Review Problems -- Chapter 14

1. Initially, 0.20 mole PCl₃ and 0.10 mole Cl₂ are placed in a 1.00-L container. The following reaction occurs.

\[
\text{PCl₃(g) + Cl₂(g) \rightleftharpoons PCl₅(g)}
\]

Consider two alternative problems.

(a) If the equilibrium concentration of PCl₅ is found to be 0.080 M, calculate \( K_c \).

(b) If \( K_c \) is known to be 33.3, calculate the concentration of PCl₅ at equilibrium.

2. For the following reaction, \( K_c = 64 \). Initially, 0.10 mole H₂ and 0.10 mole I₂ are placed in a 500-mL container. Calculate the equilibrium concentrations of all three species.

\[
\text{H₂(g) + I₂(g) \rightleftharpoons 2 HI(g)}
\]

3. For the following reaction, which occurs in air, \( K_c = 4.8 \times 10^{-31} \). If the initial concentrations are \([\text{N₂}] = 0.033 \text{ M and } [\text{O₂}] = 0.0081 \text{ M}, calculate the concentration of NO at equilibrium.

\[
\text{N₂(g) + O₂(g) \rightleftharpoons 2 NO(g)}
\]

4. For the following reaction, \( K_c = 4.3 \times 10^{4} \). Initially, 0.200 mole of H₂CO₂ is placed in a 1.0-L container. Calculate the equilibrium concentrations of all three species.

\[
\text{H₂CO₂(g) \rightleftharpoons CO(g) + H₂O(g)}
\]

5. Consider the following gas-phase reaction for which \( K_c = 5.8 \times 10^{6} \) at 850 K. At this temperature, 0.60 moles of NH₃ and 0.30 moles of H₂ are combined in a 1.00-L container and the system is allowed to reach equilibrium. Determine the equilibrium concentrations of all three gases. (Clearly state and justify any assumptions that you make.)

\[
2 \text{NH₃(g) \rightleftharpoons N₂(g) + 3 H₂(g)}
\]

6. Ammonia can be synthesized according to the following reaction:

\[
\text{N₂(g) + 3 H₂(g) \rightleftharpoons 2 NH₃(g)} \quad K_c = 5.3 \times 10^{-5}
\]

A 200.0 L reaction container initially contains 1.27 kg of N₂ and 0.310 kg of H₂ at a certain temperature. Assuming ideal gas behavior, calculate the mass of NH₃ (in g) present in the reaction mixture at equilibrium. (Clearly state and justify any assumptions that you make.)
Answers to Review Problems -- Chapter 14

1.a  33.3
b.  0.08 mol/L

2.  \([\text{HI}] = 0.32 \text{ M}; \ [\text{H}_2] = 0.04 \text{ M}; \ [\text{I}_2] = 0.04 \text{ M}\)

3.  \([\text{NO}] = 2x = 1.13 \times 10^{-17} \text{ M}\)

4.  \([\text{H}_2\text{CO}_2] = 9.3 \times 10^{-7} \text{ M}; \ [\text{CO}] = [\text{H}_2\text{O}] = 0.2 \text{ M}\)

5.  At equilibrium: \([\text{NH}_3] = 3.0 \times 10^{-4} \text{ M} \quad [\text{N}_2] = 0.30 \text{ M} \quad [\text{H}_2] = 1.20 \text{ M}\)

6.  8.0 g