Kinetics Answers

Question	Marking Guidance	Mark	Comments
2(a)(i)	**M1** The peak of the new curve is displaced to the right. **M2** **All of the following** are required • The new curve starts at the origin • The peak of the new curve is lower than the original • and the new curve only crosses the original curve once • and an attempt has been made to draw the new curve correctly towards the energy axis but not to touch the original curve • the new curve must not start to diverge from the original curve	2	M1 is low demand M2 is higher demand.
2(a)(ii)	**M1** Increase in the number / proportion of molecules with $E \geq E_a$ OR more molecules have $E \geq E_a$ OR more molecules have sufficient energy to react **M2** More effective / productive / successful collisions	2	Ignore "molecules have more energy" Ignore "more energetic collisions" Ignore "molecules gain activation energy" Ignore "more collisions" Accept "particles" for "molecules" but NOT "atoms" Ignore "chance of collision"; this alone does not gain M2
2(b)(i)	Iron ***OR*** Fe	1	

2(b)(ii)	**M1** Catalysts provide an alternative route / pathway / mechanism ***OR*** (in this case) <u>surface adsorption / surface reaction</u> occurs. **M2** that has a <u>lower activation energy</u> ***OR*** <u>lowers the activation energy</u>	2	For M1, not simply "provides a surface" alone For M2, the candidate may use a definition of activation energy without referring to the term

Question	Marking Guidance	Mark	Comments
1(a)	**Award in either order for curve** **M1** curve is steeper than original and starts at the origin **M2** curve levels at the top line on the graph	2	"Steeper" requires line to be on the left of the original line, starting from the origin
1(b)	**Award in either order for curve** **M1** curve is shallower than original and starts at the origin **M2** curve levels at the first line on the graph	2	"Shallower" requires line to be on the right of the original line, starting from the origin
1(c)	**M1** curve would be steeper than original **M2** curve levels at the same original volume of O_2	2	"Steeper" requires line to be on the left of the original line, starting from the origin
1(d)	**M1** The (concentration / amount of) H_2O_2 or reactant falls / decreases / used up ***OR*** The number of H_2O_2 or reactant molecules/ particles falls / decreases **M2** The rate of reaction / rate of decomposition / rate of formation of oxygen / frequency of collisions / (effective) collisions in a given time decreases / is slower	2	Mark independently

1(e)(i)	**2**H_2O_2 ⟶ **2**H_2O + O_2	1	Ignore state symbols Accept only this equation or its multiples Extra species must be crossed through
1(e)(ii)	hydrogen bromide / it does not appear in the overall equation ***OR*** hydrogen bromide / it is not <u>used up</u> in the reaction / <u>unchanged at the end</u> of the reaction ***OR*** hydrogen bromide / it is regenerated / re-formed (in Step 2)	1	

Question	Marking Guidance	Mark	Comments
3(a)	Number / proportion / percentage / fraction of molecules	1	Ignore "particles"
3(b)	None ***OR*** no effect ***OR*** no change	1	
3(c)	**X**	1	
3(d)	**Answers in either order** **M1** collision ***OR*** collide **M2** collision / molecules / particles with the activation energy ***OR*** with $E \geq E_{act}$ ***OR*** with sufficient /enough energy ***OR*** with the minimum energy ***OR*** with the correct orientation	2	Mark independently Ignore "correct" amount of energy
3(e)	A small increase in temperature results in many more / much higher proportion of / a lot more / significantly more molecules / particles / collisions with $E \geq E_{act}$ / energy greater than the activation energy / sufficient energy / enough energy / minimum energy to react (compared with a small increase in concentration)	1	Not just "more molecules with $E \geq E_{act}$" The answer must convey that the increase is **significant** Accept reference to "atoms", molecules", "particles" Ignore "species"

Question	Marking Guidance	Mark	Comments
3(a)	**M1** On the energy axis E_{mp} at the maximum of the original peak **M2** The peak of their new curve is displaced to the left and higher than the original **M3 All of the following** are required • The new curve starts at the origin and should begin to separate from the original almost immediately • and the new curve crosses the original curve once • and an attempt has been made to draw the new curve correctly towards the energy axis below the original curve but not to touch the original curve or the axis	3	**M1** The limits for the horizontal position of E_{mp} are defined as above the word "the" in the sentence below the graph.
3(b)	**The rate of reaction decreases as the temperature decreases because** **M1** A decrease in the number / proportion of molecules with $E \geq E_a$ ***OR*** fewer molecules have $E \geq E_a$ ***OR*** fewer molecules have sufficient / enough energy to react / decompose **M2** Fewer effective / productive / successful collisions in a given time / given period ***OR*** fewer frequent effective / productive / successful collisions ***OR*** lower rate of effective / productive / successful collisions	2	**In M1** Ignore "molecules have less energy". Ignore "less energetic collisions". Ignore "molecules do not gain activation energy". Ignore "fewer collisions". Credit "particles" for "molecules" but NOT "atoms". Ignore "chance of collision"; this alone does not gain **M2**

Question	Marking Guidance	Mark	Comments
1(a)(i)	Change in concentration (of a substance / reactant / product) in unit time / given time / per (specified) unit of time ***OR*** Amount of substance formed / used up in unit time / given time / per (specified) unit of time	1	This may be written mathematically ***OR*** may refer to the gradient of a graph of concentration / volume against time Ignore additional information including reference to collisions
1(a)(ii)	At **W** **M1 (QoL)** The rate / it is zero **M2** The magnesium has all reacted / has been used up ***OR*** No more collisions possible between acid and Mg ***OR*** Reaction is complete / it has stopped ***OR*** No more hydrogen / product is produced	2	Ignore reference to the acid being used up

