AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.6.1.1

Calculating rates of reactions

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**24**
Available paper years	**2008–2025**

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.

4.6.1.1 Calculating rates of reactions

Answer 01 · Mark scheme

January 2008 | CHY2H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
(a)	sensible line of best fit which goes through or close to all the points **except** the anomalous point	allow wobbly / short double lines ± ½ square	1
(b)	loss of gas / loss of CO_2	idea of gas produced / formed	1

4.6.1.1 Calculating rates of reactions

Answer 02 · Mark scheme June 2009 | CHY2H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
1(a)(i)	a continuous straight line missing anomalous point	allow a line which does not start at zero / origin	1
1(a)(ii)	any **two** sensible errors eg • timing errors and / or example • measurement errors and / or example • apparatus errors and / or example • human / experimental / random error and / or example or 'did not do it right' • temperature fluctuation • anomalous point • results not recorded correctly • plotting error • rate calculated incorrectly	ignore systematic / zero error / weighing error **or** error unqualified could be two from **same** category eg two timing errors – watch not started at the same time plus difficulty in deciding when the cross has disappeared. accept outlier / wrong result ignore 'not repeated'	2
1(b)(i)	straight line **or** as concentration increases the rate goes up **or** converse	accept numerical example accept positive correlation accept same gradient ignore 'most points near / on line of best fit'	1

Question 1 continues on the next page…

CHY2H

Question 1 Continued

question	answers	extra information	mark
1(b)(ii)	more collisions	accept greater chance of collisions accept collide more successfully accept alternative versions of collide eg 'bump / hit' ignore references to energy / speed of particles / surface area	1
	more particles (in each volume of solution)(i.e. an attempt at defining concentration)	accept 'particles are closer together' allow ions / atoms / molecules for particles ignore reactants accept greater frequency of collisions **or** greater number of collisions per second for **2** marks	1
Total			**6**

4.6.1.1 Calculating rates of reactions

Answer 02 · Mark scheme

June 2009 | CHY2H | Original Q1 | Legacy

CHY2H

4.6.1.1 Calculating rates of reactions

Answer 03 · Mark scheme January 2010 | CHY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	0.2	correct answer gains **2** marks with or without working accept answer in table if answer incorrect 5/25 gains **1** mark	2
5(a)(ii)	any **one** from: • wider range of temperatures (owtte) • (repeat at the same temperature) to improve accuracy / reliability • reveal anomalous results (owtte) • so you can get an average / better average	 allow to make it reliable / accurate allow to eliminate random / human errors / to check results owtte ignore to make it a fair test / to get better results ignore precision and validity	1
5(b)	any **two** from: • particles gain energy / have more energy • particles move faster • particles collide more • more of the particles have the activation energy **or** more of the collisions are successful (owtte) **or** particles <u>collide</u> with more force / harder / more energy	allow atoms / molecules / they instead of particles throughout ignore increases particles activation energy ignore move more / vibrate more ignore increases / decreases activation energy allow more successful collisions alone for **1** mark	2
Total			**5**

4.6.1.1 Calculating rates of reactions

Answer 03 · Mark scheme

January 2010 | CHY2H | Original Q5 | Legacy

CHY2H

4.6.1.1 Calculating rates of reactions

Answer 04 · Mark scheme

June 2010 | CHY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	same number of (gaseous) molecules / moles / volume on both sides of the equation	allow particles for molecules do **not** accept atoms ignore amount	1
6(b)	(forward) reaction is exothermic	accept reverse answer	1
6(c)	any **three** from: • particles gain energy • particles move faster • particles collide more **or** more collisions • more of the collisions are successful **or** more of the particles have the activation energy **or** particles collide with more force / energy	 allow particles collide faster / quicker ignore move more / vibrate more	3

Question 6 continues on the next page

4.6.1.1 Calculating rates of reactions

CHY 2H

Question 6 continued

question	answers	extra information	mark
6(d)	any **two** from: • more product (obtained in shorter time) • less fuel needed **or** lower fuel costs • less pollution caused by burning fuels **or** less specified type of pollution caused by producing heat / burning fuels • using less fuel conserves resources	 accept better yield (of product) accept less energy / heat / electricity needed ignore cheaper unqualified allow correct specified pollutants caused by burning fossil fuels eg CO_2 / greenhouse gases **or** correct effect of burning fossil fuels eg global warming accept thermal / heat pollution accept sustainable accept fossil fuels are non-renewable	2
Total			**7**

4.6.1.1 Calculating rates of reactions

Answer 05 · Mark scheme

January 2011 | CHY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)(i)	less drying time **and/or** less soaking time	allow it is quicker / faster allow converse if they state water	1
6(a)(ii)	forces of attraction / bonds between molecules are weak (owtte) **or** intermolecular forces / bonds are weak (owtte)	do not accept intramolecular forces / covalent bonds are weak forces of attraction are weak (without specifying between molecules / intermolecular) gains **1** mark (accept easily broken / not much energy needed to break instead of weak) bonds are weak without specifying intermolecular would **not** gain a mark and would be ignored. made of small molecules / simple molecular gain **1** mark an answer such as, it is made of small molecules with weak forces of attraction, would gain **2** marks	2
6(b)(i)	exothermic reaction (owtte)	accept answers based on Le Chatelier eg when temperature is low the reaction moves to increase the temperature accept reverse argument	1

Question 6 continued on the next page

Question 6 contd

question	answers	extra information	mark
6(b)(ii)	fewer product molecules / particles (than reactants molecules) (owtte)	accept three molecules / particles / volumes / moles on the left and one on the right (numbers given must be correct) accept answers based on Le Chatelier eg when pressure is high, reaction moves to the side with fewest molecules / smaller volume **or** when pressure is high, reaction moves to reduce the pressure do **not** accept reference to atoms do not accept more reactants than products unless qualified	1
6(b)(iii)	any **two** from: • molecules / particles / they move faster • collide more (often) / quicker • more of the collisions are successful **or** more have the activation energy (owtte) **or** more energetic collisions	 ignore move / vibrate more allow harder collisions allow collide with more force	2
6(c)(i)	16	correct answer with or without working accept correct rounding if the answer is incorrect then check the working. for **1** mark look for correct method in one line of the working. Moles of CO = 14/28 **or** 0.5 **or** Mass of CH_3OH = 0.5 × 32 **or** 28 → 32 **or** 14 → 32/2 **or** $\frac{32}{28}\times 14$	2

Question 6 contd

question	answers	extra information	mark
6(c)(ii)	75	correct answer with or without working allow correct answer with ecf from (c)(i) for **2** marks if the answer is incorrect $\frac{12}{16}\times 100$ **or** $\frac{12}{\text{their (c)(i)}}\times 100$ gains **1** mark **OR if working from 18 g** 66.6 recurring or correctly rounded to a max of 67 = **2** marks incorrect rounding eg 66 = **1** mark **or** $\frac{12}{18}\times 100$ gains **1** mark	2
6(c)(iii)	reversible reaction **or** not all reactants converted to product (owtte) **or** other sensible reason such as: loss of product / reactant **or** impurities in reactants **or** side reactions / other products **or** temperature too high / pressure too low	 allow 'it did not all react' allow gas is lost ignore mass lost ignore some is lost	1
Total			**12**

4.6.1.1 Calculating rates of reactions

Answer 06 · Mark scheme June 2011 | CHY2H | Original Q3 | Legacy

Question 3

question	answers	extra information	mark
3(a)	particles move faster **or** particles have more energy so they collide more often / frequently **or** more of the collisions are successful / have the activation energy	accept molecules / atoms / ions instead of particles ignore move / vibrate more allow particles collide harder / with more force ignore collide quicker ignore collide more / more collisions	1 1
3(b)	any **one** from: • increase surface area (of the rock) • increase the concentration (of the acid) • add a catalyst • stir / mix the mixture	 accept crush / powder the rock ignore increase the pressure / temperature	1
Total			**3**

