2.20.19

$A + B \rightarrow C + D$

$\text{Rate} = k[A]^m[B]^n$ ← order (tells how rate depends on concentration)

↑ rate constant.
(Large k = Fast RXN, small k = slow RXN)

- units of **K** depend on order of **RXN**, but rate is always M/s.

Ex/ $\underset{M/s}{\text{Rate}} = k\underset{M}{[A]}$ $\qquad k = \dfrac{\text{Rate}}{[A]} = \dfrac{M/s}{M} = s^{-1}$

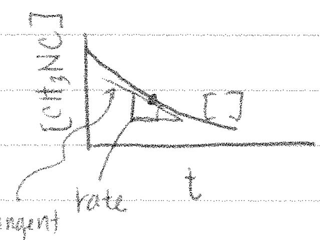
[Clicker Question: c) $\text{Rate} = k[A]^2$ b/c $\text{Rate} = k[A]^m\cancel{[B]^n}$ $n = 0$

First Order RXN -

$CH_3NC \rightarrow CH_3CN$

$\text{Rate} = k[CH_3NC] = -\dfrac{\Delta[CH_3NC]}{\Delta t}$

$= k[CH_3NC]$



Differential Rate Law:

$\text{Rate} = -\dfrac{\Delta[CH_3NC]}{\Delta t}$ ⟹ Integrated Rate Law!

$\dfrac{-d[CH_3NC]}{dt} = k[CH_3NC]$

$$\boxed{\ln[CH_3NC]_t = \ln[CH_3NC]_0 - kt}$$

$y = b + mx$

In general, First Order RxN

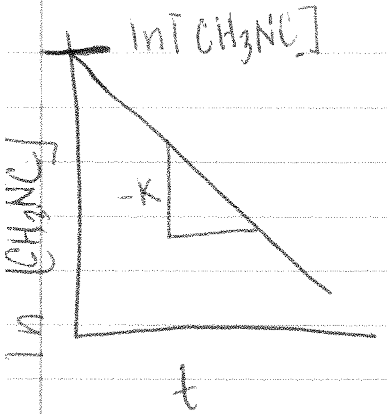
$A \rightarrow B$

$\text{Rate} = \dfrac{-\Delta[A]}{\Delta t} = k[A]$

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

$$-\int_{[A]_0}^{[A]_t} \frac{d[A]}{[A]} = \int_0^t -k\,dt$$

Integrated from $t = 0$ to time t where $[A]_0$ is concentration at time $= 0$.



$$\boxed{\ln[A]_t = \ln[A]_0 - kt}$$

also could be written like this:

$$\boxed{\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt}$$

- straight line means First order RXN.

(*) KNOW INTEGRATED RATE LAW!

(*) Know integrated Rate Law

Ex 2/ $SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$ $k = 0.17/h$

How long would it take for the concentration of SO_2Cl_2 to decrease from 1.25×10^{-3} M to $0.31 \cdot 10^{-3}$ M given that it's a First Order process?

$$\text{Rate} = k[SO_2Cl_2]$$

$$\ln\left(\frac{[SO_2Cl_2]_t}{[SO_2Cl_2]_0}\right) = -kt$$

$$\ln\left(\frac{0.31 \times 10^{-3} M}{1.25 \times 10^{-3} M}\right) = (0.17 h^{-1})t$$

$$t = \frac{-1.39}{-0.17 h^{-1}} = \boxed{8.2 h}$$

>> Half Life: First Order RXN <<

Half life: time required for concentration to decrease to half its initial volume.

$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt \qquad t_{1/2} \text{ time when } [A]_t = \tfrac{1}{2}[A]_0$$

$$\ln\left(\tfrac{1}{2}\right) = \ln\left(\frac{\tfrac{1}{2}\cancel{[A]_0}}{\cancel{[A]_0}}\right) = -kt_{1/2}$$

$$-0.693 = -kt_{1/2}$$

$$\boxed{t_{1/2} = \frac{0.693}{k}}$$

general relationship for First Order RXN.

Second Order RXN

$2NO_2(g) \rightarrow 2NO(g) + O_2(g)$

Rate Law $= k[NO_2]^2$

$$\frac{d[NO_2]}{[NO_2]^2} = -k\,dt$$

$$\left.\frac{1}{[NO_2]} = \frac{1}{[NO_2]_0} + kt\right] \text{Integrated Rate Law}$$

$$y = b + mx$$

Diff. Rate law

$$\text{Rate} = k[NO_2]^2 = -\frac{\Delta[NO_2]}{\Delta t}$$

straight ← $\frac{1}{[NO_2]}$ vs $\ln[NO_2]$ ← curved