Exercise walk-through

Effect of temperature on reaction rates and the concept of activation energy ▪ 8.2

eXercise

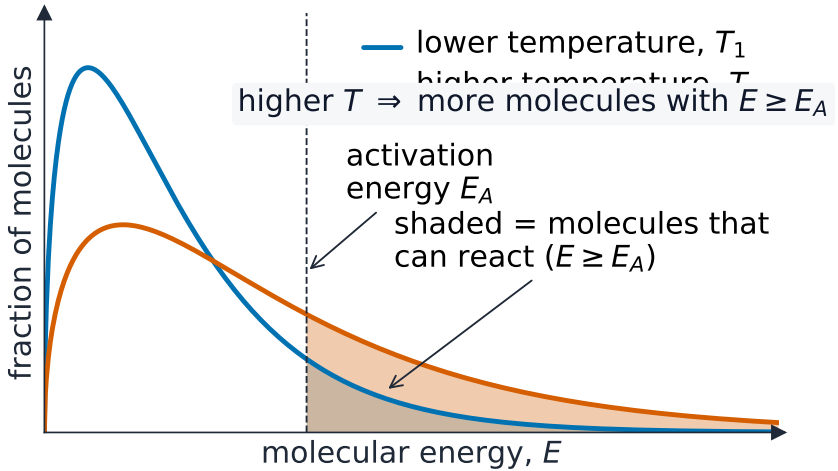
You must be able to

- define activation energy and sketch the Boltzmann distribution
- use the Boltzmann distribution to explain the significance of E_A
- explain the effect of temperature in terms of the distribution and effective collisions

Method — Activation energy and the Boltzmann distribution

The **activation energy** E_A is the minimum energy a collision needs to be effective. *The curve starts at the origin, peaks, then tails off; only molecules to the right of E_A can react. At higher T the curve spreads right, so a larger fraction can react*

Method — Activation energy and the Boltzmann distribution



Method — Activation energy and the Boltzmann distribution

effective collision

reactive ends line up

$\Rightarrow$ **reaction**

ineffective collision

wrong orientation

$\Rightarrow$ **no reaction**

Higher temperature gives more effective collisions

Method — Why temperature has a big effect

Raising the temperature:

- spreads the curve to the right, so a **much larger fraction** of molecules exceed E_A (the bigger effect);
- makes molecules move faster, so they collide more often.

So a small temperature rise gives a large rate rise.

Practice 2.1 ▪ 1 mark

Define **activation energy**.

Solution 2.1

Method: Activation energy and the Boltzmann distribution

Worked steps

the minimum energy a collision needs to be effective (to react) B1.

Practice 2.2 ▪ 1 mark

On a Boltzmann distribution, state which molecules are able to react.

Solution 2.2

Method: Activation energy and the Boltzmann distribution

Worked steps

those with energy greater than (to the right of) the activation energy B1.

Exam-style 3.1 ▪ 1 mark

When the temperature is increased, the main reason the rate rises is:

A the activation energy falls

B a much larger fraction of molecules have energy $\geq E_A$

C the molecules get bigger

D the enthalpy change increases

Solution 3.1

Method: Why temperature has a big effect

A the activation energy falls

B a much larger fraction of molecules have energy $\geq E_A$ ✓

C the molecules get bigger

D the enthalpy change increases

Worked steps

B. A higher temperature gives a larger fraction of molecules with energy $\geq E_A$.

Exam-style 3.2 ▪ 1 mark

The total area under a Boltzmann distribution curve represents:

A the activation energy

B the total number of molecules

C the rate of reaction

D the temperature

Solution 3.2

Method: Activation energy and the Boltzmann distribution

A the activation energy

B the total number of molecules ✓

C the rate of reaction

D the temperature

Worked steps

B. The area under the curve is the total number of molecules.

Exam-style 3.3 ▪ 3 marks

Sketch a Boltzmann distribution curve. Mark the activation energy E_A and shade the molecules that can react.

Solution 3.3

Method: Activation energy and the Boltzmann distribution

Worked steps

curve from the origin rising to a peak then tailing off, not touching the x-axis **B1**; E_A marked on the energy axis to the right of the peak **B1**; area to the right of E_A shaded **B1**.

Exam-style 3.4 ▪ 3 marks

Explain, using the Boltzmann distribution, why a 10 °C rise in temperature can roughly double the rate of a reaction.

Solution 3.4

Worked steps

at higher temperature the curve spreads to the right **M1**; the fraction of molecules with energy $\geq E_A$ increases greatly **M1**; so many more collisions are effective each second, roughly doubling the rate **A1**.