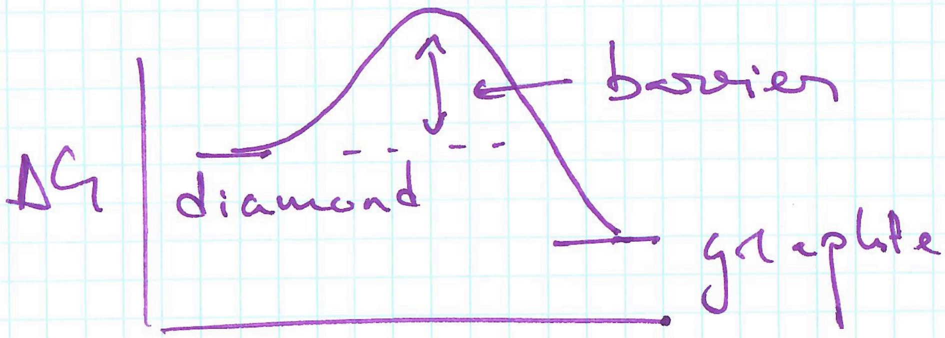
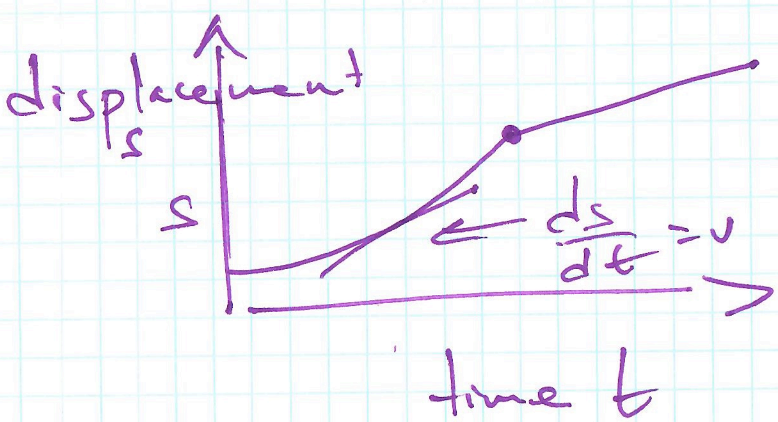
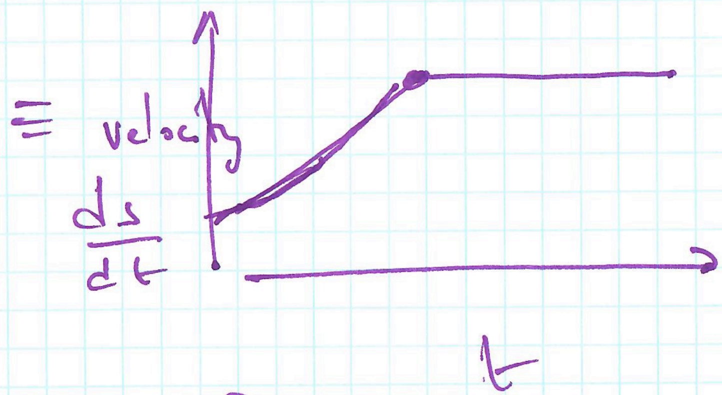
Class 1



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.





How fast are things?

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}} = \frac{\Delta(\text{distance})}{\Delta(\text{time})} = \frac{ds}{dt}$$

$$\text{acceleration} = \frac{d\,(\text{speed})}{dt} = \frac{dv}{dt} = \frac{d^2 s}{dt^2}$$

Chemical reactions

A $\longrightarrow$ products (a generic reaction)

the differential rate is

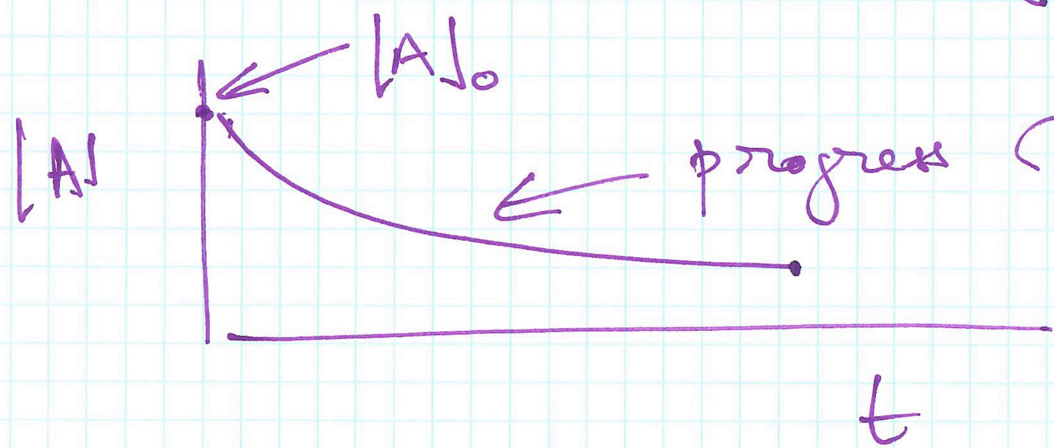
$-\dfrac{d\,[A]}{dt}$ where $[A]$ is the concentration (moles L^{-1}) at any point in time

