

<b>M1.</b>	(a) (i) Z (1)	1
	(ii) Collisions (1) Cause some molecules to slow down or lose energy (1)	2
	(b) Curve starts at origin and is displaced to the right (1) Curve lower and does not touch energy axis (1)	2
	(c) (i) Only a small percentage/very few collisions have $E > E_a$ (1)	1
	(ii) Add a catalyst (1) Lowers $E_a$ (1) More collisions/molecules have energy $> E_a$ (1)	3

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<b>M2.</b>	(a) Peak lower	1
	and moved to right	1
	start at the origin and curve crosses once only	1
	(b) (i) (Rate of reaction) <u>increases</u>	1
	(At a higher temperature) <u>more molecules/particles</u>	1
	have the minimum energy needed to react/have activation energy/have successful collisions <i>Mark CE if incorrect effect given</i>	

- (ii) (Rate of reaction) increases 1  
 lowers activation energy 1  
 so that more molecules are able to react 1  
*Mark CE if incorrect effect given*

[9]

M3.C

[1]

M4.B

[1]

- M5.** (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
- M1 is low demand*  
*M2 is higher demand.*

(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

*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

(ii) **M1** Catalysts provide an alternative route/pathway/mechanism

**OR**

(in this case) surface adsorption/surface reaction occurs.

*For M1, not simply "provides a surface" alone*

**M2** that has a lower activation energy

**OR**

lowers the activation energy

*For M2, the candidate may use a definition of activation energy without referring to the term*

2

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**M6.** (a) **M1** The activation energy is the minimum / least / lowest energy

*Mark independently*

*Ignore "heat" and ignore "enthalpy"*

- M2** (energy) for a reaction to occur / to go / to start  
 OR (energy) for a successful / effective collision  
*Ignore "breaking the bonds"* 2
- (b) **M1** Catalysts provide an alternative route OR an alternative mechanism OR alternative / different path(way)  
**M2** Lowers the activation energy  
*Mark independently*  
*Ignore reference to "surface"* 2
- (c) (i) Stay(s) the same 1  
 (ii) Increases  
*Credit "increase" or "increased"* 1  
 (iii) Increases  
*Credit "increase" or "increased"* 1  
 (iv) Stay(s) the same 1
- (d) (i) **M1** yeast or zymase  
**M2** ethanol  
*Ignore "enzyme"*  
*In M2, ignore "alcohol" and ignore any formula* 2
- (ii) **M1** (Concentrated)  $\text{H}_3\text{PO}_4$  OR (Concentrated)  $\text{H}_2\text{SO}_4$   
**M2** butan-2-ol  
*Credit correct names*  
*Ignore "hydrogenphosphate or hydrogensulfate"*  
*Ignore "dilute" or "aq"*  
*Do not penalise absence of hyphens in name.*  
*In M2, ignore any formula* 2

**M7.(a)** Number / proportion / percentage / fraction of molecules

*Ignore "particles"*

1

(b) None **OR** no effect **OR** no change

1

(c) **X**

1

(d) **Answers in either order**

**M1** collision **OR** collide

*Mark independently*

**M2** collision / molecules / particles

*Ignore "correct" amount of energy*

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

(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)

*Not just "more molecules with  $E \geq E_{act}$ "*

*The answer must convey that the increase is **significant***

*Accept reference to "atoms", "molecules", "particles"*

**M8.(a)** Amount / number / proportion / percentage / fraction / moles of molecules / particles

*Penalise an incorrect qualification of the number eg NOT number of molecules with E greater than Ea.*

*Not 'atoms'.*

1

(b) There are no molecules / particles with zero energy

**OR**

All of the molecules / particles are moving / have some energy

*Not 'atoms'.*

*The answer should relate the energy to the molecules.*

1

(c) **C** (The most probable energy)

1

(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

(e) None / no effect / stays the same

1

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**M9.(a)** M1 On the energy axis  $E_{mp}$  at the maximum of the original peak

**M1** *The limits for the horizontal position of  $E_{mp}$  are defined as above the word “the” in the sentence below the graph.*

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

(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

**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”.*

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

*Ignore “chance of collision”; this alone does not gain M2*

2

[5]