Class 1

ΔG | diamond → graphite

Thermodynamics tells us about energies and stability, but does not say anything about how slow or fast processes are.

→ That is the realm of kinetics.

\[ \frac{ds}{dt} = v \]

How fast are things?
Speed = \frac{\text{distance travelled}}{\text{time taken}} = \frac{\Delta \text{(distance)}}{\Delta \text{(time)}} = \frac{ds}{dt}

\text{Acceleration} = \frac{d}{dt} \left( \frac{d}{dt} \right) = \frac{dv}{dt} = \frac{d^2 s}{dt^2}

\underline{Chemical reactions}

A \rightarrow \text{products} \quad \text{(a generic reaction)}

The differential rate is

\frac{-d[A]}{dt}

where \([A]\) is the concentration (mole L\(^{-1}\)) at any point in time.
More details

reaction rate = \frac{\Delta [A]}{\Delta t} = \frac{\Delta [A]}{\Delta p} \frac{\Delta p}{\Delta t}

Units of the rate are mol L^{-1} s^{-1} (molar per second)

\[ \text{progress of reaction as } A \rightarrow \text{products} \]
Calculus refreshers

\[ \frac{dy}{dx} = f'(x) \]

\[ y = mx + c \]

Slope \( m = \frac{dy}{dx} \) at that point

\[ y = ax^2 + bx + c \]

\[ \frac{dy}{dx} = 2ax + b \text{ etc.} \]
A $\rightarrow$ products

rate law

rate = $-\frac{d[A]}{dt}$

rate law (generic): $-\frac{d[A]}{dt} = k[A]^n$

$\exists n = 0, 1, 2, \text{ etc}$

rate constant

What about

A + B $\rightarrow$ products?

then $-\frac{d[A]}{dt} = -\frac{d[B]}{dt} = k[A]^n\cdot[B]^m$
Where \( n \& m \) are the orders with respect to \( A \& B \).

Let us also consider

\[
A + 2B \rightarrow 3C
\]

We rewrite this as

\[
0 = -A - 2B + 3C
\]

Then

\[
-\frac{d(A)}{dt} = -\frac{1}{2} \frac{d(B)}{dt} = + \frac{1}{3} \frac{d(C)}{dt}
\]
Units of the rate constant depend on the nature of the reaction

On (zeroth) order

\[- \frac{d[A]}{dt} = k[A]_0 = k\]

\[\rightarrow \text{ the rate does not depend on the concentration of A} \]

Units of \( k \) & \( \frac{d[A]}{dt} \) are the same

\( = \text{mol L}^{-1} \text{s}^{-1} \)
1st order reaction

\[- \frac{d[A]}{dt} = k[A] \]

units of \( k \) are \( \text{mol}^{-1} \text{L} \text{s}^{-1} \)

2nd order reaction

\[- \frac{d[A]}{dt} = k[A]^2 \]

units of \( k \) are \( \text{mol}^{-1} \text{L}^2 \text{s}^{-1} \)

Note: Reactions can be very complex. Google the reaction.