Forestville Central School • AP Chemistry Name ______________________________

15 • Chemical Equilibrium

15.4- 15.5 Calculating Equilibrium Concentrations and Constants

The Reaction Quotient

When we start with only reactants or only products, there is only one possible direction in which the reaction can go. In the case of the Haber process, if we start with N_2 and H_2 but no NH_3, the reaction can only proceed as

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

The reaction must proceed to the right in order to achieve equilibrium. Likewise, if we were to start with only NH_3 and no H_2 or N_2, the reaction must proceed to the left to achieve equilibrium. When we start with quantities of both reactants *and* products, we must *determine* which direction the reaction will go to achieve equilibrium. We do this by calculating the **reaction quotient**. The reaction quotient is calculated the same way as the equilibrium constant—by plugging concentrations of reactants and products into the equilibrium expression. The difference is that the concentrations we plug in to get the reaction quotient are not *equilibrium* concentrations.

If we start with a mixture that is 0.1 *M* H_2, 0.1 *M* N_2, and 0.1 *M* NH_3, the reaction quotient, Q, is

$$Q = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.1)^2}{(0.1)(0.1)^3} = 100$$

Having calculated Q, we compare its value to that of K. If Q is *less* than K, the reaction will proceed to the right. If Q is *greater* than K, the reaction will proceed to the *left*. Q is *equal* to K at equilibrium.

At 472°C, K_c for this reaction is 0.105. Since Q is greater than K, this reaction will proceed to the left, meaning that NH_3 concentration will decrease and the concentrations of N_2 and H_2 will increase to achieve equilibrium.

$Q > K$	$Q = K$	$Q < K$
Reaction proceeds to the left to achieve equilibrium.	System is at equilibrium.	Reaction proceeds to the right to achieve equilibrium.

Practice problem: At 448°C the equilibrium constant, Kc, for the reaction is 51.

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

Predict how the reaction will proceed to reach equilibrium at 448°C if we start with 2.0×10^{-2} mol of HI, 1.0×10^{-2} mol of H_2, and 3.0×10^{-2} mol of I_2 in a 2.0 L container.