Solving Equilibrium Problems

In solving equilibrium problems, we must be aware of the balanced equation that represents the system, and we must keep track of the changes that occur within the system as it progresses toward equilibrium. It is convenient to organize the data in a logical format so that the proper conclusions may be drawn. A table like the one below is very useful.

Balanced equation: A + 2B <-> C + D

Initial concentration				
Change in concentration				
Equilibrium concentration				

Sample Problem 1.

The reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ is carried out at 690. K with the following initial concentrations: $[H_2] = 1.000 \times 10^{-3}$ M; $[I_2] = 2.000 \times 10^{-3}$ M; [HI] = 0.000 M. When the reaction reaches equilibrium, $[HI] = 1.880 \times 10^{-3}$ M. Calculate the equilibrium constant K_c for this reaction.

Sample Problem 2.

$PCl_5(g)$ undergoes the following dissociation reaction at 500°C: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$.

1.000 mole of PCl_5 is placed in a 2.000-liter container. At equilibrium, 19.04% of the PCl_5 molecules have dissociated. Calculate the equilibrium constant for this reaction.

Sample Problem 3.

At 690. K, the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ has an equilibrium constant $K_c = 55.6$. A 255.8-gram sample of HI is placed in a 2.000 liter container at 690 K. When equilibrium is attained, what are the equilibrium concentrations of H_2, I_2, and HI?

Sample Problem 4.

At 523 K, the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ has an equilibrium constant $K_p = 78.3$. A 0.150-mole sample of PCl_5 is placed in a 5.00-liter container and allowed to come to equilibrium at 523 K. Calculate the total pressure in the container.

How do we know when the equilibrium constant is small enough to use approximation methods? A handy rule of thumb is to employ the "5% rule":

- If the equilibrium constant *seems* small to you, assume it is small enough and solve the problem by approximation.
- Compare the value you calculated for x with the value from which x is neglected.
- If $x < 5\%$ of this value, your approximation was correct. If not, you must solve the resulting equation exactly.

Sample Problem 5.

At a certain temperature, the reaction $2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$ has an equilibrium constant $K_c = 2.0 \times 10^{-13}$. A 3.00-liter container at this temperature contains 0.150 mole of N_2 and 0.270 mole of O_2 initially. Calculate the equilibrium concentrations of N_2, O_2, and N_2O.