

Mark schemes

1

- (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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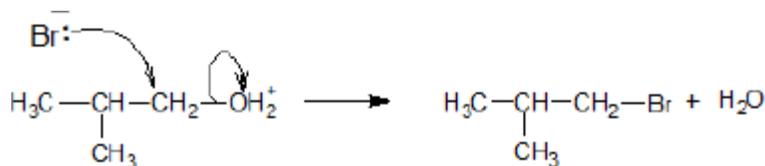
2

- (a) (i) **M1** double-headed curly arrow from the lone pair of the bromide ion to the C atom of the CH₂

Penalise additional arrows.

M2 double-headed arrow from the bond to the O atom

As follows



2

(ii) **M1** nucleophilic substitution
M1 both words needed (allow phonetic spelling).

M2 1-bromo(-2-)methylpropane
M2 Require correct spelling in the name but ignore any hyphens or commas.

2

(b) **M1** hydrolysis
For M1 give credit for 'hydration' on this occasion only.

M2 C≡N with absorption range 2220–2260 (cm⁻¹)
Credit 1 mark from M2 and M3 for identifying C≡N and either O–H(acids) or C=O or C–O without reference to wavenumbers or with incorrect wavenumbers.

M3 O–H(acids) with absorption range 2500–3000 (cm⁻¹)

OR

C=O with absorption range 1680–1750 (cm⁻¹)

OR

C–O with absorption range 1000–1300 (cm⁻¹)

Apply the list principle to M3

3

(c) (i) **M1** Yield / product **OR** ester increases / goes up / gets more

M2 (By Le Chatelier's principle) the position of equilibrium is driven / shifts / moves to the right / L to R / in the forward direction / to the product(s)

M3 – requires a correct statement in M2

(The position of equilibrium moves)

to oppose the increased concentration of ethanol

to oppose the increased moles of ethanol

to lower the concentration of ethanol

to oppose the change and decrease the ethanol

If no reference to M1, marks M2 and M3 can still score BUT if M1 is incorrect CE=0

If there is reference to 'pressure' award M1 ONLY.

3

(ii) **M1**

Catalysts provide an alternative route / pathway / mechanism

OR

surface adsorption / surface reaction occurs

For M1, not simply 'provides a surface' as the only statement.

M1 may be scored by reference to a specific example.

M2

that has a lower / reduced activation energy

OR

lowers / reduces the activation energy

Penalise M2 for reference to an increase in the energy of the molecules.

For M2, the student may use a definition of activation energy without referring to the term.

Reference to an increase in successful collisions in unit time alone is not sufficient for M2 since it does not explain why this has occurred.

2

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3

(a) (Measure the) volume of gas / mass of the container + contents

1

Suitable named piece of equipment

Gas syringe (or inverted burette or measuring cylinder, as long as student has referred to the cylinder being filled with water) / balance.

Equipment must be correct for the measurement stated.

1

(b) Any **one** of:

- Mass of magnesium
Allow amount of magnesium.
- Surface area of magnesium

1

(c) (i) Gravity: Conical flask or beaker and funnel /

Vacuum: Sealed container with a side arm and Buchner or Hirsch funnel

Must be either gravity filtration (with a V-shaped funnel) or vacuum filtration (with a side-arm conical flask) appropriately drawn.

1

Filter paper

Must show filter paper as at least two sides of a triangle (V-shaped) for gravity filtration or horizontal filter paper for vacuum filtration.

1

- (ii) Wash with / add (a small amount of cold) water
Ignore filtering.

1

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4

- (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

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5

- (a) As concentration increases the amount of heat given out increases / temperature increases
(M1)

Any order.

Ignore references to an exothermic reaction.

1

More successful collisions or reactions in a given time **OR** more particles have the activation energy **(M2)**

Allow could be a second / nth order reaction.

1

(An increase in temperature or more heat given out) increases the rate of a reaction **(M3)**

1

(b) The magnesium is coated with an oxide / MgO **(M1)**

Allow magnesium hydroxide.

1

MgO / the coating / the corrosion product has to be removed before Mg will react
OR Mg and MgO / the coating / the corrosion product react at different rates
OR Initially MgO / the coating / the corrosion product reacts not Mg **(M2)**

Ignore inert coating.

1

(c) Any **two** from:

Any order.

Slower with hot water or faster with steam

The hot water produces Mg(OH)₂ / the hydroxide **OR** steam produces MgO / the oxide

(Slow) bubbling with hot water **OR** bright white light / flame / white solid with steam

2 max

(d) Magnesium sulfate is soluble and calcium sulfate is insoluble / slightly soluble / magnesium sulfate is more soluble / calcium sulfate is less soluble / correct trend in solubility **(M1)**

Any order.

M1 requires a comparison of the two solubilities.

Calcium sulfate coats the surface of the calcium **(M2)**

Coating prevents further contact with / reaction by the acid **(M3)**

'Calcium sulfate forms a protective coating' scores M2 only.

