Success 24/7 Chemistry: Rate Law

Rate Law

- ⊡ equation that is written that expresses how the reaction rate of a particular reaction is dependent upon the concentrations of its reactants.

- ⊡ For the reaction $aA + bB \rightarrow cC + dD$, the general form of the rate law would be:

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

- ⊡ Rate is usually expressed as mol/L·time.

- ⊡ k is the specific rate constant. It is constant for a given reaction at a given temperature. The faster a reaction, the larger the k value.

- ⊡ [A] and [B] represent the concentrations of reactants A and B in moles per liter (M).

- ⊡ x and y are the order of the reactant. They can only be determined by analyzing experimental data. These exponents are usually positive integers.

Determining the exponent for each reactant:
(We must use experimental data for this!):

- Find the trials that the reactant changes concentration and the other reactant STAYS THE SAME.
- Then, you will see what changes occurred to the rate between those two trials.
- Repeat this process for each reactant in the reaction.

Determining the order of the reaction:

$\text{Rate} = k[A][B]^2$

- The exponents determine the order of the reactants.
- *The sum of the exponents is the order of the reaction*.
- $\text{Rate} = k[A][B]^2$ is first order in A, second order in B, and third order overall.

Examples:

$2A + B \rightarrow 2C$			
Trial	[A]	[B]	Rate
1	0.10	0.20	0.10
2	0.10	0.40	0.20
3	0.20	0.40	0.80
Rate law:			

$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$			
Trial	$[NH_4^+]$	$[NO_2^-]$	Rate
1	0.100	0.005	1.35×10^{-7}
2	0.100	0.010	2.70×10^{-7}
3	0.200	0.010	5.40×10^{-7}
Rate law:			

How to solve for k:

Pick a trial. It does not matter which trial you pick just as long as you only use data from that trial.

$2\ ICl + H_2 \rightarrow I_2 + HCl$

Experiment	**[ICl]**	**$[H_2]$**	**Rate (mol/(L•s)**
1	0.1	0.1	1.6×10^{-3}
2	0.1	0.2	3.2×10^{-3}
3	0.2	0.1	6.4×10^{-3}

Determine the rate law for the above equation.

What is the value for k?

If the initial concentration for ICl is 0.4 M and H_2 is 0.7 M, what is the overall rate?

Reaction Mechanisms

Think about a group of friends getting ready for a fun night out. Every friend has their own bathroom and gets ready at different paces. Jill is ready in 30 minutes. Sam is ready in 90 minutes. Joe is ready in 15 minutes. Sean is ready in 100 minutes. Yvette is ready in 5 minutes. When can they leave? Why?

The friends are only as fast as their slowest friend. That's how reactions work. They are only as fast as their slowest step.

- A reaction mechanism is a series of steps (reactions) that make up the overall reaction. Most reactions do not occur in a single step but are the sum of multiple steps.

- Rate-limiting or rate-determining step -slowest step in a reaction. This determines how fast the reaction can go.

- Mechanisms are usually not completely known because of the short life of their "temporary products". Possible mechanisms must:
  - Agree with the rate law
  - Add up to the overall reaction

Y	→	M	(slow)
M + X	→	N	(fast)
N + X	→	Z	(fast)