Rate laws

$$A + 2B \longrightarrow C + 3D$$

$$\text{rate} = k\,[A]^x[B]^y$$

order

any/all reactant

rate constant

$$\frac{\Delta[\text{product}]}{\Delta t}$$

[ ] = Molarity

Use the following data to determine the rate law for the reaction
$2SO_2 + O_2 \rightarrow \cancel{2}SO_3$

$\text{rate} = k\,[SO_2]^x[O_2]^y$

Expt #	$[SO_2]$	$[O_2]$	Rate (M/s)
1	0.100 M	0.100 M	2.36
2	0.200 M	0.100 M	9.44
3	0.200 M	0.200 M	9.44

$\text{rate} = k\,[SO_2]^2[O_2]^0$

3 now... get k

1

$$\frac{\text{rate}_2}{\text{rate}_1} = \frac{\cancel{k}[SO_2]_2^x\,\cancel{[O_2]_2^y}}{\cancel{k}[SO_2]_1^x\,\cancel{[O_2]_1^y}}$$

$$\frac{\text{rate}_2}{\text{rate}_1} = \frac{[SO_2]_2^x}{[SO_2]_1^x}$$

$$\frac{9.44}{2.36} = \frac{(.2)^x}{(.1)^x} = \left(\frac{.2}{.1}\right)^x$$

$$4 = 2^x$$

$$x = 2$$

2

$$\frac{\text{rate}_3}{\text{rate}_2} = \frac{[O_2]_3^y}{[O_2]_2^y}$$

$$\frac{9.44}{9.44} = \frac{(.2)^y}{(.1)^y}$$

$$1 = 2^y \qquad y = 0$$

rate = $k [SO_2]^2$

$\frac{M}{s} = k\ M^2$

$\frac{1}{M \cdot s}$

rate = $k [A]^4 [B]^2$

$\frac{M}{s} = k\ M^4 \cdot M^2$

$\frac{M}{s} = k\ M^6$

$\frac{1}{M^5 s}$

Order

rate = $k [A]^1 [B]^2$

1st order in A

2nd order in B

3rd order overall

Arrhenius Equation

$A + 2B \longrightarrow C + 3D$

rate $= k\,[A]^x\,[B]^y$

Arrhenius

$$k = Ae^{-E_a/RT}$$

collision factor

$\approx$ % of collision w/ correct orientation

natural log base

$-E_a/RT$

Act NRG

8.314 $\frac{J}{K \cdot mol}$

in K

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rate @ $T_1 \longrightarrow k_1$

rate @ $T_2 \longrightarrow k_2$

$$\frac{k_1}{k_2} = \frac{\cancel{A}e^{-E_a/RT_1}}{\cancel{A}e^{-E_a/RT_2}}$$

$\ln(e^x) = x$

$\ln\left(\frac{e^x}{e^y}\right) = x - y$

$$\ln\frac{k_1}{k_2} = -E_a/RT_1 + E_a/RT_2$$

$$= \frac{E_a}{R}\left(-\frac{1}{T_1} + \frac{1}{T_2}\right)$$

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

can solve for E_a

Integrated Rate Laws - 0th order

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

$$\boxed{rate = k}$$

$$\frac{\Delta[product]}{\Delta t} = (-1)\frac{\Delta[react]}{\Delta t}$$

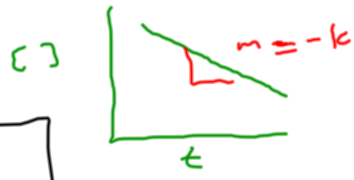
$$-\frac{\Delta[A]}{\Delta t} = k$$

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

$$[A] = -kt + const$$

@ $t = 0$

$$[A] = [A]_0$$



$$\boxed{\begin{array}{l} y = mx + b \\ [A] = -kt + [A]_0 \end{array}}$$