3

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6

- (a) (i) Change in concentration (of a substance / reactant / product) in unit time / given time / per (specified) unit of time

*This may be written mathematically **OR** may refer to the gradient of a graph of concentration / volume against time*

OR

Amount of substance formed / used up in unit time / given time / per (specified) unit of time

Ignore additional information including reference to collisions

1

- (ii) At **W**

M1 (QoL)

The rate / it is zero

M2

The magnesium has all reacted / has been used up

Ignore reference to the acid being 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

(iii) M1

Twice / double as many particles / hydrogen ions (in a given volume)

Penalise reference to (hydrochloric acid) molecules in M1

Penalise reference to "HCl particles" in M1

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 $E \geq E_a$

OR

double the successful / effective collision frequency

2

(b) (i) The activation energy is the minimum energy for a reaction to go / start

OR

Minimum energy for a successful/ effective collision

1

(ii) M1 Products lower than reactants on the profile

Mark independently

M2 Activation energy (E_a) shown and labelled correctly from reactants to peak of curve

Mark independently

2

(c) (i) $Ba + 2H_2O \longrightarrow Ba(OH)_2 + H_2$

$Ba + 2H_2O \longrightarrow Ba^{2+} + 2OH^- + H_2$

Allow multiples

Ignore state symbols

1



Ignore state symbols in M1

Not multiples in M1

M2 White precipitate / solid

Extra ions must be cancelled

Penalise contradictory observations in M2

2

(iii) M1 Barium meal / barium swallow / barium enema

Accept a correct reference to M1 written in the explanation in M2, unless contradictory

OR used in X-rays **OR** to block X-rays **OR** X-ray contrast medium **OR** CT scans

M2 BaSO₄ / barium sulfate is insoluble (and therefore not toxic)

For M2 NOT barium ions

NOT barium

NOT barium meal and NOT "It"

Ignore radio-tracing

2

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7 (a) (If any factor is changed which affects an equilibrium), the (position of) equilibrium will shift / move so as to oppose / counteract the change.

Must refer to equilibrium

Ignore reference to "system" alone

A variety of wording will be seen here and the key part is the last phrase

OR

(When a system / reaction in equilibrium is disturbed), the (position of) equilibrium shifts / moves in a direction which tends to reduce the disturbance

An alternative to shift / move would be the idea of changing / altering the position of equilibrium

1

- (b) (i) M1
 A substance that speeds up the reaction / alters the rate but is chemically unchanged at the end / not used up
Both ideas needed for M1
Credit can score for M1, M2 and M3 from anywhere within the answer
- M2
 Catalysts provide an alternative route / alternative pathway / different mechanism
- M3
 that has a lower activation energy / E_a
- OR**
lowers the activation energy / E_a

3

- (ii) (Time is) less / shorter / decreases / reduces
Credit "faster", "speeds up", "quicker" or words to this effect

1

- (iii) None

1

- (c) (i) R

1

- (ii) T

1

- (iii) R

1

- (iv) P

1

- (v) Q

1

[11]

8

- (a) **Award in either order for curve**

"Steeper" requires line to be on the left of the original line, starting from the origin

M1 curve is steeper than original and starts at the origin

M2 curve levels at the top line on the graph

2

(b) **Award in either order for curve**

“Shallower” requires line to be on the right of the original line, starting from the origin

M1 curve is shallower than original and starts at the origin

M2 curve levels at the first line on the graph

2

(c) **M1** curve would be steeper than original

“Steeper” requires line to be on the left of the original line, starting from the origin

M2 curve levels at the same original volume of O₂

2

(d) **M1** The (concentration / amount of) H₂O₂ or reactant falls / decreases / used up
Mark independently

OR

The number of H₂O₂ 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

(e) (i) $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$

Ignore state symbols

Accept only this equation or its multiples

Extra species must be crossed through

1

(ii) hydrogen bromide / it does not appear in the overall equation

OR

hydrogen bromide / it is not used up in the reaction / unchanged at the end of the reaction

OR

hydrogen bromide / it is regenerated / re-formed (in Step 2)

1

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9

(a) $q = 500 \times 4.18 \times 40$

Do not penalise precision.

1

$= 83600 \text{ J}$

Accept this answer only.

Ignore conversion to 83.6 kJ if 83600 J shown.

Unit not required but penalise if wrong unit given.

Ignore the sign of the heat change.

An answer of 83.6 with no working scores one mark only.

An answer of 83600 with no working scores both marks.

1

(b) Moles $(= 83.6 / 51.2) = 1.63$

Using 77400 alternative gives 1.51 mol

Allow (a) in kJ / 51.2

Do not penalise precision.

1

Mass $= 1.63 \times 40(.0) = 65.2 \text{ (g)}$

Allow 65.3 (g)

Using 77400 alternative gives 60.4 to 60.5

Allow consequential answer on M1.

1 mark for M_r (shown, not implied) and 1 for calculation.

Do not penalise precision.

2

(c) Molarity $= 1.63 / 0.500 = 3.26 \text{ mol dm}^{-3}$

Allow (b) $M1 \times 2$

Using 1.51 gives 3.02

1

(d) Container splitting and releasing irritant / corrosive chemicals

*Must have reference to both aspects; splitting or leaking (can be implied such as contact with body / hands) **and** hazardous chemicals.*

Allow 'burns skin / hands' as covering both points

Ignore any reference to 'harmful'.

Do not allow 'toxic'.

1



Allow fractions / multiples in equation.

Ignore state symbols.

1

(ii) Iron powder particle size could be increased / surface area lessened

Decrease in particle size, chemical error = 0 / 3

Change in oxygen, chemical error = 0 / 3

1

Not all the iron reacts / less reaction / not all energy released / slower release of energy / lower rate of reaction

Mark points M2 and M3 independently.

1

Correct consequence of M2

An appropriate consequence, for example

- *too slow to warm the pouch effectively*
- *lower temperature reached*
- *waste of materials*

1

(f) (i) Conserves resources / fewer disposal problems / less use of landfill / fewer waste products

Must give a specific point.

Do not allow 'does not need to be thrown away' without qualification.

Do not accept 'no waste'.

1

(ii) Heat to / or above 80 °C (to allow thiosulfate to redissolve)

Accept 'heat in boiling water'.

If steps are transposed, max 1 mark.

1

Allow to cool before using again

Reference to crystallisation here loses this mark.

1

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10

(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"

Ignore "species"

1

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