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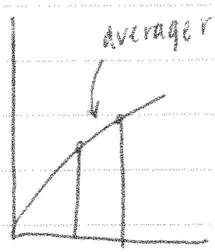
RXN RATES cont'd



, where rate is $R = \dfrac{\Delta[NO]}{\Delta t}$

(*) insantaneous rate – slope of the tangent line at a given point (derivative)

(*) Average rate is calculated from adjacent data points using $R = \dfrac{\Delta[A]}{\Delta t}$

(*) Initial Rate is the instantaneous rate at time 0.

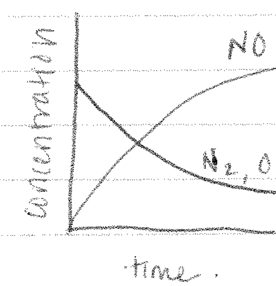
Ex/ C_4H_9Cl goes from 0.100 M to 0.060 M as time goes from 0s to 210 s.

$$\underbrace{\text{Rate}}_{\text{always positive \#.}} = \underset{\text{reactant is decreasing}}{-}\frac{\Delta[C_4H_9Cl]}{\Delta t} = \frac{-(0.60M - 0.100M)}{(210_s - 0_s)} = \boxed{+1.9 \cdot 10^{-4}\ \frac{M}{s}}$$

How do rates of change of reactants and products compare?

$$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$$

- concentrations of N_2 & O_2 decrease, while NO increases
- Rate of production of NO is 2x rate of loss of N_2 and O_2.



$$\text{Rate}_{N_2} = -\frac{\Delta[N_2]}{\Delta t} = \frac{-(9.6\mu M - 13.1\mu M)}{(10-5)\,\mu s} = 0.70\ \frac{M}{s}$$

Rate that NO is produced is 2x rate that N_2 is lost.

$$\cancel{\text{Rate}_{NO}} = \boxed{\frac{\Delta[NO]}{\Delta t} = -2\,\frac{\Delta[N_2]}{\Delta t}}$$ ← also based on stoichiometry.

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cont'd from previous example -

rate NO produced $= 2^x$ rate N_2 lost

$$\frac{1}{2}\frac{\Delta[NO]}{\Delta t} = -\frac{\Delta[N_2]}{\Delta t}$$

~ IN GENERAL ~

$$aA + bB \longrightarrow cC + dD$$

$$\text{Rate} = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = +\frac{1}{c}\frac{\Delta[C]}{\Delta t} = +\frac{1}{d}\frac{\Delta[D]}{\Delta t}$$

Review: Factors that affect RXN rates
- Physical state of reactants
- Reactant concentrations
- temperature
- Presence of catalyst.

Class demo:

T	t (s)	Factors that affect B
1	35	½ H_2O, ½ B
2	13	all B
3	28	B on ice
4	7	B + catalyst

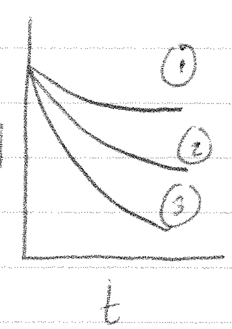
>> Determine Rate Law <<

Ex/ ~~Determining~~ $2NO + 2H_2 \longrightarrow N_2 + 2H_2O$

Trial	[NO] M	$[H_2]$ M	init rate, M/s
1	.0057	.140	$7 \cdot 10^{-5}$
2	.0057	.280	$1.4 \cdot 10^{-4}$
3	.0114	.140	$2.81 \cdot 10^{-4}$

2x 2x 2x 4x [NO]

• Always pick 2 trials in which only one of the concentrations changes.



$\text{Rate} \propto [H_2][NO]^2$

In general, $A + B \longrightarrow C + D$

$$\text{Rate} \propto [A]^m[B]^n$$

small

$\text{Rate} = k[H_2][NO]^2$ order $= 1+2 = \underline{\underline{3}}$

General,

$$\text{Rate} = k[A]^m[B]^n$$

$\boxed{*}$ m, n = change in concentration & change in rate

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$\boxed{\text{Rate Law}}$

$$\frac{Rate_2}{Rate_1} = \frac{k[H_2]_2^m \cancel{[NO]_2^n}}{k[H_2]_1^m [NO]_1^n} = \left(\frac{[H_2]_2}{[H_2]_1}\right)^m$$

$$= \frac{1.4 \cdot 10^{-4}}{7.0 \cdot 10^{-5}} = \left(\frac{0.280}{0.140}\right)^m \qquad 2 = (2)^m \Rightarrow m = 1$$

$$Rate = k[A]^m[B]^n$$

orders

orders = 1 + 2 = 3

$$Rate = k[H_2][NO]^2$$

$$7.0 \cdot 10^{-5} = k(0.14\ M)(0.0057\ M)^2$$

$$15.4\ M^{-2}s^{-1} = k$$

units determined by overall units of rate