ICHO PRACTICE EXERCISE SOLUTIONS

GAS AND SOLUTION EQUILIBRIUM

1. Write the equilibrium constant expression, K_c and K_p for the following reactions (if applicable):

(a) $3O_2(g) \rightleftharpoons 2O_3\,(g)$

$$K_p = \frac{P^2O_3}{P^3O_2}$$

(b) $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$

$$K_p = \frac{P_{COCl_2}}{P_{CO}\,P_{Cl_2}}$$

(c) $2\,NO_2(g) + 7H_2(g) \rightleftharpoons 2NH_3(g) + 4H_2O(\ell)$

$$K_p = \frac{P_{NH_3}^2}{P_{NO_2}^2\,P_{H_2}^7}$$

(d) $H_2O(g) + C(s) \rightleftharpoons CO(g) + H_2(g)$

$$K_p = \frac{P_{CO}\,P_{H_2}}{P_{H_2O}}$$

2. The equilibrium constant (Kc) for the following reaction

$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$ is 4.1×10^{-34} at 25^oC.

Calculate the equilibrium constant for the reaction:

(a) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$

Note: When the equation for a reversible reaction is written int he opposite direction, the equilibrium constant becomes the reciprocal of the original equilibrium constant

$$K_c = \frac{1}{4.1 \times 10^{-34}} = \mathbf{2.44 \times 10^{33}}$$

(b) $4H_2(g) + 4Cl_2(g) \rightleftharpoons 8HCl(g)$

K_c = **$[2.44 \times 10^{34}]^4$**

3. Consider the following equilibrium process:

$$H_2(g) + S_2(g) \rightleftharpoons H_2S\ (g)$$

Analysis shows that there are 2.5 mols of H_2 and 1.35 X 10^{-5} moles of S_2, and 8.70 moles of H_2S in a 12.0L flask Calculate the equilibrium constant K_c for the reaction.

$[H_2] = \frac{2.5\ mols}{12.0\ L} = 0.2083$ M, $[S_2] = = \frac{1.35 \times 10^{-5}\ mols}{12.0\ L} = 1.125 \times 10^{-6}$M

$[H_2S] = \frac{8.70\ mols}{12.0\ L} = 0.725$ M

$K_c = \frac{[0.725M]}{[0.2083M][1.125 \times 10^{-6}M]} = \frac{[0.725M]}{[2.343 \times 10^{-7}M]} = \mathbf{3.094 \times 10^6}$

4. The equilibrium constant Kp for the reaction,

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$

is 1.8 X 10^{-5} at 350°C. What is the K_c for this reaction.

$K_p = K_c\,(RT)^{\Delta n}$

$K_c = \frac{K_p}{(RT)^{\Delta n}} = \frac{1.8 \times 10^{-5}}{(0.0821 \times (350+273)K)^1} = \frac{1.8 \times 10^{-5}}{0.0821 \times 623K} = \mathbf{3.617 \times 10^{-7}}$

5. What is the K_p at 1273°C for the reaction $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$ if K_c is 2.24 X 10^{22}. Comment on the extent of the equilibrium.

$K_p = K_c\,(RT)^{\Delta n}$

$= (2.24 \text{ X } 10^{22})[(0.0821)(1273 + 273)K^{(2-3)}]$

$= (2.24 \text{ X } 10^{22})[(0.0821)(1546K)^{-1}]$

$= (2.24 \times 10^{22})(7.879 \times 10^{-3})$

$= \mathbf{1.765 \times 10^{20}}$

The reaction goes 100% to completion

6. Pure phosgene gas ($COCl_2$), 3 .00 X 10^{-2} mol, was placed in a 1.5 L container. It was heated to 800K, and at equilibrium the pressure of CO was found to be 0.497 atm. Calculate the equilibrium concentration, Kp for the reaction:

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

7. The following equilibrium constants were calculated for hydrosulfuric acid at 25 °C:

$$H_2S(aq) \rightleftharpoons H^+(aq) + HS^-(aq) \quad K'_c = 9.5 \text{ X } 10^{-8}$$

$$HS^-(aq) \rightleftharpoons H^+(aq) + S^{2-}(aq) \quad K''_c = 1.0 \text{ X } 10^{19}$$

Calculate the equilibrium constant for the following reaction:

$H_2S(aq) \rightleftharpoons 2H^+ + S^{2-}(aq)$

$K_c = K'_c \times K''_c$

$= (9.5 \text{ X } 10^{-8})(1.0 \text{ X } 10^{19}) = \mathbf{9.5 \times 10^{11}}$