4.6.1.1 Calculating rates of reactions

Answer 06 · Mark scheme

June 2011 | CHY2H | Original Q3 | Legacy

CHY2H

4.6.1.1 Calculating rates of reactions

Answer 07 · Mark scheme

January 2013 | CH2HP | Original Q1 | Legacy

question	answers	extra information	mark
1(a)	because sulfur / S forms which is insoluble / a solid / a precipitate		1 1
1(b)(i)	32	correct answer with or without working gains **2** marks accept evidence of 31 + 33 / 2 for **1** mark allow 35 for **1** mark	2
1(b)(ii)	reaction rate increases because of more particles (per unit volume) and because there is an increase in frequency of collisions	if incorrect reference to energy = max **2** allow because particles are closer together accept because particles are more likely to collide **or** higher chance of collision ignore more (successful) collisions	1 1 1
Total			**7**

4.6.1.1 Calculating rates of reactions

Answer 07 · Mark scheme

January 2013

CH2HP

4.6.1.1 Calculating rates of reactions

Answer 08 · Mark scheme

June 2013 | CH2HP | Original Q2 | Legacy

Question 2

question	answers	extra information	Mark
2(a)	any **two** from: • effervescence / bubbles / fizzing • magnesium disappears / dissolves • heat given off / exothermic • change in pH	 allow gas / hydrogen is given off allow volume of gas allow magnesium floats allow change in mass of magnesium allow temperature change do **not** accept temperature decreases do **not** accept pH decreases	2

2(b)	Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5.		6
0 marks	**Level 1 (1-2 marks)**	**Level 2 (3-4 marks)**	**Level 3 (5-6 marks)**
No relevant content.	A simple plan without reference to changing any variable but should include an attempt at measuring rate **or** an attempt at fair testing	A plan including change of concentration / 'volume' of acid **and** should include an attempt at measuring rate **and / or** an attempt at fair testing	A workable plan including change of concentration **and** measurement of rate **and** fair testing

examples of chemistry points made in the response could include:

Plan:

- add magnesium to acid
- time reaction / 'count bubbles' / measure volume of gas
- change concentration / 'volume' of acid

Control Variables:

- amount / mass / length / same 'size' of magnesium
- volume / amount of acid

Total			**8**

4.6.1.1 Calculating rates of reactions

Answer 09 · Mark scheme June 2014 | CH2HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
3(a)	O_2 in correct space		1	2 / 2.4	E
	correct balancing	accept multiples	1		
3(b)(i)		*incorrect reference to energy = max **2***		1 / 2.4.1d	E
		ignore references to equilibrium			
	rate increases		1		
	because particles are closer together	accept because there are more particles (per unit volume)	1		
		allow particles have less space / room to move around			
	so frequency of collisions increases	*accept particles are more likely to collide*	1		
		ignore more collisions			
		ignore more successful collisions			
3(b)(ii)	has a greater surface area		1	3 / 2.4.1f/g	E
	so the reaction is faster	*accept so more frequent collisions*	1		
3(c)	the (minimum) amount of energy (particles must have) to react ***or*** *to start a reaction*	accept the energy needed to break bonds	1	1 / 2.4.1b	E
		ignore references to heat			
3(d)(i)	(potassium is) too / *very* reactive	*ignore potassium is a Group 1 / alkali metal*	1	1 + 2 / 2.6.1b	E
	so dangerous / *violent reaction*	accept hydrogen produced rapidly	1		
3(d)(ii)		accept products in either order		2 / 2.6.2b	E
		ignore names of substances			
		*do **not** accept brackets or charges in the formulae*			
	$ZnSO_4$		1		
	H_2		1		

4.6.1.1 Calculating rates of reactions

3(d)(iii)	any **one** from: • increase concentration (of sulfuric acid) • increase temperature **or** heat it • increase surface area of zinc		1	1 / 2.4.1	E
Total			**13**		

4.6.1.1 Calculating rates of reactions

Answer 09 · Mark scheme

June 2014 | CH2HP | Original Q3 | Legacy



4.6.1.1 Calculating rates of reactions

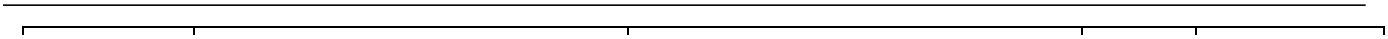
Answer 10 · Mark scheme June 2015 | CH2HP | Original Q1 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
1(a)(i)	the higher the temperature, the greater the rate **or** at 40 °C rate is faster than at 20 °C	accept the higher the temperature, the faster the reaction	1	**AO3** 2.4.1c
1(a)(ii)	40 °C curve is steeper **or** correct comparison of data from the graph	accept the 40 °C line becomes horizontal sooner accept at higher temperatures the reaction finishes sooner accept reaction finishes sooner at 40 °C accept at higher temperatures the gas is produced faster	1	**AO3** 2.4.1c
1(a)(iii)	2		1	**AO2** 2.4.1a
1(b)(i)	Concentration of acid Mass of marble chips		2	**AO3** 2.4.1e
1(b)(ii)	increases rate (because of) more frequent collisions (between particles)	incorrect reference to energy = max **1** accept particles are more likely to collide ignore more collisions ignore more successful collisions	1 1	**AO1** 2.4.1f
1(c)	any **one** from: • increases rate of reaction • reduces energy required • lower temperature can be used • catalyst is not used up		1	**AO1** 2.4.1g,h
Total			**8**	

4.6.1.1 Calculating rates of reactions

Answer 10 · Mark scheme

June 2015 | CH2HP | Original Q1 | Legacy



4.6.1.1 Calculating rates of reactions

Answer 11 · Mark scheme June 2016 | CH2HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / SpecRef
4(a)	because sulfur / S (forms) (which) is solid / insoluble / a precipitate/ a suspension		1 1	AO2 2.6.1a
4(b)	any **two** from: • volume of sodium thiosulfate • volume of (hydrochloric) acid • concentration of sodium thiosulfate • concentration of (hydrochloric) acid	ignore amount of sodium thiosulfate ignore amount of (hydrochloric) acid if no other mark, allow **1** mark for same cross **or** same flask **or** unspecified volume **or** unspecified concentration ignore same person do **not** accept references to temperature	2	AO3 2.4.1
4(c)	rate increases because particles move faster so frequency of collisions increases more particles/ collisions have energy greater than (or equal to) the activation energy	 accept particles have more energy accept particles are more likely to collide **or** more chance of collisions ignore more collisions	1 1 1 1	AO1 2.4.1b,c
4(d)	cool **or** decrease the temperature (of the solutions)	accept refrigerate **or** method to decrease temperature	1	AO3 2.4.1c
Total			**9**	

4.6.1.1 Calculating rates of reactions

Answer 12 · Mark scheme

June 2017 | CH2HP | Original Q1 | Legacy

The full source mark scheme begins on page 55. Follow original question 1 in that document.

4.6.1.1 Calculating rates of reactions

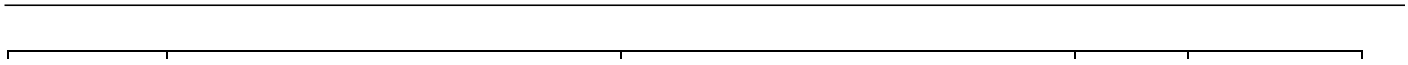
Answer 13 · Mark scheme June 2018 | 8462/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	a gas is produced	allow carbon dioxide is produced do **not** accept an incorrect gas	1	AO2 4.3.1.3 4.6.1.1
	(which) escapes	**max 1** mark if evaporation mentioned	1	
08.2	all eight points plotted correctly	allow a tolerance of ± half a small square. allow six or seven points plotted correctly for **1** mark	2	AO2 4.6.1.1
	line of best fit		1	
08.3		an incorrect answer for one step does not prevent allocation of marks for subsequent steps		AO2 4.6.1.1
	correctly drawn tangent at 0.95 g		1	
	correct value for x step **and** y step from tangent	allow evidence of use of two points on tangent either on the graph or in the text	1	
	(rate =) $\frac{\text{value for y step}}{\text{value for x step}}$		1	
	correctly evaluated and rounded to 2 sig figs	allow (rate =) $\frac{\text{value for x step}}{\text{value for y step}}$ (ie inverted division) correctly evaluated and rounded to 2 sig figs	1	
Total			**9**	

