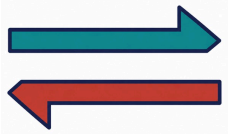
Equilibria Map

Cambridge International AS & A Level Chemistry · Topic 7 Equilibria

1 Dynamic equilibrium 7.1.1

- Reversible: ⇌; needs a **closed system**
- **Forward rate = reverse rate**
- **Concentrations constant**, not equal
- Reached from either side



2 Kc and Kp 7.1.4–7.1.9

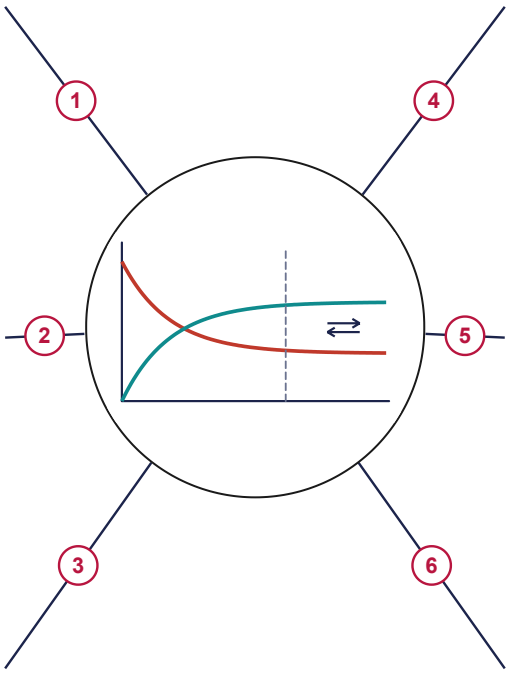
- **Kc** from concentrations; **Kp** from partial pressures
- p = **mole fraction × total pressure**
- Quantities at equilibrium from data
- Only **temperature** changes K



3 Concentration 7.1.3

- Le Chatelier: shifts to **oppose** a change
- Add a substance: some is used up
- Remove one: more is made
- CrO_4^{2-} ⇌ $Cr_2O_7^{2-}$: acid gives orange





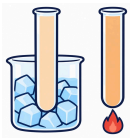
4 Pressure 7.1.3

- Count **gas moles** only
- Higher P: towards **fewer** gas moles
- Equal gas moles: no shift
- $N_2 + 3H_2 \rightleftharpoons 2NH_3$: 4 → 2



5 Temperature, catalysts 7.1.3

- Hotter: the **endothermic** direction
- Cooler: the exothermic direction
- **Catalyst**: same position, sooner
- $N_2O_4 \rightleftharpoons 2NO_2$: browner when hot



6 Industry 7.1.10

- Yield v **rate** v **cost**
- Haber: 450 °C, 200 atm, iron
- Contact: 450 °C, 1–2 atm, V_2O_5
- Unreacted gases **recycled**



Predicting the shift

state the direction, then the change it opposes

Equilibrium	Higher temperature	Higher pressure	Catalyst
$N_2 + 3H_2 \rightleftharpoons 2NH_3$, ΔH −92	left (less NH_3)	right (4 → 2)	no shift
$2SO_2 + O_2 \rightleftharpoons 2SO_3$, ΔH −196	left	right (3 → 2)	no shift
$N_2O_4 \rightleftharpoons 2NO_2$, ΔH +58	right (browner)	left (2 → 1)	no shift
$H_2 + I_2 \rightleftharpoons 2HI$	depends on ΔH	no shift (2 v 2)	no shift
$CH_4 + H_2O \rightleftharpoons CO + 3H_2$, ΔH +206	right	left (4 → 2)	no shift

Worked examples

From either side

- 1.00 mol H_2 + 1.00 mol I_2
- → 1.58 mol HI, 0.21 mol each
- 2.00 mol HI gives the same

Deduce ΔH

- pink → blue when heated
- heat favours endothermic
- forward ΔH **positive**

Why 450 °C?

- low T: high yield, slow
- high T: fast, low yield
- **compromise** + iron + recycling

Acid–base equilibria follow in Topic 7.2; reaction kinetics in Topic 8.

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