1. Write the equilibrium constant expression for the following reaction:

\[
4 \text{NH}_3(\text{g}) + 7 \text{O}_2(\text{g}) \leftrightarrow 4 \text{NO}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{g})
\]

\[
K_c = \frac{[\text{NO}_2]^4[\text{H}_2\text{O}]^6}{[\text{NH}_3]^4[\text{O}_2]^7}
\]

2. The following equilibrium concentrations were observed for the Haber process at 127°C. [\text{NH}_3] = 3.1 \times 10^{-2} \text{ M}, [\text{N}_2] = 8.5 \times 10^{-1} \text{ M}, [\text{H}_2] = 3.1 \times 10^{-3} \text{ M}.

\[
\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \leftrightarrow 2 \text{NH}_3(\text{g})
\]

a. Calculate the value of \(K_c\) at 127°C for this reaction.

\[
K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}
\]

\[
K_c = \frac{(3.1 \times 10^{-2})^2}{(8.5 \times 10^{-1})(3.1 \times 10^{-3})^3} = 3.8 \times 10^4
\]

b. Calculate the value of the equilibrium constant at 127°C for the reaction

\[
2 \text{NH}_3(\text{g}) \leftrightarrow \text{N}_2(\text{g}) + 3 \text{H}_2(\text{g})
\]

\[
K'_c = \frac{1}{K_c}
\]

\[
K'_c = \frac{1}{3.8 \times 10^4} = 2.6 \times 10^5
\]

c. Calculate the value of the equilibrium constant at 127°C for the reaction

\[
\frac{1}{2} \text{N}_2(\text{g}) + \frac{3}{2} \text{H}_2(\text{g}) \leftrightarrow \text{NH}_3(\text{g})
\]

\[
K_c^* = (K_c)^{1/2}
\]

\[
K_c^* = \left(3.8 \times 10^4\right)^{1/2} = 1.9 \times 10^2
\]
d. Calculate $K_p$ for the at 127°C for the reaction

\[ \text{N}_2 \, (g) \, + \, 3 \, \text{H}_2 \, (g) \leftrightarrow 2 \, \text{NH}_3 \, (g) \]

\[
K_p = K_c(RT)^\Delta n = (3.8 \times 10^4)((0.0821)(400 \text{ K}))^{-2} = 35
\]

3. The equilibrium constant for the reaction

\[ \text{H}_2 \, (g) \, + \, \text{F}_2 \, (g) \leftrightarrow 2 \, \text{HF} \, (g) \]

has the value $2.1 \times 10^3$ at a particular temperature. When the system is analyzed at equilibrium at this temperature, the concentrations of $\text{H}_2 \, (g)$ and $\text{F}_2 \, (g)$ are both found to be 0.0021 $M$. What is the concentration of $\text{HF} \, (g)$ in the equilibrium system under these conditions?

\[
K_c = \frac{[\text{HF}]^2}{[\text{H}_2][\text{F}_2]}
\]

\[
2.1 \times 10^3 = \frac{[\text{HF}]^2}{(0.0021)^2}
\]

\[
[\text{HF}]^2 = 9.261 \times 10^{-3}
\]

\[
[\text{HF}] = 9.6 \times 10^{-2} \, M
\]