

how fast a reaction runs, and order is measured, never assumed

Rate of reaction

average rate over an interval $r_{avg} = -\frac{\Delta[R]}{\Delta t} = \frac{\Delta[P]}{\Delta t}$

instantaneous rate, interval shrunk to zero $r_{inst} = -\frac{d[R]}{dt} = \frac{d[P]}{dt}$

square brackets mean concentration; the minus sign on a reactant just keeps the rate positive, since $[R]$ is falling

Rate and stoichiometry

- for $aA + bB \rightarrow cC + dD$, divide each term by its own coefficient: rate = $-\frac{1}{a} \frac{d[A]}{dt} = -\frac{1}{b} \frac{d[B]}{dt} = \frac{1}{c} \frac{d[C]}{dt} = \frac{1}{d} \frac{d[D]}{dt}$
- so rate is one single number, whichever reactant or product you measure it off

Factors affecting rate *

- concentration: usually more reactant, more rate, exact dependence is the rate law, never guessed
- temperature: rate roughly doubles for every 10°C rise, more molecules cross the activation energy barrier
- catalyst: opens an alternate, lower- E_a pathway, speeds forward and reverse equally, doesn't shift equilibrium
- surface area: more exposed surface (powder vs lump) means more collisions, faster heterogeneous reactions

rate answers how fast, equilibrium answers how far: kinetics never tells you where a reaction ends up

Rate law and order

- $aA + bB \rightarrow \text{products}$: rate = $k[A]^x[B]^y$; x, y are the order in A, B, found by experiment
- order is not read off the equation, only molecularity is; can be zero, fractional, even negative
- overall order = $x+y$, the sum of the individual orders
- k belongs to that reaction at that temperature; its units change with the overall order

Order vs molecularity

Order

- experimental, read from the rate law
- can be zero, fractional, or negative
- defined for the overall reaction, any step or the net one

Molecularity

- theoretical, molecules colliding in one elementary step
- always a whole number: 1, 2, rarely 3
- defined only for a single elementary step

for a one-step (elementary) reaction, order and molecularity happen to match; for anything with a real mechanism, they usually don't