5.2 – Equilibrium Constant – K_{eq} – Worksheet

1. Write equilibrium expressions for the following reversible reactions:

a. $2\,NO_{2\,(g)} \leftrightarrow N_2O_{4\,(g)}$

$$K_{eq} = \frac{[N_2O_4]}{[NO_2]^2}$$

b. $N_{2\,(g)} + 3\,H_{2\,(g)} \leftrightarrow 2\,NH_{3\,(g)}$

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

c. $H_2O_{(g)} + \cancel{C_{(s)}} \leftrightarrow H_{2(g)} + CO_{(g)}$

$$K_{eq} = \frac{[H_2O]}{[H_2][CO]}$$

d. $2\,SO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2\,SO_{3\,(g)}$

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

e. $\cancel{Cu_{(s)}} + 2Ag^+_{(aq)} \leftrightarrow Cu^{2+}_{(aq)} + 2\cancel{Ag_{(s)}}$

$$K_{eq} = \frac{[Cu^{2+}]}{[Ag^+]^2}$$

2. For the equilibrium system described by $2\,SO_2\,(g) + O_2\,(g) \leftrightarrow 2\,SO_3\,(g)$ at a particular temperature the equilibrium concentrations of SO_2, O_2 and SO_3 were 0.75 M, 0.30 M, and 0.15 M, respectively. At the temperature of the equilibrium mixture, calculate the equilibrium constant, Keq, for the reaction.

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{[0.15M]^2}{(0.75M)^2(0.3M)} = \boxed{0.13}$$

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3. For the equilibrium system described by: $PCl_5\ (g) \leftrightarrow PCl_3\ (g) + Cl_2\ (g)$ Keq equals 35 at 487°C. If the concentrations of the PCl_5 and PCl_3 are 0.015 M and 0.78 M, respectively, what is the concentration of the Cl_2?

$$K_{eq} = \frac{[PCl_3][Cl_2]}{[PCl_5]} \Rightarrow 35 = \frac{(0.78M)[Cl_2]}{(0.015M)}$$

$$[Cl_2] = 0.67M$$

4. Find the concentration of the products for the following:

$NH_4Cl_{(s)} \leftrightarrow NH_{3(g)} + HCl_{(g)}$ when $K_{eq} = 6.0 \times 10^{-9}$

$$K_{eq} = [NH_3][HCl]$$

$$6.0\times10^{-9} = (x)(x)$$

$$\sqrt{6.0\times10^{-9}} = x$$

$$x = 7.7\times10^{-5}M = [NH_3] = [HCl]$$

5. For the equilibrium reaction

$CO_{(g)} + H_2O_{(g)} \leftrightarrow CO_{2(g)} + H_{2(g)}$

the K_{eq} value at 690°C = 10.0. A reaction mixture is analyzed and found to contain 0.80M CO, 0.050M H_2O, 0.50M CO_2, and 0.40M H_2. Show that the reaction is not at equilibrium.

$$K_{eq} = \frac{[CO_2][H_2]}{[CO][H_2O]} = \frac{(0.5M)(0.4M)}{(0.8M)(0.05M)} = 5$$

since $K_{eq} \neq 10$, it is not at equilibrium

6. For each of the following reactions, state whether the value of the equilibrium constant favours the formation of reactants or products.

a. $I_{2(g)} + Cl_{2(g)} \rightleftharpoons 2ICl_{(g)}$ $K_{eq} = 2\times10^{6}$ Products

b. $H_{2(g)} + Cl_{2(g)} \rightleftharpoons 2HCl_{(g)}$ $K_{eq} = 1.08$ Neither

c. $I_{2(g)} \rightleftharpoons I_{(g)} + I_{(g)}$ $K_{eq} = 3.8\times10^{-7}$ Reactants.