stable point take final temperature reading using a thermometer
6. calculate temperature change by doing final temp - initial temp
7. Repeat steps 1-6 with different masses of calcium oxide e.g 6g, 8g. and compare results.

(for more accurate results use cotton wool in the beaker as an insulator and use a digital thermometer)

In this response, the student has stated a valid volume of water and mass of calcium oxide. The initial temperature (before the solid is added) and final temperature are recorded. They repeat with different masses of calcium oxide and are using the same volume of water so are credited with having a control variable. They have shown how the temperature change is determined. The student uses a measuring cylinder, suitable container (an insulated cup), balance and a thermometer which are additional valid points in the mark scheme.

There are all five key steps, a control variable, how the temperature change is determined with lots of additional information, so this is a Level 3 response and is awarded 6 marks.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 20 · Examiner comments

Question 4 (Standard, Standard/High and High demand)

04.1 Although well attempted, only a third of students were able to accurately describe a formulation. Several students knew that it was a mixture but did not expand on this any further to give the reason for the mixture. Several knew that you needed to add a number of substances together for a purpose but did not know that this would then be a mixture.

04.2 Well over half of students were able to select the correct response of 91 kJ/mol.

04.3 Half of all students could identify Le Chatelier as the scientist, although there were a variety of spellings offered.

04.4 Half of all students were able to select the correct response of 'the proportion of methanol decreases'. The most common incorrect answer was the opposite, being the proportion of methanol increases.

04.5 Again, half of all students were able to select the correct response of the proportion of methanol stays the same. A significant number however selected the proportion of methanol increases.

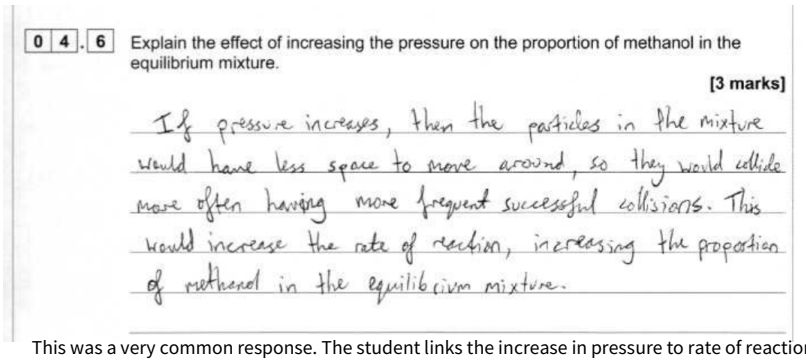
04.6 Students found equilibrium difficult. A large number of students related the increase in pressure to an increase in energy and number of collisions and hence an increase in the rate of reaction, but did not make any link to the effect on equilibrium.
A common misconception appeared to be that the proportion of methanol in the mixture was equivalent to the yield of methanol. Only a quarter of students gained 1 mark, with very few scoring 2 or 3.

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5.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 20 · Examiner comments

June 2025 | 8464/C/2H | Original Q4



0 4 . 6 Explain the effect of increasing the pressure on the proportion of methanol in the equilibrium mixture.

[3 marks]

If pressure increases, then the particles in the mixture would have less space to move around, so they would collide more often having more frequent successful collisions. This would increase the rate of reaction, increasing the proportion of methanol in the equilibrium mixture.

This was a very common response. The student links the increase in pressure to rate of reaction and hence to increased proportion of methanol. One mark is awarded for the increase in proportion of methanol.

04.7 Most students were able to state that a catalyst will increase the rate of a reaction. Less were able to explain that this is due to a lowered activation energy, and even fewer could link this to an alternative reaction pathway.
There was a common misconception that catalysts increase the rate of a reaction due to there being more frequent collisions, as this is a common explanation for how changing other factors affects the rate of reaction. Some students also incorrectly stated that catalysts cause the particles to gain energy.

04.8 Only half of all students answered this question well. Most of these identified that less energy used would be cheaper, but very few linked the idea of less fuels burning and the reduced contribution to global warming.
Some students gave ideas around the speed of the reaction decreasing at a lower temperature so the reaction could be controlled/monitored/more accurate results, lower temperatures being safer to work with, or lower temperatures resulting in less evaporation of methanol.

04.9 Just under a third of students gained both marks.
A large number of students did not know the formula for hydrogen and 6H was commonly used instead of $3H_2$
A small number of students could not gain marks due to errors in the size of the letter used eg Co_2 rather than CO_2 and $H2o$ rather than H_2O.
Students are expected to use subscript, superscript and size of letters appropriately.