

Reaction Kinetics

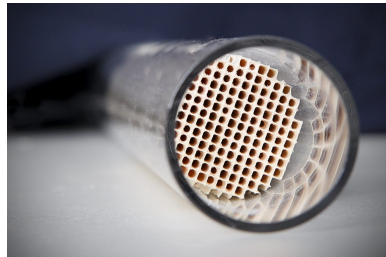
A-Level Chemistry ■ Topic 8

A-Level Chemistry



What we will cover

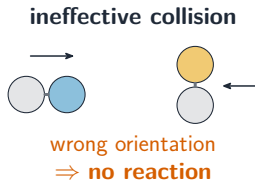
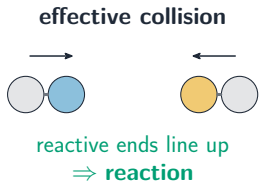
- 1 Rate & collisions
- 2 Concentration & pressure
- 3 The Boltzmann distribution
- 4 Catalysts
- 5 Types of catalyst



a catalyst speeds reactions



Rate and collisions

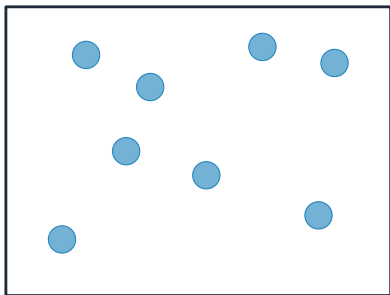


To react, particles must **collide** .

An **effective collision** has enough **energy** and the right **orientation**. The rate depends on how many happen each second.

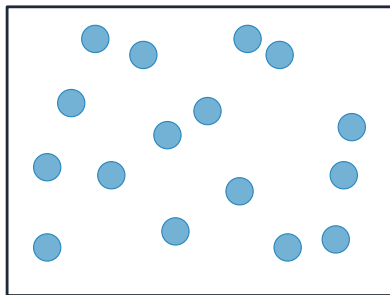
Concentration and pressure

Higher **concentration** (or gas **pressure**) packs particles closer. They **collide** more often, so there are more effective collisions each second – the rate **rises**.



lower concentration
fewer collisions

more
→



higher concentration
more collisions

Measuring a rate, and what a catalyst does

the rate of reaction

how fast a reactant is used or a product is made, per unit time

measuring it

volume of gas made divided by the time taken; or mass lost, or a colour change

reading the graph

the rate is **fastest at the start** – the graph is steepest – because the reactants are most concentrated, and it slows as they are used

collision frequency

more particles per volume means more collisions per second

a non-effective collision

one with too little energy, or the wrong orientation – most collisions are these

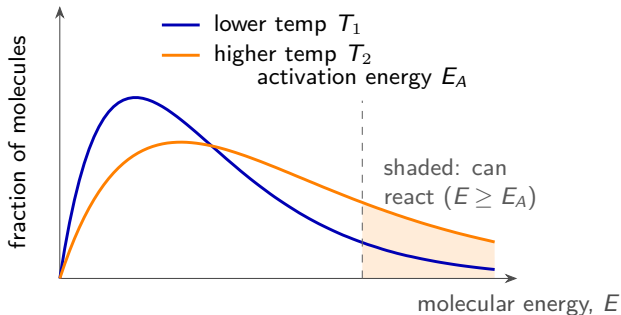
a catalyst

speeds the reaction and is **not used up**; **catalysis** is the name for the action

A catalyst gives an alternative **reaction pathway** of **lower activation energy** – so a larger fraction of collisions is effective. It never changes the position of equilibrium.



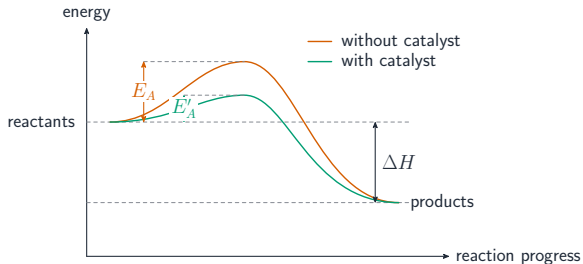
The Boltzmann distribution



Only molecules past the **activation energy** E_A can react.

Raising the temperature spreads the **Boltzmann distribution** to the right, so a **much larger fraction** exceed E_A – a small rise gives a big rate increase.

Catalysts



A **catalyst** speeds a reaction without being used up: it offers a different **reaction mechanism** – a new route with a **lower** E_A . On a **reaction pathway diagram** the catalysed route has a lower hill.

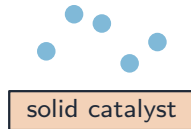
More molecules now exceed E_A , so the rate rises – but the **enthalpy change** ΔH is **unchanged**.

Types of catalyst

- a **homogeneous catalyst** is in the **same** state as the reactants
- a **heterogeneous catalyst** is in a **different** state (a solid surface, like a catalytic converter)



homogeneous
(same state,
mixed in)

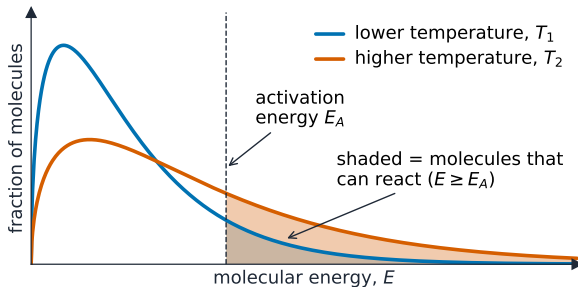


heterogeneous
(different state,
a surface)

Exam tips

- Explain rate changes with **collision theory** – more frequent and/or more energetic **effective collisions**.
- On a **Boltzmann distribution** mark E_A , shade to its right, and show the curve **flatten and shift right** at higher temperature; it starts at the origin and never touches the axis.
- A **catalyst** gives an alternative route with **lower** E_A **and does not** change ΔH .
- Say why a small temperature rise gives a large rate rise: a **much greater proportion** of molecules now exceed E_A (the main effect).

At higher temperature the curve spreads to the right



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

At higher temperature the curve spreads to the right, so a larger fraction of molecules can react



Worked example – average rate

A reaction gives off CO_2 . In the first 30 s, 48 cm^3 is collected. Find the average rate.

- $\text{Rate} = \frac{\text{change in amount}}{\text{time taken}}$
- $= \frac{48 \text{ cm}^3}{30 \text{ s}} = 1.6 \text{ cm}^3 \text{ s}^{-1}$
- That is the **average** over the 30 s, not the rate at any instant.

Average rate = total change $\div$ total time. **Instantaneous** rate = gradient of the **tangent** – always steepest at $t = 0$.

Topic 8 – key takeaways

1

Collisions

effective = enough energy + right angle

2

Concentration

more particles → more collisions
→ faster

3

Temperature

spreads Boltzmann right; big rate rise

4

Catalyst

lower E_A ; ΔH unchanged

Check yourself

- 1 What two things make a collision effective?
- 2 Why does higher concentration speed a reaction?
- 3 What does raising temperature do to the Boltzmann curve?
- 4 Does a catalyst change ΔH ?



Answers 1. enough energy and the right orientation 2. more frequent collisions
3. spreads it to the right 4. no