AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.6.2.6

The effect of temperature changes on equilibrium (HT only)

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**6**
Available paper years	**2018–2025**

Using this booklet

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

Name: _____ **Date:** _____

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

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 01 · 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**	

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 02 · 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**	

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 03 · 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

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

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**	

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

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

Answer 04 · Mark scheme

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

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 05 · Mark scheme

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

Question 5

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

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

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

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

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

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 05 · Mark scheme

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

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

Total Question 5	13

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 06 · Mark scheme

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

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

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		

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 06 · Mark scheme

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**

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 01 · Examiner comments

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

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.

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 01 · 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.

Answer 03 · 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.

5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 03 · Examiner comments

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Mark Ranges and Award of Grades

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5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 04 · 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.

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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 05 · Examiner comments

Question 5 (standard/high & high demand)

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

05.2 Half of students identified the correct equilibrium shift.

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

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

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

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

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

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

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

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

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5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 05 · Examiner comments

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

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

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

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

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

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

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

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

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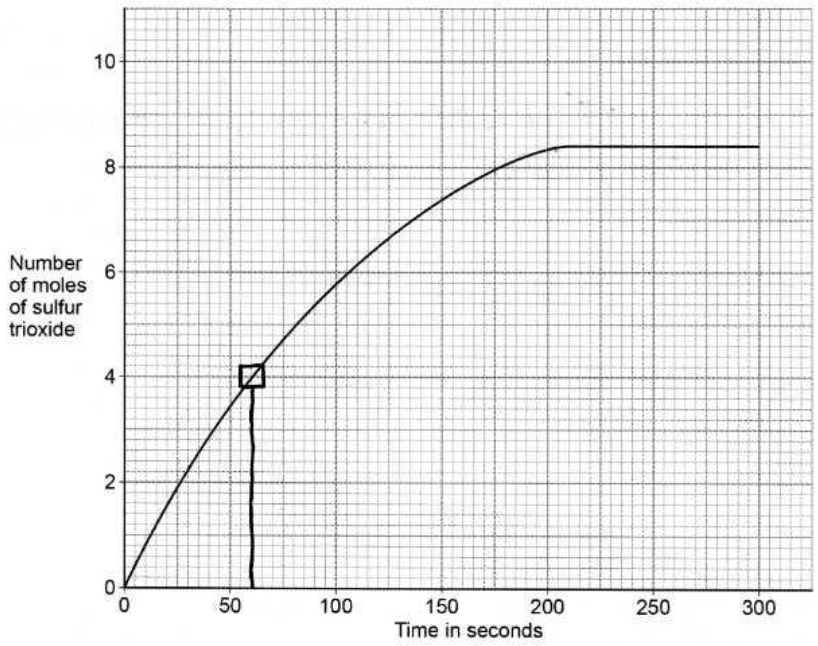
5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 05 · 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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5.6.2.6 The effect of temperature changes on equilibrium (HT only)

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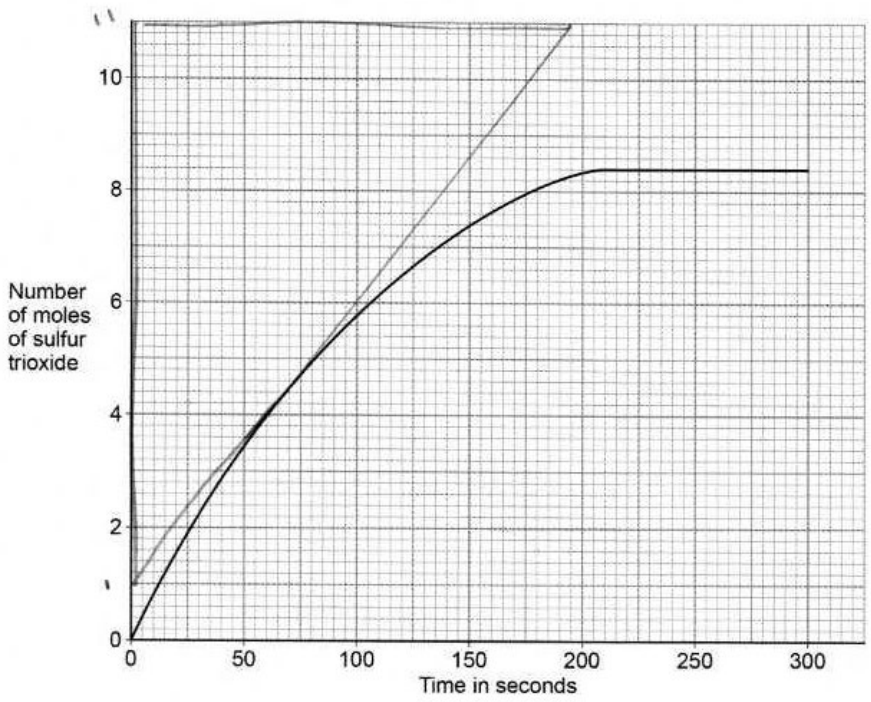
The most common errors were misreading the *x*-step and/or the *y*-step. Progress could still be made in the calculation if it was clear that the values had come from a tangent and had been used correctly. Substitution into the equation upside down meant that neither marking point 3 nor marking point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

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

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

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

195 − 0 = 195

Rate = 0.051282 mol/s

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

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5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 06 · Examiner comments

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

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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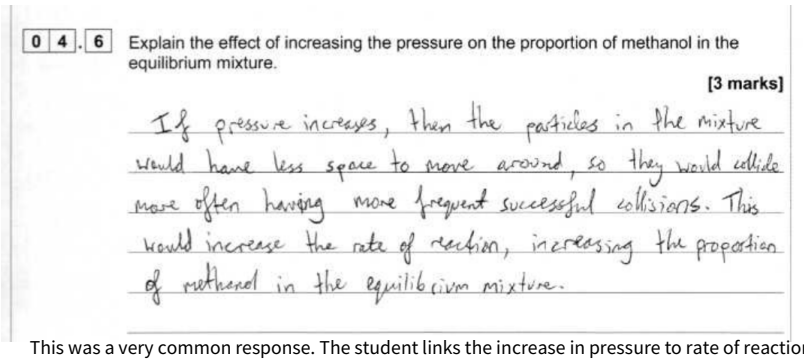
5.6.2.6 The effect of temperature changes on equilibrium (HT only)

Answer 06 · 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.