4.6.1.1 Calculating rates of reactions

Answer 13 · Mark scheme

June 2018 | 8462/2H | Original Q8



4.6.1.1 Calculating rates of reactions

Answer 14 · Mark scheme June 2018 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	enzyme		1	AO2 4.6.1.4
09.2	2.0×10^3 moles		1	AO2 4.3.2.1
09.3	smaller yield (because) favours endothermic reaction	allow less methanol is produced allow (because) favours reverse reaction allow equilibrium / reaction shifts to the left allow equilibrium / reaction shifts to reduce the temperature ignore reference to forward reaction is exothermic ignore references to rate	1 1	AO2 4.6.2.4 4.6.2.6

4.6.1.1 Calculating rates of reactions

Answer 14 · Mark scheme June 2018 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	(yield) equilibrium position moves to the product side	allow converse arguments allow equilibrium / reaction moves to the right allow equilibrium / reaction shifts to reduce the pressure	1	AO2 4.6.1.3 4.6.2.4 4.6.2.7
	(because) fewer molecules / moles / particles on product side	allow (because) fewer molecules / moles / particles on the right allow (because) smaller volume on product side	1	
	(rate) more collisions per unit time	allow increases collision frequency / rate ignore more collisions alone ignore faster collisions do **not** accept any indication of more energetic / forceful collisions	1	
	(because) more molecules / particles per unit volume	allow (gas) molecules / particles closer together ignore more molecules / particles alone	1	
09.5	provides different reaction pathway (which has a) lower activation energy	allow provides a different mechanism / route ignore references to collisions	1 1	AO1 4.6.1.4

4.6.1.1 Calculating rates of reactions

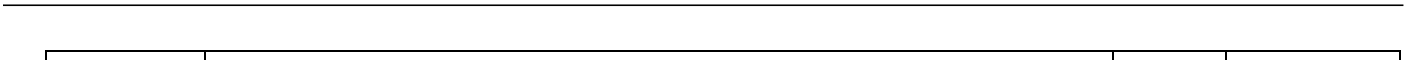
Answer 14 · Mark scheme June 2018 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.6	less energy is needed	allow reduces the temperature required allow reduces costs ignore references to pressure ignore references to rate or time	1	AO2 4.6.1.4
09.7	no effect / change		1	AO3 4.6.1.4 4.6.2.3
Total			**12**	

4.6.1.1 Calculating rates of reactions

Answer 14 · Mark scheme

June 2018 | 8462/2H | Original Q9



4.6.1.1 Calculating rates of reactions

Answer 15 · Mark scheme

June 2019 | 8462/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	(aq)	allow aqueous / aq	1	AO1 4.2.2.1 4.2.2.2
03.2	(gas) syringe stopclock / stopwatch	allow measuring cylinder (and water trough) allow balance allow timer / clock / watch	1 1	AO1 4.6.1.1
03.3	all points plotted correctly line of best fit	allow a tolerance of ± ½ a small square allow at least 3 points plotted correctly for **1** mark. allow correctly drawn line of best fit for incorrectly plotted points	2 1	AO2 4.6.1.1
03.4	(rate) decreases (rate decreases) more slowly as time increases (rate) becomes zero at 60 s	allow slows down allow (rate decreases) at a non-linear rate allow the reaction stops at 60 s allow ecf from question **03.3**	1 1 1	AO3 4.6.1.1
03.5	more bubbles were produced in the first 10 seconds the magnesium was used up more quickly		1 1	AO2 4.6.1.2
Total			**11**	

4.6.1.1 Calculating rates of reactions

Answer 16 · Mark scheme

June 2019 | 8462/2H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	glowing splint	do **not** accept burning splint	1	AO1 4.8.2.2
	(which) relights	dependent on correct test in MP1 ignore with a pop	1	
09.2	place the conical flask in a water bath at constant temperature.		1	AO3 4.6.1.2
	use a mass of 1 g manganese dioxide each time.		1	
09.3		an answer of 0.092 (cm^3/s) scores **3** marks allow an answer of 0.091666 (cm^3/s) correctly rounded to at least 2 significant figures for **2** marks allow an answer of 0.033 (cm^3/s) for **2** marks allow an answer of 0.033333 (cm^3/s) for **1** mark		AO2 4.6.1.1
	11 (cm^3) **and** 120 (seconds)		1	
	(mean rate of reaction = $\frac{11}{120}$) = 0.09167	allow a correct calculation using incorrectly determined value(s) for difference in volume and / or time	1	
	= 0.092 (cm^3/s)	allow a correctly calculated answer given to 2 significant figures from an incorrect attempt at the rate equation	1	

4.6.1.1 Calculating rates of reactions

Answer 16 · Mark scheme

June 2019 | 8462/2H | Original Q9

09.4	line starts at origin **and** less steep than solid line line levelling off at 40 (cm^3)	 allow a tolerance of ± ½ a small square	1 1	AO2 AO3 4.6.1.2
09.5	(because) surface area (of fine manganese dioxide powder) greater (so) more collisions (with hydrogen peroxide molecules / particles) per unit time	allow converse for coarse lumps do **not** accept references to changes in kinetic energy or speed (of molecules / particles) ignore references to activation energy.	1 1	AO2 4.6.1.2 4.6.1.3
Total			**11**	

Answer 17 · Mark scheme

November 2020 | 8462/2H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	all seven points plotted correctly	allow a tolerance of ±½ small square allow **1** mark for five or six points plotted correctly	2	AO2 4.6.1.1
	line of best fit		1	
08.2	0.0038 **and** 0.0014		1	AO2 4.6.1.1
	$\frac{0.0038 - 0.0014}{105 - 20}$	allow correct use of incorrectly determined mole value(s)	1	
	= 0.000028 **or** = 2.8×10^{-5}		1	
	mol/s	allow moles per second	1	
08.3	(for large lumps) a smaller number of moles of gas is collected in the same time **or** (for large lumps) more time is needed to collect the same number of moles of gas **or** the line (of best fit for large lumps) is less steep	allow converse statement for small lumps allow the line (of best fit for large lumps) takes more time to become horizontal	1	AO2 4.6.1.1

Question 8 (continued)

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	(surface area = 6 x 0.5 x 0.5) = 1.5 (cm^2)		1	AO2 4.6.1.3
	(volume = 0.5 x 0.5 x 0.5) = 0.125 (cm^3)		1	
	(surface area : volume =) 12 : 1	allow correctly calculated ratio using incorrectly calculated values for surface area and/or volume	1	
08.5	decreases by a factor of 10	allow 10 times smaller allow one tenth allow 1/10 allow 1 : 10 (large cube to small cube)	1	AO2 4.2.4.1 4.6.1.3
Total			**12**	

4.6.1.1 Calculating rates of reactions

Answer 18 · Mark scheme

November 2021 | 8462/2H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(delivery) tube is in (sulfuric) acid		1	AO3 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2	reaction has stopped (because a) reactant is used up	allow no more gas produced allow named reactants	1 1	AO2 4.6.1.1 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	any **one** from: • the line (for 0.05 mol/dm^3 sulfuric acid) is less steep • (0.05 mol/dm^3 sulfuric acid) produces less gas in a fixed time • the reaction (using 0.05 mol/dm^3 sulfuric acid) takes longer to finish	allow converse statements about 0.10 mol/dm^3 sulfuric acid ignore produces less gas do **not** accept produces less gas in total	1	AO1 4.6.1.1 RPA5

Question 9 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	tangent drawn at 80 s on 0.05 mol/dm^3 curve (from tangent) value for *x*-step **and** value for *y*-step (rate =) $\frac{\text{value for } y\text{-step}}{\text{value for } x\text{-step}}$ calculation of rate answer to 2 significant figures	 allow a tolerance of ± ½ a small square allow correct use of incorrectly determined values from tangent for *x*-step and/or *y*-step allow an answer correctly calculated to 2 significant figures from an incorrect calculation of rate	1 1 1 1 1	AO2 4.6.1.1 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	Cu^{2+}		1	AO2 4.1.3.2 4.6.1.4

Total			10

4.6.1.1 Calculating rates of reactions

Answer 19 · Mark scheme

June 2022 | 8462/2H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	(nitrogen) air (hydrogen) natural gas	allow atmosphere allow methane allow water / steam	1 1	AO1 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	there is only one product		1	AO2 4.3.3.2 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	(mixture is) cooled (so that only) ammonia liquefies	 allow (so that only) ammonia condenses	1 1	AO1 4.10.4.1

