

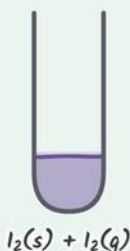
forward and reverse running at the same rate, and the constant that says where they meet

Reversible vs Irreversible Reactions

- irreversible reactions run ONE direction only, until a reactant is used up
- e.g. $C(s) + O_2(g) \rightarrow CO_2(g)$, shown with a single arrow
- reversible reactions run BOTH directions at once: forward and reverse
- shown with a double arrow, e.g. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
- classic colour-change demo: $Co(H_2O)_6^{2+} + 4Cl^- \rightleftharpoons CoCl_4^{2-} + 6H_2O$
- pink on cooling, blue on heating, same reaction, direction set by temperature
- the SAME reaction can be reversible closed, irreversible open
- e.g. heating $CaCO_3$: CO_2 escapes in an open vessel, stays and recombines in a closed one

Equilibrium in Physical Processes *

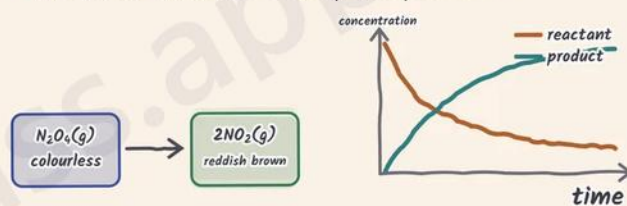
- liquid-vapour: in a CLOSED vessel, evaporation and condensation reach equal rates
- giving a constant SATURATED VAPOUR PRESSURE, $H_2O(l) \rightleftharpoons H_2O(g)$
- solid-liquid: ice and water together at exactly 273 K, neither melts nor freezes net
- solid-vapour (sublimation): solid iodine and its violet vapour reach a stable colour in a closed vessel
- $I_2(s) \rightleftharpoons I_2(g)$; camphor and ammonium chloride behave the same way
- solute-solid, in a SATURATED solution: dissolution rate equals crystallisation rate, $Sugar(aq) \rightleftharpoons Sugar(s)$



solid iodine sublimating in a sealed tube: once the violet vapour's colour stops deepening, sublimation and condensation are running at equal rates

Chemical Equilibrium: the Dynamic State

- a reversible reaction in a closed system does NOT reach 100% yield
- concentrations stop changing once the system reaches equilibrium
- equilibrium is DYNAMIC, not static: forward and reverse reactions keep running
- at exactly EQUAL rates, so there is no NET change
- equilibrium can be approached from either side: starting from $H_2 + I_2$ or from HI
- reaches the SAME mixture at a given temperature
- $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ is easy to WATCH: colourless N_2O_4 turns visibly brown
- the colour stabilises exactly at equilibrium



an equilibrium you can literally watch happen: the colour stops changing exactly when the forward and reverse rates become equal

reactant concentration falls, product concentration rises, both levelling off together the moment equilibrium is reached