A-LEVEL CHEMISTRY • EXERCISE SHEET

8.2 Effect of temperature on reaction rates and activation energy

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS activation energy 活化能 • boltzmann distribution 玻尔兹曼分布 • effective collision 有效碰撞 • rate of reaction 反应速率 • collide 碰撞

Objective

Build the skills to answer exam questions on **temperature and activation energy** — **activation energy** 活化能, the **Boltzmann distribution** 玻尔兹曼分布, and why temperature has a large effect on rate.

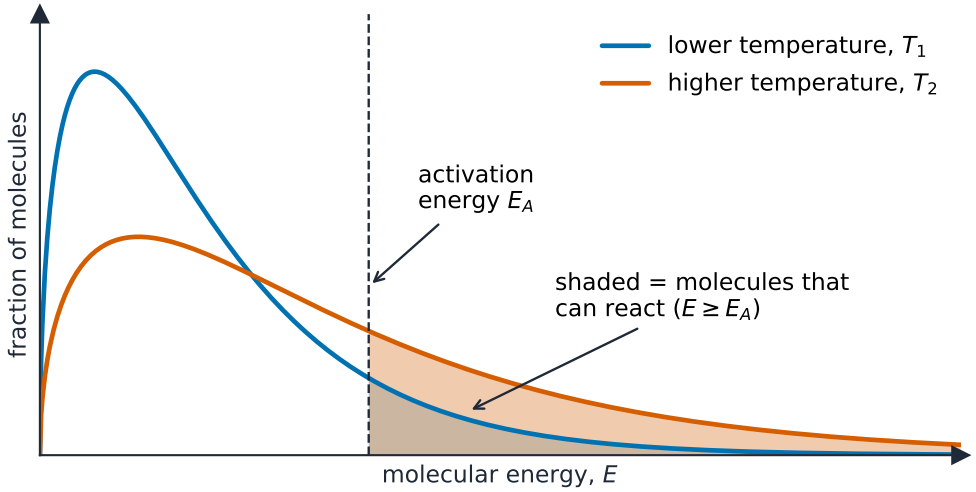
You must be able to:

- 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

1 Worked examples

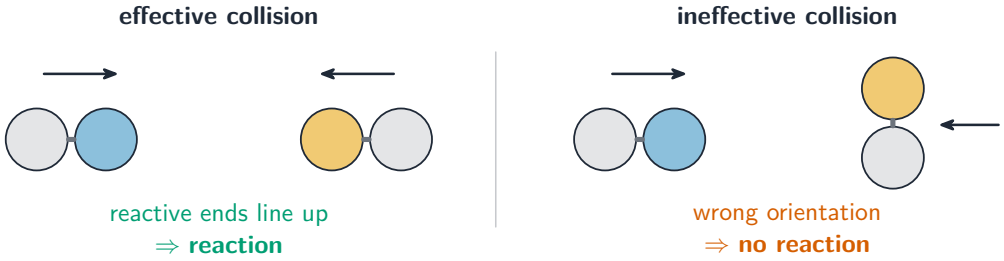
■ Activation energy and the Boltzmann distribution

The **activation energy** E_A is the minimum energy a collision needs to be effective.



higher T ⇒ more molecules with $E \geq E_A$

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



Higher temperature gives more effective collisions

■ 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.

2 Practice

2.1 Define **activation energy**. [1]

2.2 On a Boltzmann distribution, state which molecules are able to react. [1]

3 Exam-style questions

3.1 When the temperature is increased, the main reason the rate rises is: [1]

- **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

3.2 The total area under a Boltzmann distribution curve represents: [1]

- **A** the activation energy
- **B** the total number of molecules
- **C** the rate of reaction
- **D** the temperature

3.3 Sketch a Boltzmann distribution curve. Mark the activation energy E_A and shade the molecules that can react. [3]

3.4 Explain, using the Boltzmann distribution, why a 10 °C rise in temperature can roughly double the rate of a reaction. [3]

Solutions

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

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

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

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

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

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