4.6.1.1 Calculating rates of reactions

Answer 19 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	scale labelled at 100, 200, 300 and 400 (atm)	allow scale labelled at 50, 150, 250 and 350 (atm)	1	AO2 4.10.4.1
	all five points plotted correctly	allow a tolerance of ± ½ a small square allow **1** mark for three / four points plotted correctly	2	
	line of best fit		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5 View with Figure 5	extrapolation to 500 atmospheres		1	AO2 4.10.4.1
	percentage value at 500 atmospheres	allow a tolerance of ± ½ a small square	1	

4.6.1.1 Calculating rates of reactions

Answer 19 · Mark scheme

June 2022 | 8462/2H | Original Q7

Question	Answers	Mark	AO / Spec. Ref.
07.6	**Level 3**: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 4.6.1.3 4.6.1.4 4.6.2.6 4.6.2.7 4.10.4.1
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content **rate** • higher temperature gives higher rate because of more frequent collisions • higher temperature gives higher rate because more particles have the activation energy • higher pressure gives higher rate because of more frequent collisions • use of catalyst gives higher rate because the activation energy is lowered **equilibrium** • higher temperature shifts the position of equilibrium to the left because reaction is exothermic • higher pressure shifts the position of equilibrium to the right because more molecules on left-hand side • use of catalyst has no effect on the position of equilibrium **other factors** • higher temperature (than 450°C) uses more energy so increases costs • higher pressure (than 200 atmospheres) uses more energy so increases costs • higher pressure (than 200 atmospheres) requires stronger reaction vessels so increases costs • use of a catalyst reduces energy costs **compromise** • the temperature chosen is a compromise between rate of reaction and position of equilibrium • the temperature chosen is a compromise between rate and cost • the pressure chosen is a compromise between yield / rate and cost		

Total Question 7		**17**

4.6.1.1 Calculating rates of reactions

Answer 20 · Mark scheme

June 2022 | 8462/2H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	(sulfur is a) precipitate / solid **or** (sulfur is an) insoluble substance		1	AO2 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2 **View with Figure 7**	correctly drawn tangent at 30 s		1	AO2 4.6.1.1 RPA5
	correct values for *x* step **and** *y* step from tangent	allow correct use of an incorrectly drawn tangent allow a tolerance of ± ½ a small square for each coordinate	1	
	(ratio =) $\frac{\text{value for y step}}{\text{value for x step}}$	allow correct use of incorrectly determined values from tangent for *x* step and/or *y* step	1	
	correct calculation of ratio		1	
	(conversion rate = ratio × 7.1 × 10^{-5}) correct evaluation of rate (mol/s)	allow correct use of an incorrectly calculated ratio	1	

4.6.1.1 Calculating rates of reactions

Answer 20 · Mark scheme

June 2022 | 8462/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	rate decreases (because) concentration of reactants decreases **alternative approach:** greatest rate at start (1) (because) greatest concentration of reactants at start (1)	allow the collision frequency decreases allow the collision frequency is highest at the start	1 1	AO2 4.6.1.1 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	(hydrochloric) acid is used up	allow (hydrochloric) acid is the limiting reactant ignore reactants used up	1	AO3 4.3.2.4 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.5 View with Figure 8	decreasing curve starting at (0,95) **and** steeper initially than curve for 0.10 mol/dm^3 sodium thiosulfate solution levelling at 24%		1 1	AO2 4.6.1.2 RPA5

4.6.1.1 Calculating rates of reactions

Answer 20 · Mark scheme

June 2022 | 8462/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.6	stop light from other sources reaching the light sensor		1	AO3 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.7	repeatable		1	AO3 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.8	$V \propto m$		1	AO2 4.6.1.2

4.6.1.1 Calculating rates of reactions

Answer 20 · Mark scheme

June 2022 | 8462/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.9 View with Figure 9	volume of sodium thiosulfate solution **and** volume of hydrochloric acid at any fixed mass	allow a tolerance of ± ½ a small square for volume readings	1	AO2 4.6.1.2
	$\left(\frac{\text{volume of } Na_2S_2O_3 \text{ solution}}{\text{volume of hydrochloric acid}} = \right)$ 0.25	allow $\left(\frac{\text{volume of hydrochloric acid}}{\text{volume of } Na_2S_2O_3 \text{ solution}} = \right)$ 4 allow correct use of incorrectly determined volumes	1	
	1 : 4		1	

Total Question 8		17

4.6.1.1 Calculating rates of reactions

Answer 21 · Mark scheme

June 2023 | 8462/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	to reduce the escape of gas		1	AO3 4.6.1.1 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	(mean rate =) $\frac{0.78 + 0.81 + 0.81}{3}$	allow $\frac{0.78 + 0.81 + 0.68 + 0.81}{4}$	1	AO3
	0.80 (cm^3/s)	= 0.77 (cm^3/ s) for **1** mark	1	AO2
	$0.80 = \frac{20}{\text{mean time taken}}$	allow correct use of incorrectly determined mean rate	1	AO2
	(mean time taken =) $\frac{20}{0.80}$		1	AO2
	= 25 (s)		1	AO2 4.6.1.1 RPA5
	alternative approach: $0.78 = \frac{20}{\text{time}}$ **or** $0.81 = \frac{20}{\text{time}}$ (1)			
	(trial 1 time = $\frac{20}{0.78}$ =) 25.6 (1)			
	(trial 2 and 4 time = $\frac{20}{0.81}$ =) 24.7 (1)			

	(mean time =) $\frac{25.6 + (2 \times 24.7)}{3}$ (1) = 25 (s) (1)	allow correct use of incorrectly determined value(s) for time allow $\frac{25.6 + 29.4 + (2 \times 24.7)}{4}$ = 26.1 (s) for **1** mark		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	use a lower temperature use sulfuric acid of a lower concentration		1 1	AO1 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	(test) burning / lit splint (result) burns with a (squeaky) pop sound	MP2 is dependent upon MP1 being awarded allow flame do **not** accept glowing splint allow pops	 1 1	AO1 4.8.2.1

Total Question 1	10

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	(a catalyst) provides a different pathway for the reaction (which has a) lower activation energy		1 1	AO1 4.6.1.3 4.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	(oxygen is) a gas (which) escaped from the flask		1 1	AO2 4.3.1.3 4.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	correct value for *x* step **and** *y* step from tangent (rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$ correct calculation of rate answer to 2 significant figures	 allow correct use of incorrectly determined *x* and/or *y* step allow an answer correctly rounded to 2 significant figures from an incorrect calculation which uses values determined from the graph.	1 1 1 1	AO2 4.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	line starting at 0,0 which is less steep than existing line which becomes level at 0.80 g	 allow a tolerance of ± ½ a small square	1 1	AO2 4.3.4 4.6.1.2

Total Question 7	10

4.6.1.1 Calculating rates of reactions

Answer 23 · Mark scheme

June 2024 | 8462/2H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(some) hydrogen / gas escapes (from the flask) (because the reaction starts) before the stopper is put in	 allow (because) stopper cannot be inserted instantly allow for **1** mark some air (from the conical flask) is collected **or** allow some hydrogen remains in the conical flask **or** allow some hydrogen remains in the delivery tube	1 1	AO3 4.6.1.2 RPA5

4.6.1.1 Calculating rates of reactions

Answer 23 · Mark scheme

June 2024 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2	(volume = 39 − 25 =) 14 (cm^3)		1	AO2 4.3.5
	(14 cm^3 =) 0.014 (dm^3)	allow correct use of an incorrectly determined volume	1	4.6.1.1 RPA5
	(moles of hydrogen =) $\frac{0.014}{24}$	allow correct use of an incorrectly determined volume allow correct use of an incorrect / no conversion of volume	1	
	= 5.8 x 10^{-4} (mol)	allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol)	1	
	alternative approach 1:			
	(24 dm^3 =) 24 000 (cm^3) (1)			
	(volume = 39 − 25 =) 14 (cm^3) (1)			
	(moles of hydrogen =) $\frac{14}{24000}$ (1)	allow correct use of an incorrectly determined volume allow correct use of an incorrect / no conversion of volume		
	= 5.8 x 10^{-4} (mol) (1)	allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol)		

	alternative approach 2: (24 dm^3 =) 24 000 (cm^3) (1) (moles of hydrogen at 100 s = $\frac{39}{24000}$ =) 0.001625 **and** (moles of hydrogen at 40 s = $\frac{25}{24000}$ =) 0.00104 (1) (moles 100 s – moles 40 s =) 0.001625 – 0.00104 (1) = 5.8 x 10^{-4} (mol) (1) **alternative approach 3:** (39 cm^3 =) 0.039 (dm^3) **and** (25 cm^3 =) 0.025 (dm^3) (1) (moles of hydrogen at 100 s = $\frac{0.039}{24}$ =) 0.001625 **and** (moles of hydrogen at 40 s = $\frac{0.025}{24}$ =) 0.00104 (1) (moles 100 s – moles 40 s =) 0.001625 – 0.00104 (1) = 5.8 x 10^{-4} (mol) (1)	allow correct use of an incorrect / no conversion of volume allow correct use of an incorrectly determined number of moles allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol) allow correct use of an incorrect / no conversion of volume allow correct use of an incorrectly determined number of moles allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol)		

