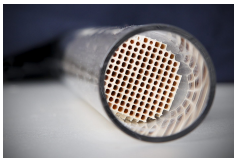
Reaction Kinetics

A-Level Chemistry ▪ Topic 8

A-Level Chemistry

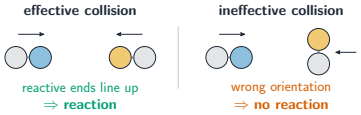
What we will cover



a catalyst speeds reactions

1 Collisions

Rate and collisions

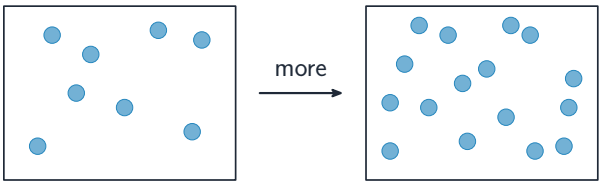


To react, particles must **collide** 碰撞.

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

Concentration and pressure

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



lower concentration — higher concentration

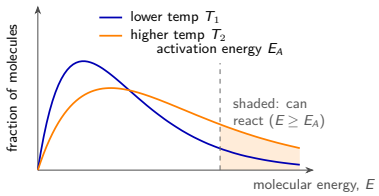
Measuring a rate, and what a catalyst does

the rate of reaction 反应速率	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 碰撞频率	more particles per volume means more collisions per second
a non-effective collision 无效碰撞	one with too little energy, or the wrong orientation – most collisions are these
a catalyst 催化剂	speeds the reaction and is not used up; **catalysis** 催化作用 is the name for the action

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

2 Temperature and catalysts

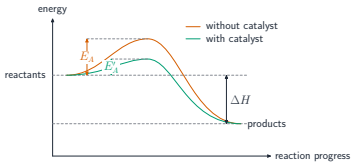
The Boltzmann distribution



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

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

Catalysts



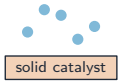
A **catalyst** 催化剂 speeds a reaction without being used up: it offers a different **reaction mechanism** 反应机理 – a new route with a lower E_A. On a **reaction pathway diagram** 反应路径图 the catalysed route has a lower hill.

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

Types of catalyst

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

homogeneous (same state, mixed in)

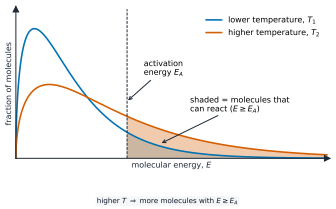


heterogeneous (different state, a surface)

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



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

3 Recap

Worked example – average rate

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

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

Average rate = total change ÷ 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