2 Types of Reactions:

Completion Reactions:

- Results in a complete conversion of reactants to products
- ex: $Pb(NO_3)_2$ (aq) + 2NaI (aq) --> PbI_2 (s) + 2 $NaNO_3$ (aq)
- Will form a precipitate (insoluble solid) or a gas
- Most reactions DO NOT go to completion.
- Have a one-sided arrow

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2 Types of Reactions:

Reversible Reactions:

- Can occur in both the forward and reverse directions
  ex: N_2 (g) + 3 H_2 (g) <--> $2NH_3$ (g) ⇌
- Reactants can form products (forward):
  N_2 (g) + 3 H_2 (g) --> $2NH_3$ (g)
- Products can form reactants (reverse):
  $2NH_3$ (g) <-- N_2 (g) + 3 H_2 (g)
- Both occur at the same time whenever all the substances are present.

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Chemical Equilibrium:

- A state in which the forward and reverse reactions take place at equal rates.

  Forward rate = Reverse rate

- The amounts of the reactants and products are constant at equilibrium.
- Equilibrium is dynamic -- reactions are still occurring, although we may not be able to see it.

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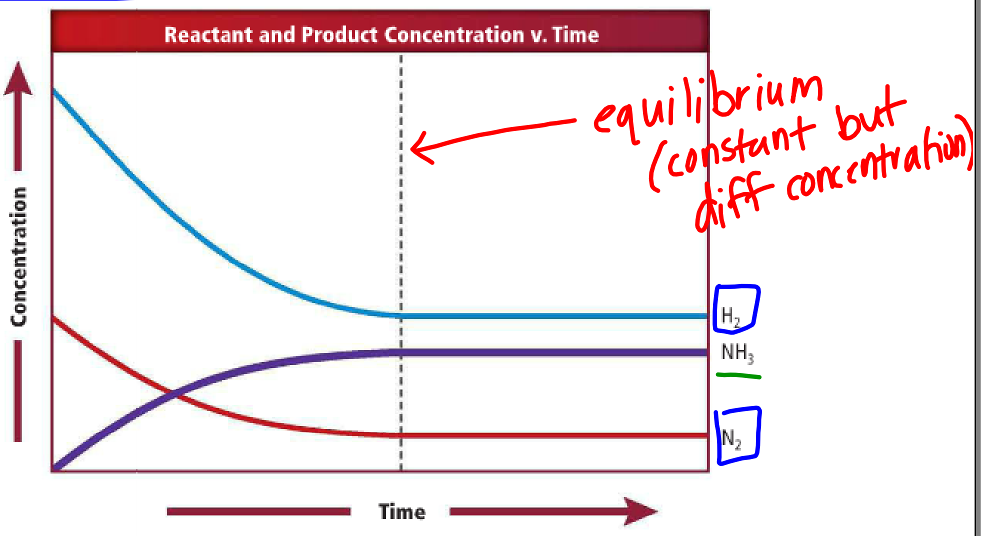
Chemical Equilibrium:

- N_2 (g) + 3 H_2 (g) --> $2NH_3$ (g)



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Law of Chemical Equilibrium:

- At a given temperature, a chemical system may reach a state in which a particular ratio of reactant and product concentrations has a constant value.

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Law of Chemical Equilibrium:

- For example, if this is a reaction:

$$aA + bB \leftrightarrow cC + dD$$

coefficients   reactants   products

Then you get a constant

$$K_{eq} = \frac{\text{Products}}{\text{reactants}} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

equilibrium constant

[ ] = concentration in M $\frac{mol}{L}$

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Law of Chemical Equilibrium:

$$Keq = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Keq

- is called the equilibrium constant
- is a number that can be calculated by inserting the molarity of each substance
- has no unit (or label)
- changes with temperature

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Law of Chemical Equilibrium:

$$Keq = \frac{[C]^c[D]^d}{[A]^a[B]^b} = \frac{\text{products}}{\text{reactants}}$$

If Keq > 1

- more products than reactants at equilibrium are favored
- products are favored

$\frac{5}{2} > 1$

If Keq < 1

- more reactants than products at equilibrium are favored
- reactants are favored

$\frac{2}{5} < 1$

Which do you think is better for business?

Keq > 1

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Law of Chemical Equilibrium:

$$Keq = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Homogeneous equilibrium: when all substances are in the same state of matter.

Heterogeneous equilibrium: when the substances are in more than one state of matter.

--NOTE: if any of the substances in the reaction are liquids or solids, leave them out of the expression

--Only leave gases and aqueous solutions in the expression for Keq

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Example:

$$Keq = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Write the equilibrium expression for the following equation:

$N_2O_4(g)$ <--> $2NO_2(g)$

$$Keq = \frac{[NO_2]^2}{[N_2O_4]}$$

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Example:

$$Keq = \frac{[C]^c[D]^d}{[A]^a[B]^b} = \frac{\text{products}}{\text{reactants}}$$

Write the equilibrium constant for the following equation:

~~C(s)~~ + H_2O (g) <--> CO (g) + H_2(g)

$$Keq = \frac{[CO][H_2]}{[H_2O]}$$

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Example:

$$Keq = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Calculate the Keq for the reaction below when $[SO_3]$=0.0160M, $[SO_2]$=0.00560M, and $[O_2]$=0.0210M. Are the products or the reactants favored?

$2SO_3$(g) <--> $2SO_2$(g) + O_2(g)

$$Keq = \frac{[SO_2]^2[O_2]}{[SO_3]^2} = \frac{([.00560]^2[.0210])}{([.0160]^2)}$$

$$= .00257$$

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