More details

reaction rate $= -\dfrac{\Delta[A]}{\Delta t} \approx -\dfrac{d[A]}{dt}$

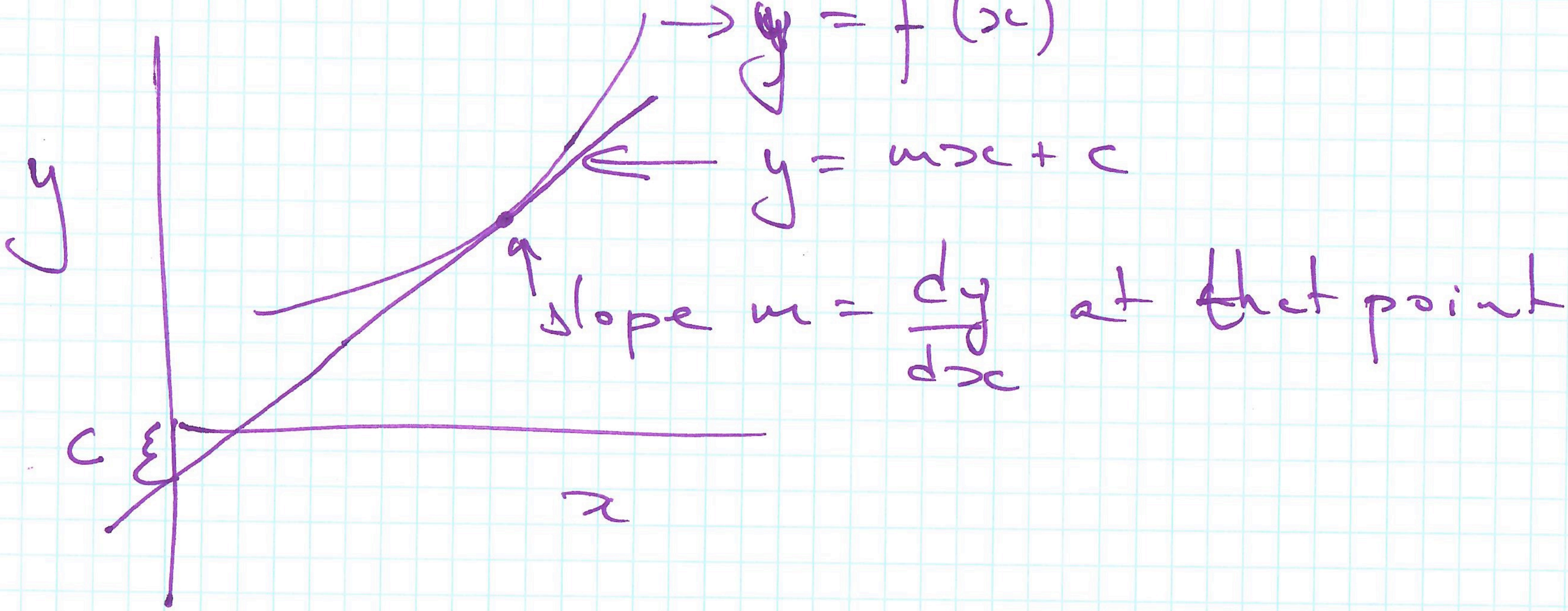
units of the rate are

$mol\ L^{-1} s^{-1}$ (molar per second)



progress of reaction as
$A \rightarrow$ products

Calculus refresher



$$y = ax^2 + bx + c$$

$$\frac{dy}{dx} = 2ax + b \quad \text{etc.}$$

A → products rate law

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

rate law (generic):

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

← order of reaction: $n = 0, 1, 2$ etc

↑ rate constant

What about

A + B → products ?

then $\frac{-d[A]}{dt} = \frac{-d[B]}{dt} = k[A]^n[B]^m$ ...

Where n & m are the orders with respect to A & B.

Let us also consider

$$A + 2B \rightarrow 3C$$

we rewrite this →

$$0 = -A - 2B + 3C$$

Then

$$-\frac{d[A]}{dt} = -\frac{1}{2}\frac{d[B]}{dt} = +\frac{1}{3}\frac{d[C]}{dt}$$

Units of the rate constant depends on the nature of the reaction

0^{th} (zeroth) order

$$-\frac{d[A]}{dt} = k[A]^0 = k$$

→ the rate does not depend on the concentration of A

units of k & $\left|\frac{d[A]}{dt}\right|$ are the same

$\equiv$ mol L^{-1} s^{-1}

1st order reaction

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

units of k are $\frac{mol\ L^{-1} s^{-1}}{mol\ L^{-1}} = s^{-1}$

2nd order reaction

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

units of k are $mol^{-1}\ L\ s^{-1}$

N.B. Reactions can be very complex. Google B-Z reaction