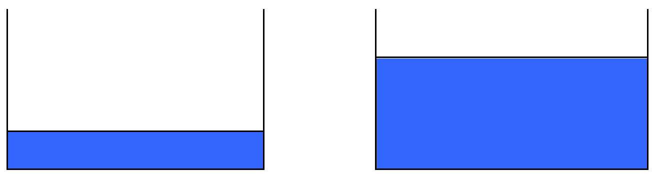
Equilibrium Notes #2
Equilibrium Constants (K): What they Tell Us

Consider the following reversible chemical reaction:

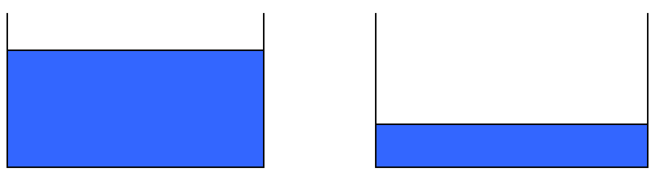
A + B ⇆ C + D $$K = \frac{[C]\,[D]}{[A]\,[B]}$$

By knowing the equilibrium constant (K), we can determine if we have more reactants or more products once the system reaches equilibrium.

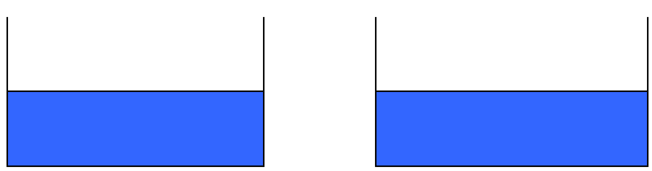
	A	+	**B**	⇆	**C**	+	**D**	**K** =
Equilibrium Conc.	0.2 M		0.1 M		0.6 M		0.7 M	



	A	+	**B**	⇆	**C**	+	**D**	**K** =
Equilibrium Conc.	0.8 M		0.5 M		0.03 M		0.02 M	



	A	+	**B**	⇆	**C**	+	**D**	**K** =
Equilibrium Conc.	0.3 M		0.3 M		0.3 M		0.3 M	



If K >> 1……………**PRODUCTS FAVORED** AT EQUILIBRIUM

If K << 1……………**REACTANTS FAVORED** AT EQUILIBRIUM

If K = 1……………..**NEITHER SIDE IS FAVORED** [REACTANTS] = [PRODUCTS]

Consider the following reversible chemical reaction.

$H_2CO_3\ (aq) \leftrightarrows H^{1+}\ (aq) + HCO_3^{1-}\ (aq)$ $K = 4.2 \times 10^{-7}$

(a) Which side of this equilibrium reaction is favored?

(b) Write the generic equilibrium expression for this reaction.

What happens to the equilibrium constant, K, if we reverse the way this reaction is written?

$H^{1+}\ (aq) + HCO_3^{1-}\ (aq) \leftrightarrows H_2CO_3\ (aq)$ $K_{reverse} = ???$

(c) Write the generic equilibrium expression for this <u>reverse reaction</u>.

$K_{reverse} =$

(d) What is the actual $K_{reverse}$ value?

What if all of the coefficients in the equation are "doubled? How will that change the equilibrium constant K ?

$H_2CO_3\ (aq) \leftrightarrows H^{1+}\ (aq) + HCO_3^{1-}\ (aq)$ $K = 4.2 \times 10^{-7}$

$\mathbf{2}\ H_2CO_3\ (aq) \leftrightarrows \mathbf{2}\ H^{1+}\ (aq) + \mathbf{2}\ HCO_3^{1-}\ (aq)$ $K_{double} = ???$

Key Aspects of Equilibrium Constants (K values) and Equilibrium Expressions

1. K values have no units. They are dimensionless.

2. K values correspond to specific temperatures. Each K value has a temperature associated with it because the K values will change with temperature increases or decreases.

3. Doubling the coefficients will cause K values to be squared. Likewise, tripling coefficients will cause the K values to be cubed. Easy to show this with math!

4. $K_{reverse} = \dfrac{1}{K_{forward}}$ Easy to show this with math!

5. Pure solids and pure liquids do NOT appear in the equilibrium expression

$$\mathbf{NH_3\,(aq) + H_2O\,(l) \leftrightarrows NH_4^{1+}\,(aq) + OH^{1-}\,(aq)}$$

$$K = \frac{[NH_4^{1+}]\,[OH^{1-}]}{[NH_3]\,[H_2O]}$$ *must cancel out the liquid H_2O*

$$\mathbf{HC_2H_3O_2\,(aq) + H_2O\,(l) \leftrightarrows C_2H_3O_2^{1-}\,(aq) + H_3O^{1+}\,(aq)}$$

$$K = \frac{[C_2H_3O_2^{1-}]\,[H_3O^{1+}]}{[HC_2H_3O_2]\,[H_2O]}$$ *must cancel out the liquid H_2O*

$$\mathbf{CaCO_3\,(s) \leftrightarrows CaO\,(s) + CO_2\,(g)}$$

$$K = \frac{[CaO]\,[CO_2]}{[CaCO_3]}$$ *must cancel out the solids*