<u>Equilibrium Constant Problems</u>

Calculating Equilibrium Concentrations:

Step 1: Write out the equation of the reaction
Step 2: Write out the K_{eq} expression
Step 3: Use ICE diagrams if needed

Example # 1: For the following equilibrium system:

$$2\ NO_{2\,(g)} \Leftrightarrow 2\ NO_{(g)} + O_{2\,(g)} \qquad K_{eq} = 8.0 \times 10^{-1}$$

When the system is at equilibrium it is known that $[NO_{2\,(g)}] = 0.60$ mol/L and $[NO_{(g)}] = 0.40$ Calculate the equilibrium concentration of $O_{2\,(g)}$.

Example #2: At the same temperature, the same system as above is at equilibrium with
$[NO_{(g)}] = 0.25$ mol/L and $[O_{2(g)}] = 0.20$ mol/L

Example #3: Initially 0.32 moles of $N_{2\,(g)}$ gas and 0.66 moles $H_{2\,(g)}$ were placed in a 1.0 L container. At equilibrium the concentration of $H_{2(g)}$ was 0.30 mol/L. Calculate the equilibrium concentrations of all the entities and then calculate the K_{eq}.

$$N_{2\,(g)} + 3\,H_{2\,(g)} \Leftrightarrow 2\,NH_{3\,(g)}$$

Example #4: Using the following information calculate the value of $HI_{(g)}$. Initially the concentrations of $H_{2\,(g)}$ and $I_{2\,(g)}$ were 0.200 mol/L. Calculate the concentration of $HI_{(g)}$ at equilibrium.

$$H_{2\,(g)} + I_{2\,(g)} \Leftrightarrow 2\,HI_{(g)}$$

Questions:

1. Consider the following reaction, which is at equilibrium:

   $2\ SeO_{2\,(g)} + O_{2\,(g)} \Leftrightarrow 2SeO_{3\,(g)}$ $\quad K_{eq} = 3.6 \times 10^{-2}$

   At equilibrium, $[SeO_2] = 4.5 \times 10^{-1}$ mol/L and $[O_2] = 7.0 \times 10^{-1}$ mol/L. Calculate the equilibrium $[SeO_3]$.

2. For the reaction: $2\ SO_{3\,(g)} \Leftrightarrow 2\ SO_{2\,(g)} + O_{2\,(g)}$

   A chemist placed 0.100 mol of $SO_{3\,(g)}$ and 0.200 mol of $SO_{2\,(g)}$ in a 5.00 L container. At equilibrium, the $[SO_3]$ was found to be 0.0160 mol/L. Calculate the value of K_{eq}.

3. Consider the equation of the reversible reaction:

$$CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2\,(g)} + H_{2\,(g)} \qquad \Delta H = -300kJ$$

Initially 0.500 mol of $CO_{(g)}$ and 0.500 $H_2O_{(g)}$ are placed in a 2.00 L container at 400°C. Calculate the equilibrium concentrations of all species at equilibrium. Calculate K_{eq} if the final $[H_2O] = 0.100M$.

If the reaction were carried out at 700°C how would the value of K_{eq} compare with that of 400°C?

4. For the reaction: $2\ H_2S_{(g)} \Leftrightarrow 2\ H_{2\,(g)} + S_{2\,(g)}$
   4.8×10^{-2} mol of $H_2S_{(g)}$ was placed in a 2.00 L container. At equilibrium, the $[S_2]$ was found to be 1.1×10^{-2} mol/L. Calculate the value of K_{eq}.

5. 1.00 mol of each of $A_{(aq)}$, $B_{(aq)}$, $C_{(aq)}$, $D_{(aq)}$ are dissolved in 500 mL of water, The following equilibrium is achieved:

$$A_{(aq)} + B_{(aq)} \Leftrightarrow C_{(aq)} + D_{(aq)} \qquad K_{eq} = 0.25$$

Calculate the equilibrium concentrations of all four species. (Which direction will the system move to achieve equilibrium?)

6. At 1000°C, $K_{eq} = 3.60$ for the reaction:

$$NO_{2\,(g)} + SO_{2\,(g)} \Leftrightarrow NO_{(g)} + SO_{3\,(g)}$$

Initially, 0.200 mol of $NO_{2\,(g)}$ and 0.200 mol of $SO_{2\,(g)}$ are placed in a 5.00 L container. Calculate the equilibrium concentrations of all four species.