CHEMICAL EQUILIBRIUM

Chemical equilibrium is a condition in which the concentrations of all of the reactants and products ease to change with time when equilibrium is established, the rate at which products are produce from the reactants equals the rate at which reactants are produced from products.

An adequate representation of chemical equilibrium is shown by observing the **Haber process**. The Haber process is defined as the catalyst system and conditions of temperature and pressure developed by a German chemist known as Fritz Haber (1868-1934) and co-workers for the formation of NH3 (ammonia) from H2 (hydrogen gas) and N2 (nitrogen gas). The following is the equation for the Haber process:

$$N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$$

Now you should have the basics behind the concept of chemical equilibrium. Now, we must set up an equilibrium-constant expression. The letter "K" is referred to as the equilibrium constant. The following is as example of how an equilibrium constant expression would be set up.

Equation :	**Equilibrium-Constant Expression:**	
$jA + kB \Leftrightarrow mC + nD$	$K = \dfrac{[C]^m[D]^n}{[A]^j[B]^k}$	$\dfrac{\text{products}}{\text{reactants}}$

Example Problem:

At 1285°C, the equilibrium constant for the reaction $Br_{(g)}$ in the vessel?

Step 1 : Write a balanced equation for the given reaction.

$$Br_{(g)} \Leftrightarrow 2Br_{(g)}$$

Step 2: Set up the equilibrium-constant expression.

$$K_c = 1.04 \text{ x } 10^{-3} = \frac{[Br]^2}{[Br]}$$

Step 3: Calculate the molarity for the molecules in solution.

$$[Br_2] = \frac{0.245g\ Br_2}{0.200L\ solution} \text{ x } \frac{1\ mole\ Br_2}{159.8g\ Br_2} = 7.67 \text{ x } 10^{-3}\ M$$

$$M = \frac{\text{moles of solute}}{\text{liters of solution}}$$

Step 4 : Replace the calculated values into the equilibrium-constant expression and solve for the unknown (the value you are looking for; in this case the mass of Br).

$$K_c = 1.04 \text{ x } 10^{-3} = \frac{Br]^2}{[7.67 \text{ x } 10^{-3}]}$$

Now solve for Br:

$$K_c = (1.04 \text{ x } 10^{-3})(7.67 \text{ x } 10^{-3}) = [Br]^2$$

$$K_c = 7.977 \text{ x } 10^{-6} = [Br]^2$$

$$\sqrt{7.977 \text{ x } 10^{-6}} = [Br] = 0.002824 \text{ M Br}$$

Solve for the mass of Br:

$$Molarity = \frac{moles\ of\ solute}{liters\ of\ solution}$$

Calculate the number of moles of Br when given the molarity of **Br = 0.002824 M.**

$$0.002824\ M\ Br = \frac{moles\ Br}{0.200\ L}$$

$$(0.002824 \text{ M Br})(0.200 \text{ L}) = \text{moles Br}$$

$$\text{moles Br} = 5.648 \text{ x } 10^{-4}$$

Last Step: Calculate the mass of Br needed for this experiment.

$$5.648 \text{ x } 10^{-4}\ moles\ Br\ x\ \frac{79.9g\ Br}{1\ mole\ Br} = 0.0451g\ Br$$

Utilizing the ideal-gas equation, you can calculate for K_p or K_c

Equation 1: $PV = \frac{n\ RT}{\mathbf{V}} \Rightarrow P = \frac{n\ \ RT}{\mathbf{V}} = MRT$

Note: M = molarity = $\frac{n}{V}$

$$\therefore K_p = K_c(RT)^{\Delta n}$$

$\Delta n =$ the number of moles of gaseous products minus the number of moles of gaseous reactants.
The equilibrium constant expression allows us (1) to predict the direction in which a reaction mixture will proceed to achieve equilibrium, and (2) to calculate the concentrations of reactants and products once equilibrium has been reached.

When we substitute reactant and product concentrations into the equilibrium-constant expression as we did above, the result is known as the **reaction quotient (Q).**

Q > K: The **reactants** are favored.
Q > K: The **products** are favored.
Q = K: Equilibrium is established.

Le Chatelier's principle: If a system at equilibrium is disturbed by a change in temperature, pressure, or the concentration of one of the components, the system will shift its equilibrium position so as to counteract the effect of the disturbance.

$$A_{(g)} + B_{(g)} \Leftrightarrow \uparrow C_{(g)}$$

If the number of moles of A increases (by adding solution A) then the number of moles of B decreases, but C increases.

$$\uparrow A_{(g)} + \downarrow B_{(g)} \Leftrightarrow \uparrow C_{(g)}$$

If the number of moles of A decreases (by moving solution A) then the number of moles of B increases, but C decreases.

$$\downarrow A_{(g)} + \uparrow B_{(g)} \Leftrightarrow \downarrow C_{(g)}$$

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