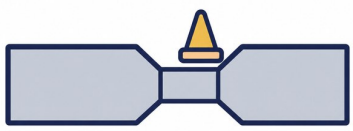
Mechanisms and Catalysts Map

Cambridge International AS & A Level Chemistry (9701) · Topic 26 Reaction kinetics · Mechanisms, temperature and catalysts

1 The slow step

26.1.1, 26.1.5

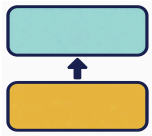
- Slowest step: **rate-determining**
- Its species: in the rate equation
- Later steps: not counted
- **Intermediate**: made, then used



2 Rate equation → mechanism

26.1.5

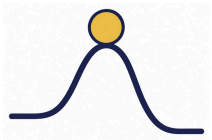
- Slow step: the rate-equation species
- Other reactants: **fast** steps after
- Steps **add up** to the equation
- **Catalyst**: used, then reformed

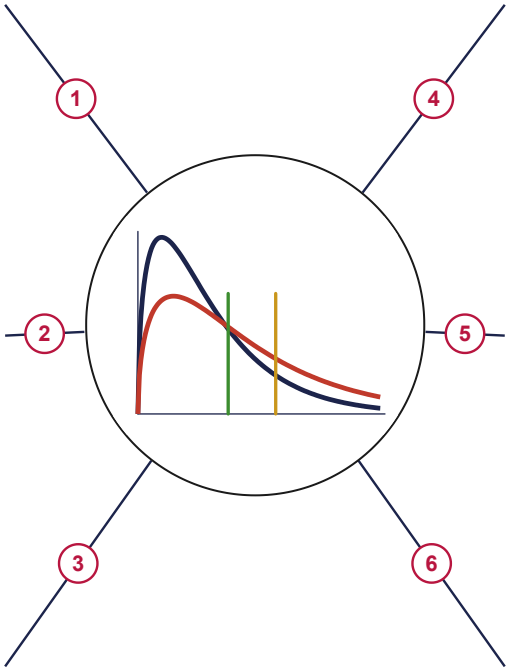


3 Temperature and k

26.1.6

- E_a: minimum energy to react
- Higher T: curve flatter, to the right
- Many more molecules with $E \geq E_a$
- **k rises**; orders unchanged

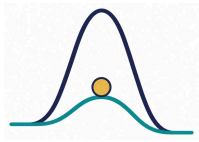




4 How catalysts work

26.2.1

- Alternative route, **lower E_a**
- More molecules with $E \geq E_a$(cat)
- ΔH and equilibrium position unchanged
- **Homogeneous** or **heterogeneous**



5 Homogeneous catalysts

26.2.3

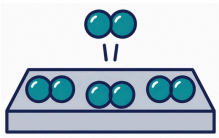
- **Same phase** as reactants
- Used in one step, **reformed** later
- NO_2 in the oxidation of SO_2
- Fe^{2+} or Fe^{3+}: I^- with $S_2O_8^{2-}$



6 Heterogeneous catalysts

26.2.2

- Solid surface, gas reactants
- **Adsorb**, bonds weaken, **desorb**
- Fe in the Haber process
- Pd, Pt, Rh in catalytic converters



Rate equation to mechanism

the species in the rate equation are the species up to and including the slow step

Reaction	Rate equation	Slow step holds	Mechanism
$NO_2 + CO \rightarrow NO + CO_2$	rate = $k[NO_2]^2$	2 NO_2, no CO	two steps, NO_3 intermediate
$2NO + O_2 \rightarrow 2NO_2$	rate = $k[NO]^2[O_2]$	2 NO and O_2	fast $2NO \rightleftharpoons N_2O_2$ first
$H_2 + 2ICl \rightarrow I_2 + 2HCl$	rate = $k[H_2][ICl]$	H_2 and one ICl	two steps, HI intermediate
$SO_2 + ½O_2 \rightarrow SO_3$ (NO_2)	catalysed by NO_2	SO_2 and NO_2	NO intermediate; NO_2 reformed

Worked examples

Rate to mechanism

- $2NO_2 + O_3$, rate = $k[NO_2][O_3]$
- slow: $NO_2 + O_3 \rightarrow NO_3 + O_2$
- fast: $NO_3 + NO_2 \rightarrow N_2O_5$

A 10 K rise

- the curve flattens and moves right
- area beyond E_a about doubles
- **k about doubles**

Fe^{2+} as a catalyst

- $S_2O_8^{2-} + 2Fe^{2+} \rightarrow 2SO_4^{2-} + 2Fe^{3+}$
- $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$
- **Fe^{2+} reformed**

Transition elements as catalysts return in Topic 28; SN1 and SN2 rate equations are in Topic 15.

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