4.6.1.1 Calculating rates of reactions

Answer 23 · Mark scheme

June 2024 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	tangent drawn at 45 s		1	AO2 4.6.1.1 RPA5
	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	
	rate given in standard form (mol/s)	allow a correctly calculated answer in standard form from an incorrect attempt at rate determination	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	line starting at 0,0.000 and less steep than existing line		1	AO2 4.3.2.4 4.3.4 4.6.1.1 RPA5
	becomes level at 0.0084 mol	allow a tolerance of ± ½ a small square	1	

4.6.1.1 Calculating rates of reactions

Answer 23 · Mark scheme

June 2024 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	(increasing the temperature) increases the rate of reaction		1	AO1 4.6.1.2 4.6.1.3
	(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 ignore successful	1	

Total Question 9	16

4.6.1.1 Calculating rates of reactions

Answer 24 · Mark scheme

June 2025 | 8462/2H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	a gas was produced	allow oxygen for gas	1	AO2 4.3.1.3 4.6.1.4
	(and the gas) escaped from the flask		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2	catalysts provide a different pathway for the reaction		1	AO3 4.6.1.3 4.6.1.4
	(and) the activation energy using **B** is lower	allow converse	1	
	(so) the rate of reaction is higher using **B**	allow converse allow (so) the reaction using **B** has more particles with an energy exceeding the activation energy	1	

Answer 24 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	tangent at 60 s		1	AO2 4.6.1.1
	value for *x* step **and** *y* step from tangent	allow a tolerance of ± ½ a small square allow correct use of an incorrect tangent	1	
	(rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$	allow correct use of incorrectly determined *x* and / or *y* step from a drawn tangent	1	
	correct calculation of rate		1	
	answer in standard form	allow an answer correctly given in standard form from an incorrect calculation which uses values determined from the graph	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4		allow converse		AO1 4.6.1.2 4.6.1.3
	the rate (of decomposition / reaction) increases at higher temperatures		1	
	(because) particles have more energy	allow (because) particles move faster	1	
	(so) collide more frequently	allow (and) a greater proportion collide with sufficient energy to exceed the activation energy	1	

Total Question 8	**13**

4.6.1.1 Calculating rates of reactions

GCSE

Additional Science / Chemistry

CH2HP
Final Mark scheme

4408 / 4402
June 2017

Version/Stage: v1.0

4.6.1.1 Calculating rates of reactions

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

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Information to Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded
- the Assessment Objectives and specification content that each question is intended to cover.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.
At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.
In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening and underlining

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **or**.
Different terms in the mark scheme are shown by a / ; eg allow smooth/free movement.

2.4 Any wording that is underlined is essential for the marking point to be awarded.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error/contradiction negates each correct response. So, if the number of error/contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (indicated as * in example 1) are not penalised.

Example 1: What is the pH of an acidic solution?

[1 mark]

Student	Response	Marks awarded
1	green, 5	0
2	red*, 5	1
3	red*, 8	0

Example 2: Name two planets in the solar system.

[2 marks]

Student	Response	Marks awarded
1	Pluto, Mars, Moon	1
2	Pluto, Sun, Mars, Moon	0

3.2 Use of chemical symbols/formulae

If a student writes a chemical symbol/formula instead of a required chemical name, full credit can be given if the symbol/formula is correct and if, in the context of the question, such action is appropriate.

3.3 Marking procedure for calculations

Full marks can be given for a correct numerical answer, without any working shown. However, if the answer is incorrect, mark(s) can be gained by correct substitution/working and this is shown in the 'extra information' column or by each stage of a longer calculation.

3.4 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.5 Errors carried forward

Any error in the answers to a structured question should be penalised once only. Papers should be constructed in such a way that the number of times errors can be carried forward are kept to a minimum. Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation 'ecf' in the marking scheme.

3.6 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term.

3.7 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.8 Accept/allow

Accept is used to indicate an equivalent answer to that given on the left-hand side of the mark scheme. Allow is used to denote lower-level responses that just gain credit.

3.9 Ignore/Insufficient/Do not allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain a marking point. Any further correct amplification could gain the marking point.
Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

4 Quality of Written Communication and levels marking

In Question 2 students are required to produce extended written material in English, and will be assessed on the quality of their written communication as well as the standard of the scientific response.

Students will be required to:
- use good English
- organise information clearly
- use specialist vocabulary where appropriate.

The following general criteria should be used to assign marks to a level:

Level 1: Basic

- Knowledge of basic information.
- Simple understanding.
- The answer is poorly organised, with almost no specialist terms and their use demonstrating a general lack of understanding of their meaning, little or no detail.
- The spelling, punctuation and grammar are very weak.

Level 2: Clear

- Knowledge of accurate information.
- Clear understanding.
- The answer has some structure and organisation, use of specialist terms has been attempted but not always accurately, some detail is given.
- There is reasonable accuracy in spelling, punctuation and grammar, although there may still be some errors.

Level 3: Detailed

- Knowledge of accurate information appropriately contextualised.
- Detailed understanding, supported by relevant evidence and examples.
- Answer is coherent and in an organised, logical sequence, containing a wide range of appropriate or relevant specialist terms used accurately.
- The answer shows almost faultless spelling, punctuation and grammar.

4.6.1.1 Calculating rates of reactions

Question	Answers	Extra information	Mark	AO / Spec. Ref.
1(a)(i)	a smooth curve through or close to all points except (30,12)		1	AO2 2.4
1(a)(ii)	correct reading from the curve in 1(a)(i) (cm^3)	allow a tolerance of +/- 0.5 cm^3	1	AO2 2.4
1(a)(iii)	45-50 (seconds)		1	AO3 2.4
1(a)(iv)	line becomes less steep because gas is produced more slowly	ignore line levels out or plateaus allow examples with figures, eg 12 cm^3 gas from 0 to 20s but 1.5 cm^3 gas in last 20s ignore reaction has stopped or no more gas produced	1 1	AO3 2.4
1(a)(v)	0.6 (cm^3 per second)	allow 0.55 to 0.65	1	AO2 2.4
1(b)(i)	 temperature volume (of hydrogen peroxide)	concentration of hydrogen peroxide = max **1** ignore amount (of hydrogen peroxide)	 1 1	AO3 2.4
1(b)(ii)	 rate increases because more particles (in the same volume) so frequency of collisions increases	incorrect reference to energy = max **2** accept particles closer together allow greater chance of collisions ignore more collisions	 1 1 1	AO1 2.4.1e

4.6.1.1 Calculating rates of reactions

1(c)	(increasing the amount of catalyst) increases rate same final volume of gas	accept steeper graph or graph levels off earlier	1 1	**AO2** 2.4.1g
Total			**13**	

4.6.1.1 Calculating rates of reactions

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>2</td><td></td><td></td><td>6</td><td rowspan="6">AO1
2.1.1h
2.2.4b,c
2.2.5a,b</td></tr>
<tr><td colspan="4">Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a ‘best-fit’ approach to the marking.</td></tr>
<tr><td colspan="4"><table>
<tr><th>0 marks</th><th>Level 1
(1–2 marks)</th><th>Level 2
(3–4 marks)</th><th>Level 3
(5–6 marks)</th></tr>
<tr><td>no relevant information given</td><td>a statement about the structure or a property of a metal
or
a statement about the structure or a property of a polymer</td><td>a statement about the structure or a property of a metal
and
a statement about the structure or a property of a polymer</td><td>a statement about the structure or a property of a metal
and
a statement about the structure or a property of a polymer
and
at least one statement linking structure and property</td></tr>
</table></td></tr>
<tr><td colspan="4">Statements shown as HT only are credited on both FT and HT.
However, HT only means that these statements are not expected in a FT answer.</td></tr>
<tr><td colspan="4">Examples of chemistry points made in response

