Equilibrium Expression:

Equilibrium, just like reaction rate, can be expressed using the equilibrium expression.

Remember the general equations for reaction rate.

$$wA + xB = yC + zD$$

Forward Reaction Rate = $K_f [C]^y[D]^z$
Reverse Reaction Rate = $K_R[A]^w[B]^x$

The Equilibrium constant K_{eq} is an expression of how complete a chemical reaction will be. A large K_{eq} means a reaction will go almost to completion.

$$wA + xB = yC + zD$$

Forward Reaction Rate = $K_f [C]^y[D]^z$
Reverse Reaction Rate = $K_R[A]^w[B]^x$

$K_{eq} = K_f / K_r$

so $K_{eq} = \dfrac{[C]^y[D]^z}{[A]^w[B]^x}$

for the chemical reaction;

$$2NaI + H_2S = 2HI + Na_2S$$

The Equilibrium expression is;

$$K_{eq} = \frac{[HI]^2[Na_2S]}{[NaI]^2[H_2S]}$$

When a chemical reaction is at equilibrium the forward reaction rate equals the reverse reaction rate so:

$$K_f [A]^w[B]^x = K_r [C]^y[D]^z$$

$$\frac{K_f}{K_r} = \frac{[C]^y[D]^z}{[A]^w[B]^x}$$

$$K_{eq} = \frac{K_f}{K_r} = \frac{[C]^y[D]^z}{[A]^w[B]^x}$$

Write the equilibrium expression for:

$K_2SO_4 + CaCl_2 \rightleftharpoons 2KCl + CaSO_4$

$$K_{eq} = \frac{[KCl]^2[CaSO_4]}{[K_2SO_4][CaCl_2]}$$

When $K_{eq} > 1$ the reaction favors the forward direction (it goes to completion)

When $K_{eq} < 1$ the reaction favors the reverse direction (not much happens)

Explain whether the following reactions favor the forward or reverse reaction.

The reaction of Strontium Chloride with Silver Sulfide where there are .25 M reactants and .01 M of the products.

The reaction of a .2575 M solution of Acetic acid with a .150 M Sodium Hydroxide Solution. A .100 M solution Sodium Acetate is formed.

$$SrCl_2 + Ag_2S \rightleftharpoons 2AgCl + SrS$$

$$K_{eq} = \frac{[AgCl]^2[SrS]}{[SrCl_2][Ag_2S]}$$

$$K_{eq} = \frac{(.01M)^2(.01M)}{(.25M)(.25M)}$$

$$K_{eq} = \frac{(.01M)^3}{(.25M)^2} = 1.6 \times 10^{-5} M$$

$$HC_2H_3O_2 + NaOH \rightleftharpoons NaC_2H_3O_2 + HOH$$

$$K_{eq} = \frac{[NaC_2H_3O_2]}{[HC_2H_3O_2][NaOH]}$$

$$K_{eq} = \frac{(.1\,M)}{(.2575\,M)(.150\,M)}$$

$$K_{eq} = 2.59\ M^{-1}$$

Find the concentration of Ammonium Chlorate for the reaction of a .250 M solution of Sodium Chlorate with a .125 M solution of Ammonium Sulfate. The concentration of the Sodium Sulfate is .125 M and the Keq = .00125

$$2NaClO_3 + (NH_4)_2SO_4 \rightleftharpoons 2NH_4ClO_3 + Na_2SO_4$$

$$K_{eq} = \frac{[NH_4ClO_3]^2[Na_2SO_4]}{[NaClO_3]^2[(NH_4)_2SO_4]}$$

$$.00125 = \frac{x^2(.125M)}{(.250)^2(.125)}$$

$$x = .00884\ M$$

K_a

K_b