

**M1.(a)** Consider experiments 1 and 2: [B constant]

[A] increases  $\times 3$ : rate increases by  $3^2$  therefore 2nd order with respect to A

1

Consider experiments 2 and 3:

[A] increases  $\times 2$ : rate should increase  $\times 2^2$  but only increases  $\times 2$

Therefore, halving [B] halves rate and so 1st order with respect to B

1

Rate equation: rate =  $k[A]^2[B]$

1

(b) rate =  $k [C]^2[D]$  therefore  $k = \text{rate} / [C]^2[D]$

1

$$k = \frac{7.2 \times 10^{-4}}{(1.9 \times 10^{-2})^2 \times (3.5 \times 10^{-2})} = 57.0$$

*Allow consequential marking on incorrect transcription*

1

$\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$

*Any order*

1

(c) rate =  $57.0 \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2} = 3.99 \times 10^{-3} \text{ (mol dm}^{-3} \text{ s}^{-1}\text{)}$

**OR**

Their  $k \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2}$

1

(d) Reaction occurs when molecules have  $E \geq E_a$  1

Doubling T by 10 °C causes many more molecules to have this E 1

Whereas doubling [E] only doubles the number with this E 1

(e)  $E_a = RT(\ln A - \ln k) / 1000$   
*Mark is for rearrangement of equation and factor of 1000 used correctly to convert J into kJ* 1

$E_a = 8.31 \times 300 (23.97 - (-5.03)) / 1000 = 72.3 \text{ (kJ mol}^{-1}\text{)}$  1 [12]

**M2.** (a) Antacid

**OR**

to neutralise acidity

**OR**

eases indigestion

*Credit suitable reference to indigestion or to laxative or to relief of constipation*

1

(b) **M1** Decrease in T decreases the energy of the particles/ions/H<sup>+</sup>/molecules

**M2 (also scores M1)** Decrease in the number of/less particles/ions/H<sup>+</sup>/molecules with  $E \geq E_{act}$  or  $E \geq$  minimum energy to react

*In M1 and M2, credit "atoms" but ignore "calcium carbonate", ignore "calcium", ignore any ion formula except H<sup>+</sup>*

**M3** Few(er)/Less effective/productive/successful collisions

**QoL**

- (c) (i) Strontium has a higher melting point than barium, because

**Correct reference to size of cations/proximity of electrons**

**M1** (For Sr) delocalised electrons closer to cations/positive ions/atoms/nucleus

**OR**

cations/positive ions/atoms are smaller

**OR**

cation/positive ion/atom or it has fewer (electron) shells/levels

*Ignore general Group 2 statements*

*Penalise M1 if Sr or Ba is said to have more or less delocalised electrons*

*Ignore reference to shielding*

**CE = 0** for reference to molecules or intermolecular forces or covalent bonds

**Relative strength of metallic bonding**

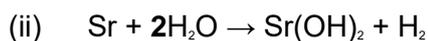
**M2** (Sr) has stronger attraction between the cations/positive ions/atoms/nucleus and the delocalised electrons

**OR**

stronger metallic bonding

(assume argument refers to Sr but accept converse argument for Ba) 2

*Ignore "Van der Waals forces (between atoms)" but penalise if "between molecules"*



*Or multiples*

1



*Or multiples*

1

[9]

**M3.(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

**[6]**

- M4.(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

[6]

**M5.(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 /  $n^{\text{th}}$  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  $\text{Mg}(\text{OH})_2$  / 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

[10]

**M6.** (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 O<sub>2</sub>

2

(d) **M1** The (concentration / amount of) H<sub>2</sub>O<sub>2</sub> or reactant falls / decreases / used up  
*Mark independently*

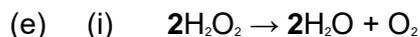
**OR**

The number of H<sub>2</sub>O<sub>2</sub> 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



*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

**[10]**