Metal:

Properties
shiny
hardness
(tensile) strength
melting point/boiling point
density
malleable/flexible
ductile
conduct electricity or thermal energy</td></tr>
</table>

Structure • metals contain atoms /((positive) ions HT only) • (the atoms/(positive) ions/particles are) closely packed / in a regular pattern / in a giant structure/in layers / in a lattice • strong bonds/(electrostatic attractions HT only) • (metal has delocalised electrons HT only) **Polymer:** **Properties** • flexible • melting/boiling point • density • can be shaped/moulded • poor conductor of electricity or thermal energy **Structure** • polymer consists of chains • polymer chains may be tangled • polymer has no cross links. • (polymer has weak intermolecular forces HT only) **Level 3:** **Examples of linked statements:** • metal can be bent and shaped because the layers can slide • some metals are soft because layers can slide • some metals are hard because they have strong bonds and/ or (the atoms/(positive) ions/particles) are closely packed / in a regular pattern / in a giant structure/ in a lattice • metal has high melting/boiling point because they have strong bonds and/ or (the atoms/(positive) ions/particles) are closely packed / in a regular pattern / in a giant structure / in a lattice • metal is strong because of strong bonds • some metals are dense because the atoms are closely packed • (metal can conduct thermal energy and electricity because metal has delocalised electrons HT only) • thermosoftening polymer melts when heated because it has no cross-links (or has weak intermolecular forces HT only) • thermosoftening polymer is flexible because the chains can move over each other	

Total			**6**

4.6.1.1 Calculating rates of reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
3(a)(i)	2 bonding pairs 4 unbonded electrons on each atom	accept dots, crosses, e, - or any combination ignore any electrons on any inner shells if no other mark awarded allow **1** mark for 1 bonding pair and 6 unbonded electrons on each atom	1 1	**AO2** 2.1.1g
3(a)(ii)	covalent	allow convalent and covelant ignore single or double ignore shared, shared bond or sharing	1	**AO1** 2.1.1g
3(a)(iii)	weak intermolecular forces require little energy to overcome	reference to weak covalent or weak ionic bonds = **0** accept weak intermolecular bonds MP2 dependent on MP1 if no other mark awarded allow 1 mark for simple/small molecules	1 1	**AO1** **AO2** 2.2.1a,b

4.6.1.1 Calculating rates of reactions

3(b)(i)	**2** Mg + O_2 → **2** MgO	accept multiples	1	**AO2** 2.2.2
3(b)(ii)		reference to incorrect particles **or** incorrect bonding **or** incorrect structure = max **2**		**AO1** **AO2** 2.1.1a,b,c,f
	magnesium loses (electrons) **and** oxygen gains (electrons)		1	
	two (electrons transferred)		1	
	noble gas structure **or** 8 electrons in outer shells **or** (electrostatic) attraction between ions **or** forms ionic bonds	accept full outer shell (of electrons)	1	
3(b)(iii)	particles 1-100 nm in size	accept contain a few hundred atoms/ions accept have a high surface area to volume ratio ignore reference to (very) small particles do **not** accept smaller than an atom/ion	1	**AO1** 2.2.6a

4.6.1.1 Calculating rates of reactions

3(c)	has a high melting point	allow will not melt allow a lot of energy needed to melt ignore boiling point reference to incorrect particles or incorrect bonding or incorrect structure = max **1** from MP2 and MP3	1	**AO1** **AO2** 2.2.3a
	because all atoms linked to other atoms	allow giant structure/lattice ignore many bonds	1	
	by covalent bonds	allow strong bonds allow a lot of energy needed to break bonds accept giant covalent structure for MP2 and MP3	1	
Total			**13**	

4.6.1.1 Calculating rates of reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
4(a)	add copper oxide and (sulfuric) acid		1	**AO1** **AO2** 2.6.1b,c
	excess (copper oxide)		1	
	filter (to remove excess)	ignore impurities	1	
	heat /boil / evaporate / leave (to crystallise)	do **not** accept to dryness	1	
4(b)	(M_r CuO =) 79.5		1	**AO2** 2.3.3c
	24.95/249.5 **or** 0.1 **OR** 79.5/249.5 **or** 0.3186…	allow ecf for M_r CuO from step 1 allow correct rounding to min 2SF	1	
	(24.95/249.5 x 79.5=) 7.95	allow ecf for M_r CuO from step 1 allow ecf from step 2 of incorrect calculation/ rounding of correct ratio allow correct rounding to min 2SF correct answer with or without working gains 3 marks	1	
4(c)(i)	as wealth decreases, ethene production decreases (with the exception of country C or D)	accept converse	1	**AO2** **AO3** 2.6
	sulfuric acid production is not linked to wealth		1	

4.6.1.1 Calculating rates of reactions

4(c)(ii)	use of products of ethene has increased	allow use of polymers / plastics / ethanol / poly(ethene) has increased ignore use of ethene as a (bio)fuel ignore cost	1	**AO3** 2.2.5
Total			**10**	

4.6.1.1 Calculating rates of reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
5(a)(i)	draw line on paper put (dots of) inks on line place (bottom of) paper in solvent / water any **one** from: line drawn in pencil allow dots of ink to dry line above solvent lid		1 1 1 1	**AO1** 2.3.2b
5(a)(ii)	any **two** from: • A has 3 colours **and** B has 4 colours • 2 colours are the same • **A** has 1 colour not in **B and B** has 2 colours not in **A**	accept 3 colours are different if no other mark awarded allow **one** more colour in ink **B** than in ink **A** (or converse)	2	**AO3** 2.3.2b
5(b)(i)	substances carried by gas through column / tube / coil (packed with solid) (different substances move through the column) at different speeds	 accept (different) substances come out at different times or have different retention times	1 1 1	**AO1** 2.3.2c
5(b)(ii)	(relative) molecular mass	allow (relative) formula mass allow RFM, RMM, M_r	1	**AO1** 2.3.2c
Total			**10**	

4.6.1.1 Calculating rates of reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
6(a)(i)	tick (✓) by: the initial temperature reading was too low		1	**AO3** 2.5
6(a)(ii)	the reaction is exothermic	allow energy is given out	1	**AO3** 2.5.1b
6(b)(i)	(positive/hydrogen) ions gain electrons hydrogen is below sodium in the reactivity series so hydrogen / H_2 is produced	accept (positive/hydrogen) ions are reduced accept reference to high reactivity of sodium If no other mark awarded allow hydrogen (and sodium) ions **or** positive ions are attracted to negative electrode for **1** mark	1 1 1	**AO1** **AO2** 2.7.1c,f,i
6(b)(ii)	**2** (Cl^-) → **Cl_2 + 2e^-**	must be completely correct allow multiples	1	**AO1** 2.7.1g
6(b)(iii)	solution is alkaline because sodium hydroxide / NaOH is produced **or** sodium hydroxide / NaOH is left over	accept hydroxide (ions) / OH^- is produced **or** hydroxide (ions) / OH^- is left over	1 1	**AO1** **AO2** 2.7.1i; 2.6.2d
Total			**8**	

Answer 13 · Examiner comments

June 2018 | 8462/2H | Original Q8

Question 8 (standard / high & high demand)

08.1 Most students recognised that a gas is given off by the reaction. Sometimes it was incorrectly identified as hydrogen.

The 'escape' mark was less commonly awarded either because the students thought it was sufficient to state that a gas is given off or because they thought that the gas 'evaporated'.

43% of students achieved full marks.

08.2 The points on the graph were almost invariably correctly drawn within tolerance. Most found the question easy although there were a significant number who omitted the point at 0,0.

The line of best fit was problematic for a number of students. A significant number assumed that the line of best fit was a straight line rather than a curve. Other students were penalised for 'double lines' or not extending the curve over the whole range of points.

83% of students were able to achieve at least two marks here.

