Chemical Equilibrium

- Some reactions are reversible

reactants → products — forward reaction

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

reactants ← products — reverse reaction

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

You show the reaction is reversible by using DOUBLE ARROWS

reactants ⇌ products

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

- Dynamic Equilibrium occurs when...

the rate of the forward reaction = the rate of the reverse reaction

@ equilibrium...

- the concentrations of the reactants and products WILL NOT CHANGE!
- the concentrations of the reactants and products DO NOT HAVE TO BE EQUAL!

The Equilibrium Expression (it's an equation)

general format

substances

$$aA + bB \rightleftharpoons cC + dD$$

coefficients

concentration (molarity)

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

equilibrium constant

Solids & Liquids are <u>NEVER</u> written in the expression!

Examples - write the equilibrium expression for these reversible reactions:

(1) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

(2) $Mg(s) + 2H_2O(l) \rightleftharpoons Mg(OH)_2(aq) + H_2(g)$

$$K_{eq} = \frac{[Mg(OH)_2][H_2]}{1}$$

(3) $Br_2(g) \rightleftharpoons Br_2(l)$

$$K_{eq} = \frac{1}{[Br_2]}$$

(4) $2C_8H_{18}(l) + 25O_2(g) \rightleftharpoons 16CO_2(g) + 18H_2O(g)$

$$K_{eq} = \frac{[CO_2]^{16}[H_2O]^{18}}{[O_2]^{25}}$$

Calculating Keq

(1) $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

calculate Keq when the equilibrium mixture contains .0203 M CH_3OH, .151 M H_2, and .0850 M CO.

$$K_{eq} = \frac{[CH_3OH]}{[CO][H_2]^2} = \frac{[.0203M]}{[.0850M][.151M]^2}$$

$$K_{eq} = 10.5 \ \frac{1}{M^2}$$

$$\frac{\cancel{M} \ 1}{(\cancel{M} \cdot M^2)} =$$

(2) The equilibrium constant for the reaction

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

is (Keq) .849. Find the concentration of I_2 when $[H_2]$ is 4.479×10^{-4} M and [HI] is 3.240×10^{-4} M.

?

$$K_{eq} = \frac{[H_2][I_2]}{[HI]^2} \qquad .849 = \frac{[4.479 \times 10^{-4} M][I_2]}{[3.240 \times 10^{-4} M]^2} \qquad \frac{M}{M^2}$$

$$1 \cdot \frac{M}{1} = \frac{1}{\frac{1}{M}}$$

$$\frac{.849}{4266.689529 \frac{1}{M}} = \frac{\cancel{4266.689529 \frac{1}{M}}[I_2]}{\cancel{4266.689529 \frac{1}{M}}}$$

$$.000199 \, M = [I_2]$$

(3) For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, Keq is .393 $1/M^2$. What is the concentration of H_2 if $[N_2]$ is .25 M and the $[NH_3]$ is .86 M

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3} \qquad .393 \ \frac{1}{M^2} = \frac{[.86M]^2}{[.25M][H_2]^3}$$

$$[H_2]^3 \cdot .393 \ \frac{1}{M^2} = \frac{2.9584M}{\cancel{[H_2]^3}} \cdot \cancel{[H_2]^3}$$

$$\frac{[H_2]^3 \cdot \cancel{.393 \ 1/M^2}}{\cancel{.393 \ 1/M^2}} = \frac{2.9584M}{.393 \ 1/M^2}$$

$$[H_2]^3 = 7.527735369 \ M^3$$

$$\sqrt[3]{[H_2]^3} = \sqrt[3]{7.527735369 M^3}$$

$$[H_2] = 2.0 \ M$$