M1. (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

[9]

M2. (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
Mark CE if incorrect effect given

Page 2

(ii)   (Rate of reaction) <u>increases</u>   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 <u>displaced to the right</u>.

M2   All of the following are required

•   The new curve starts at the origin

•   The peak of the new curve is <u>lower</u> than the original

•   <u>and</u> the new curve only crosses the original curve <u>once</u>

•   <u>and</u> 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.

2

(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

[7]

M6. (a) **M1** The activation energy is the minimum / least / lowest energy
Mark independently
Ignore "heat" and ignore "enthalpy"

M2 (energy) <u>for a reaction</u> to occur / to go / to start

OR (energy) for a <u>successful / effective collision</u>
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 <u>ethanol</u>
Ignore "enzyme"
In M2, ignore "alcohol" and ignore any formula

2

(ii)   **M1** (Concentrated) H_3PO_4 OR (Concentrated) H_2SO_4

M2 <u>butan-2-ol</u>
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

[12]

M7.(a)   <u>Number / proportion / percentage / fraction</u> of <u>molecules</u>
   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 <u>activation</u> energy

   OR with $E \geq E_{act}$

   OR with <u>sufficient /enough</u> energy

   OR with the <u>minimum</u> energy

   OR with the correct orientation

   2

(e)   A small increase in temperature results in <u>many more / much higher proportion of / a lot more / significantly more</u> <u>molecules / particles / collisions</u> with <u>$E \geq E_{act}$/ energy greater than the activation energy / sufficient energy / enough energy / minimum energy to react</u>
   (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"

Ignore "species"

1

[6]

M8.(a) <u>Amount / number / proportion / percentage / fraction / moles</u> of <u>molecules / particles</u>

*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 <u>displaced to the right</u> and <u>lower</u> 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

• <u>and</u> the new curve only crosses the original curve once

• <u>and</u> the total area under the new curve is <u>approximately</u> the same as the original

• <u>and</u> an attempt has been made to draw the new curve correctly towards the axis <u>above the original curve</u> but not to touch the original curve

2

(e)   None / no effect / stays the same

1

[6]

M9.(a)   M1 On the <u>energy axis</u> E_{mp} at the maximum of <u>the original peak</u>

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 <u>displaced to the left</u> and <u>higher</u> 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

•   <u>and</u> the new curve crosses the original curve <u>once</u>

•   <u>and</u> an attempt has been made to draw the new curve correctly towards the energy axis <u>below the original curve</u> but not to touch the original curve or the axis

3

(b)   **The rate of reaction decreases as the temperature decreases because**

M1   <u>A decrease</u> in the <u>number</u> / <u>proportion</u> of <u>molecules</u> <u>with $E \geq E_a$</u>
OR <u>fewer molecules have $E \geq E_a$</u>
OR <u>fewer molecules have sufficient / enough energy to react /</u>
<u>decompose</u>

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   <u>Fewer effective / productive / successful collisions in a given time / given</u>
<u>period</u>
OR <u>fewer frequent effective / productive / successful collisions</u>
OR <u>lower rate of effective / productive / successful collisions</u>

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

2

[5]