08.3 A significant number of students did not draw a tangent at 0.95 g but used 0.95 g to calculate the **mean** rate over the first 0.95 g lost. Such students were able to score the third and fourth marking points. A small number of students drew the tangent in the wrong place choosing the other number (50) quoted in the question.

Some students had difficulty with the scales on the graph either by:

- forgetting that the *y*-axis intervals were 0.1 and calculating the difference as a whole number rather than the actual difference eg 18 rather than 0.18
- counting the number of squares on the *y*-axis or the *x*-axis eg 1.00 − 0.8 = 10 (squares) rather than 0.2

Many students were able to state that the gradient of the tangent is calculated by the *y* value divided by the *x* value and calculate a value correctly. But some students neglected to quote their answer to two significant figures. 25% of students achieved full marks.

Answer 14 · Examiner comments

June 2018 | 8462/2H | Original Q9

Question 9 (standard, standard / high & high demand)

09.1 88% of students could identify an enzyme as a (biological) catalyst.

09.2 64% of students could use the equation to work out that 2.0×10^3 moles of carbon monoxide would react.

09.3 The endothermic nature of the backwards reaction was often identified as the reason the equilibrium position moved to the left; however many made no comment about the yield of methanol. Many students thought there would be a higher yield. 39% of students achieved both marks.

09.4 While many students did well, there were many others who demonstrated partial knowledge or who did not express themselves clearly. Many thought that an increase in pressure caused an increased yield of methanol because it was an exothermic reaction, rather than because the equilibrium moved to the position of fewer moles / molecules / particles.

The increased rate of reaction was better understood; students usually gave some indication that the particles are closer or there are **more particles** in a **fixed** volume or there are the **same number of particles** in a **smaller** volume. Simply saying there were more particles was insufficient.

In addition, students needed to link collisions **and** time to gain credit, usually by saying that the particles collide more often or there are more frequent collisions. Simply saying **more collisions** alone was insufficient. The idea that an increase in pressure supplied energy (and therefore increased the speed of the particles) was discounted.

73% of students were able to achieve some credit, with 12% of students achieving full marks.

09.5 Higher-attaining students achieved both marks for stating that catalysts reduce the activation energy by providing an alternative route or pathway, though the second point was less well known than the first. Sometimes one or other of these points was omitted. A popular incorrect idea was that catalysts supply energy.

09.6 47% of students knew that catalysts reduce costs, save energy or allow lower temperatures to be used. Others just mentioned that catalysts can be reused or that they speed up the reaction.

09.7 The effect of a catalyst on the equilibrium yield of methanol was not well understood. It was widely thought that a catalyst increased the yield of methanol because the reaction was faster and would, therefore, produce more of the product. 24% of students answered correctly.

4.6.1.1 Calculating rates of reactions

Answer 17 · Examiner comments November 2020 | 8462/2H | Original Q8

Question 8 (standard and standard / high demand)

08.1 The point that was most frequently plotted incorrectly was the final one (180, 0.0040). A number of students failed to plot (0,0). There were some examples of rulers being used to to complete lines of best fit, with a number of straight lines seen. Some students produced excessively thick or 'feathered' lines. However, the majority of students were able to score at least two marks.

08.2 If either of the mole values were incorrectly determined from the graph, it was still possible to gain credit for using these values correctly. Some attempted to determine the instantaneous rate at a particular time by drawing a tangent to the curve. Units were sometimes written imprecisely e.g. moles per s, and some wrote 'm/s'. Many students were able to score at least two marks.

08.3 This part was quite well answered by many. Most students preferred to answer in terms of line steepness rather than time and moles collected.

08.4 This item was quite well answered by many students. The most common error was to fail to multiply the area of one face by six.

08.5 Only a very few students scored here, with many just responding 'smaller' rather than stating by what factor it was smaller. A few assumed that because the cube was larger, so too was the surface area : volume ratio. Only a tiny number of students gained a mark here.

Answer 18 · Examiner comments November 2021 | 8462/2H | Original Q9

Question 9 (standard, standard / high and high demand)

09.1 Only around a third of students knew this, which may reflect a lack of practical experience.

09.2 Many students were able to say that the reaction had stopped but only a much smaller number could explain why.

09.3 Around half of the students were able to explain this in a valid way, usually by reference to the slope of the line.

09.4 There was a wide spread of marks here. There is still confusion between mean and instantaneous rate of reaction, so students who approached this as a mean reaction rate usually only scored one mark for giving an answer to 2 significant figures. Amongst the better responses, the first mark was sometimes dropped because the tangent was not close enough to 80 seconds. Some students were able to obtain all 5 marks.

09.5 Around one-third of students identified copper(II) as the only transition metal amongst the choices and therefore more likely to have a catalytic effect.

4.6.1.1 Calculating rates of reactions

Answer 19 · Examiner comments

June 2022 | 8462/2H | Original Q7

Question 7 (Standard, standard/high and high demand)

07.1 This was well answered with around half of the students scoring both marks. Incorrect responses included the atmosphere being a source of the hydrogen as well as the nitrogen. There were far fewer responses stating that biogas of any kind was suitable for the large-scale production of ammonia than in previous years.

07.2 About 25% of the students scored this mark. 'No by-products' was seen quite often and others stated there were the same number of atoms on both sides, which just means that the equation is balanced, not necessarily that there is only 1 product.

07.3 Roughly 1 in 10 students gained both marks. Many scored the second mark, but far fewer the first. This was often due to imprecise language rather than misunderstanding, but many stated that 'ammonia is cooled'. The distinction between **all** the gases being cooled but only ammonia condensing is important. A large proportion did not mention cooling at all. Some negated the second mark by stating that ammonia has a lower boiling point than the other two gases.

4.6.1.1 Calculating rates of reactions

Answer 19 · Examiner comments June 2022 | 8462/2H | Original Q7

07.4 Labelling the scale and the plotting of the given points was nearly always correct. Some did not label on the major gridlines, while a few got the scale completely wrong by labelling the major gridlines in multiples of 60 atmospheres, which did not match the pre-plotted points and therefore denied access to the plotting marks. Most students drew good best-fit curves, although some inappropriately drew a straight line. Over half of the students gained all four marks.

07.5 Most students extrapolated their line correctly and read off the value of the percentage at 500 atmospheres. About two-thirds of the students scored both marks.

07.6 This high demand extended response question gave students the opportunity to demonstrate their knowledge of collision theory, Le Chatelier's Principle and catalytic action in the context of the Haber Process.

More able students seemed to understand that they needed to consider cost implications. Explaining that a compromise is made in the choice of the temperature and the pressure was important in accessing Level 3.

The compromises made for temperature and pressure that were related to cost were more commonly stated than the compromise for temperature in relation to rate and position of equilibrium.

There was a high proportion of responses with additional material producing comprehensive, high-scoring responses. There were also a good number of weaker responses containing isolated statements, most commonly relating the conditions to rate, or more rarely position of equilibrium, but without explaining these relationships. Such responses were usually confined to Level 1. The ratio of Level 1:2:3 marks was roughly 40:20:20 with the remainder failing to gain any marks on this question.

4.6.1.1 Calculating rates of reactions

Answer 20 · Examiner comments

June 2022 | 8462/2H | Original Q8

Question 8 (Standard, standard/high and high demand)

08.1 The majority of the students recognised that the solution became cloudy due to one of the products being a precipitate / solid.

08.2 The large majority of the students were able to draw a tangent at 30 seconds.
The construction lines used to determine the values of Δ*y* and Δ*x* were less well done.
Some students appeared to have difficulty reading the scales on each of the axes.

Students should be aware that using very small portions of the graph for this type of calculation (and also in the ratio calculation in **08.9**) potentially limits the accuracy of their final answer.

Most students who determined the values of Δ*y* and Δ*x* went on to determine the correct ratio. The better responses then continued to use the ratio to determine the rate in mol/s. One-fifth of the students gained all five marks, whilst over half scored four, most often as a result of not using the factor 7.1×10^{-5} correctly.

4.6.1.1 Calculating rates of reactions

Answer 20 · Examiner comments June 2022 | 8462/2H | Original Q8

08.3 Most students recognised that the rate of reaction decreased as the reaction proceeded but a significant proportion of these students did not gain the second mark because they referred to the concentration of unspecified substances rather than stating that the concentration of the reactants decreases. Nearly one-third of students gained both of these marks.