1(a)(iii)	**M1** Twice / double as many particles / hydrogen ions (in a given volume) ***OR*** Twice / double as much hydrochloric acid **M2** Twice / double as many effective / successful collisions (in a given time) ***OR*** Twice / double as many collisions with either sufficient energy to react ***OR*** with E ≥ Ea ***OR*** double the successful / effective collision frequency	2	Penalise reference to (hydrochloric acid) molecules in **M1** Penalise reference to "HCl particles" in **M1**
1(b)(i)	The activation energy is the minimum energy for a reaction to go / start ***OR*** Minimum energy for a successful/ effective collision	1	
1(b)(ii)	**M1** Products lower than reactants on the profile **M2** Activation energy (E_a) shown and labelled correctly from reactants to peak of curve	2	Mark independently

Question	Marking Guidance	Mark	Comments
2(a)	Amount / number / proportion / percentage / fraction / moles of molecules / particles	1	Penalise an incorrect qualification of the number eg NOT number of molecules with E greater than Ea Not 'atoms'.
2(b)	There are no molecules / particles with zero energy **OR** All of the molecules / particles are moving / have some energy	1	Not 'atoms'. The answer should relate the energy to the molecules.
2(c)	**C** (The most probable energy)	1	

2(d)	**M1** The peak of the new curve is displaced to the right and lower than the original **M2** All of the following needed • The new curve starts at the origin and should begin to separate from the original almost immediately • and the new curve only crosses the original curve once • and the total area under the new curve is approximately the same as the original • and an attempt has been made to draw the new curve correctly towards the axis above the original curve but not to touch the original curve	2	

2(e)	None / no effect / stays the same	1	

7(c)	**M1** q = m c ΔT ***OR*** q =150 × 4.18 × 8.0 **M2** = (±) 5016 (J) ***OR*** 5.016 (kJ) ***OR*** 5.02 (kJ) (also scores M1) **M3** This mark is for dividing correctly the number of kJ by the number of moles and arriving at a final answer in the range shown. Using 0.00450 mol therefore ΔH = **– 1115** (kJ mol^{-1}) ***OR*** **– 1114.6 to – 1120** (kJ mol^{-1}) **Range (+)1114.6 to (+)1120 gains 2 marks** **BUT – 1110 gains 3 marks and +1110 gains 2 marks** **AND – 1100 gains 3 marks and +1100 gains 2 marks**	3	Award full marks for correct answer In **M1**, do not penalise incorrect cases in the formula Penalise **M3** ONLY if correct numerical answer but sign is incorrect; **(+)1114.6 to (+)1120 gains 2 marks** Penalise **M2** for arithmetic error and mark on If ΔT = 281; score q = m c ΔT only If c = 4.81 (leads to 5772) penalise **M2** ONLY and mark on for **M3** = – 1283 Ignore incorrect units in **M2** If units are given in **M3** they must be either kJ or kJ mol^{-1} in this case

Question	Answers	Mark	Additional Comments/Guidance
5(a)(i)	curve drawn from origin with peak clearly lower and to right.	1	new curve crosses original once only, finishes above original and does **not** clearly curve up **IGNORE** relative areas
5(a)(ii)	(Relative areas under curves indicate) <u>many</u> (owtte) more molecules with E greater than or equal to Ea (at higher T) or reverse argument (large) increase in (number of) <u>successful</u> (owtte) <u>collisions per unit time</u>	1 1	**ALLOW** 'particles' **IGNORE** 'atoms' OR '<u>frequency</u> of successful <u>collisions</u>'
5(b)(i)	Yield increases more moles/molecules (of gas) on left/fewer on right/3 on left 1 on right <u>equilibrium shifts/moves</u> (to right) to reduce pressure/oppose higher pressure	1 1 1	Yield decreases/stays the same CE = 0 If not answered mark on No M3 if 'more moles on right' in M2 **IGNORE** 'favours' **NOT** just 'oppose the change' QoL means that M3 is only awarded if these ideas are clearly linked in one statement
5(b)(ii)	Higher T would increase rate but decrease yield/make less methanol **OR** Lower T decreases rate but increases yield; Chosen T is a compromise/balance (between rate and yield) owtte	1 1	If no mention of both rate **AND** (idea of) yield max 1
Total		**8**	

8(c)	Same volume/amount of $AgNO_3$(aq) added to same volume/amount/no. of drops of haloalkane (in beaker/flask) in each experiment	1	both volume references needed **IGNORE** inappropriate volumes
	same temp **OR** same [$AgNO_3$] each time	1	
	record time to measure sensible observation about the amount of AgCl ppt	1	e.g. first appearance of ppt / ppt obscures mark / reading on a colorimeter **IGNORE** colour of ppt **ALLOW** silver mirror **NOT** reference to same time if describing method based on timing how long (for ppt to form) **ALLOW** gravimetric method based on same time for each experiment
	Rate = amount/time **OR** proportional to 1/time **OR** reference to shorter time = higher rate/longer time = lower rate	1	**ALLOW** greater mass = higher rate if gravimetric method

Total		**17**	