08.4 Some students made an insufficient general statement about reactants being used up. However a larger number mentioned the acid being used up. Few used the term limiting reactant. Over a third of students gained this mark.

08.5 Just over a third of students scored two marks on this question, understanding the meaning of a sketch graph. Others realised the gradient needed to be steeper for the sketch but did not level the line at 24%.

A sizeable minority had the sketch with a shallower gradient. Such a sketch seldom levelled out at 24%.

08.6 More than 80% of the students were able to identify the required improvement.

08.7 Just under half of the students gained the mark for this multiple choice question. Reproducible was a very common incorrect response.

08.8 Around 70% of the students were able to identify the expression representing the relationship between volume and mass.

08.9 Around half of the students gained all three marks. Students were usually able to find the smallest whole number ratio once they had determined the volumes. Students often did not indicate on the graph where the volumes were from, but this was not an actual requirement, just an aid to answering the question. Many chose the limits of the lines, i.e. 120 and 480 cm^3 respectively.

Students should be aware that using very small portions of the graph for this type of calculation (and also in the rate calculation in **08.2**) potentially reduces the accuracy of their final answer. Many answers of 6:25 were seen and awarded credit because the error in reading the graph values was within half a small square.

Some students used two masses of sulfur rather than the volumes of each reactant and therefore did not gain any marks.

4.6.1.1 Calculating rates of reactions

Answer 20 · Examiner comments

June 2022 | 8462/2H | Original Q8

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account of 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.

4.6.1.1 Calculating rates of reactions

Answer 21 · Examiner comments June 2023 | 8462/2H | Original Q1

Question 1 (standard demand)

01.1 Fewer than a quarter of students scored a mark here, with most suggesting incorrectly that no gas at all would escape. The idea of minimising escape was key to gaining the mark.

01.2 The vast majority of students used the main approach on the mark scheme. Around three-quarters of students scored all the marks. Of those who didn't, the majority scored 4 marks by failing to discard the anomalous result in MP1. Weaker responses typically calculated the mean rate of 0.80 cm^3/s but were able to take the process further and gained two marks.

01.3 This closed question was answered completely correctly by two-thirds of students, whilst more than 80% scored one mark. Of these, there was usually a conflict between a factor which would speed the reaction up and one which would slow it down.

01.4 Around three-quarters of the students gained both marks. Uncreditworthy responses usually included the squeaky pop test as a description of the test without reference to flames or burning splints, or described the use of a glowing splint.

Answer 22 · Examiner comments June 2023 | 8462/2H | Original Q7

Question 7 (standard, standard / high and high demand)

07.1 The effect of a catalyst on the rate of a reaction was generally well known. Most correct answers referred to the lowering of the activation energy. Many students also referred to the catalyst providing a different pathway for the reaction. References to changes in the number of collisions were insufficient as they did not answer the question. Over one-third of responses gained two marks, and around two-thirds of responses gained one mark.

07.2 Many responses correctly referred to a gas being produced in the reaction. However, as oxygen was given as a product in the stem of the question, if another gas, such as hydrogen or carbon dioxide, was referred to, then the first mark was not awarded.
'The gas was released' was not sufficient for the second marking point but 'being released into the air' or 'released into the surroundings' gained credit. The idea that a gas evaporates from the flask negated the idea of escape in marking point two. Nearly half of the students gained both marks.

07.3 Many students correctly used the tangent to the line drawn in the question to calculate the rate of reaction at 75 seconds.

If the tangent was not used then only MP4 was available for a correct rounding of data obtained correctly from the graph to 2 significant figures. This commonly involved the use of the student reading the y-axis value from a vertical line at 75 seconds.

For the first mark there had to be clear evidence from the graph or data put into the equation, that values for *x* and *y* were chosen from the graph. Some students counted the squares in the *y* and *x* axes and did not score MP1 but the remaining marks were still accessible.

4.6.1.1 Calculating rates of reactions

Answer 22 · Examiner comments June 2023 | 8462/2H | Original Q7

A small number of students added extra calculation steps after evaluating values in an equation. This often meant the second and third marking points were contradicted and therefore those marks could not be awarded.

If *x* and *y* values were awarded but the equation was inverted, only MP1 and MP4 were available.

Over half the students scored all four marks.

07.4 The award of both marks for this question was not often seen. The idea of a line that was less steep than the line given was often credited. However, the second marking point was not awarded on many occasions as the line sketched by the student did not level off at 0.80 g. The link between the only difference between the experiments being a halving of the concentration of hydrogen peroxide solution as the only reactant using a manganese dioxide catalyst was not recognised, resulting in a variety of incorrect responses. The most common answer was for the sketch line to finish at 1.60 g. Around 25% of students scored both marks.

4.6.1.1 Calculating rates of reactions

Answer 23 · Examiner comments

June 2024 | 8462/2H | Original Q9

Question 9 (standard, standard / high and high demand)

09.1 The idea that gas is lost was well understood but the reason why was less well known. Incorrect responses referred to the solubility of hydrogen in water and faulty apparatus. Around 15% of students gained both marks.

09.2 This question was awarded all four marks to around 20% of the students but a significant number of students did not recognise that the volume of the gas should be converted into dm^3. A small number of students believed that 1 cm^3 = 1000 dm^3 resulting in an answer 10^6 times too large.

09.3 Most students were able to construct a tangent at 45 s. The scale on the *y*-axis posed a problem for a significant number of the students. The calculation of the rate was well done, and most were able to convert their answer into standard form. A small number calculated the mean rate between 0 s and 45 s by drawing a single pair of construction lines which met the curve. Such students were only able to gain a mark for an answer correctly expressed in standard form. Just over half of the students scored five marks.

09.4 The vast majority of the students recognised that the curve started at 0,0 and rose less steeply than the curve shown, but only a minority were able to show that the curve levelled off at 0.0084 mol. Some students lost the first mark by shadowing the existing line for a significant time before becoming less steep. While around 20% of students scored both marks, more than four-fifths scored one.

09.5 This question was quite well done by a large proportion of the students, with nearly half of the students gaining all three marks. The idea that an increase in temperature increased the energy of the particles and therefore increased the rate of reaction was well understood by most students but the increase in collision frequency was less well known. A significant proportion of the students simply stated that there is an increase in the number of collisions with no reference

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to time. A ‘successful’ collision was considered insufficient to describe particles whose energy of collision exceeded the activation energy.

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4.6.1.1 Calculating rates of reactions

Answer 23 · Examiner comments

June 2024 | 8462/2H | Original Q9

Mark Ranges and Award of Grades

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

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4.6.1.1 Calculating rates of reactions

Answer 24 · Examiner comments — June 2025 | 8462/2H | Original Q8

Question 8

08.1 Three quarters of students described correctly how gas escaped from the flask to cause the decrease in mass, however, students did not always say that the gas was a product of the reaction which was marking point 1. A few students incorrectly said that the gas evaporated, which was not accepted.

08.2 Three quarters of students described how catalysts provide an alternative pathway for the reaction. A description of a shorter pathway is not equivalent to an

Answer 24 · Examiner comments — June 2025 | 8462/2H | Original Q8

alternative pathway. Marking points 2 and 3 needed comparative statements between catalyst A and B. Some students just described in general how catalysts lower activation energy. This was not enough for these two marking points. Students needed to say the activation energy was lower using B. Saying catalyst B requires a lower activation energy was also not accepted, because a catalyst provides or allows a lower activation energy rather than requiring or needing one.

08.3 This style of question is becoming more familiar to students, with over 4 in 5 gaining at least 2 marks, which would require the drawing of a tangent. Over half of all students went on to correctly calculate the rate and give the answer in standard form. Answers were often well set out showing clearly which graph points had been used to calculate the gradient. Students could successfully quote the number in standard form. There were still quite a few students who just read the value of mass and time from the graph. Without a tangent, students could only gain the mark for an answer given in standard form.

08.4 Over 40% of students gave good answers that scored full marks. Students are well versed in describing how particles have more energy at higher temperatures. The idea of particles colliding more frequently was still a stumbling block for some; some students forgetting to include the word frequently. Very few students used the idea of a greater chance of collision that is not equivalent to frequency, which is a positive sign.