1. When solid ammonium carbamate sublime, it dissociates completely into ammonia and carbon dioxide according to the equation

\[ \text{(NH}_4\text{)}(\text{H}_2\text{NCO}_2)\text{(s)} \xrightarrow{\text{\Delta}} 2\text{NH}_3\text{(g)} + \text{CO}_2\text{(g)} \]

At 25°C, experiment shows that the total pressure of the gases in equilibrium with the solid is 0.116 atm. What is the equilibrium constant, \( K_p \)?

\[
K_p = \frac{[\text{NH}_3]^2 [\text{CO}_2]}{[\text{H}_2\text{NCO}_2]} = \frac{2[\text{CO}_2]}{[\text{H}_2\text{NCO}_2]} = x
\]

\[
= \left(\frac{2x}{x}\right)^2 \left(\frac{x}{x}\right) = 4 \times x^3
\]

\[
4 \times 0.0387^3 = 2.32 \times 10^{-4}
\]

\[
2x + x = 0.116
\]

\[
3x = 0.116
\]

\[
x = 0.116/3 = 0.0387
\]

1. Dinitrogen trioxide decomposes to NO and NO\(_2\) in an endothermic process (\( \Delta H = 40.5 \) kJ/mol)

\[
2\text{NO}_3\text{(g)} \rightleftharpoons \text{NO(g)} + \text{NO}_2\text{(g)}
\]

Predict the effect of the following changes on the position of the equilibrium; that is state which way the equilibrium will shift (left, right, no change) when each of the following changes is made.

a. Adding more \( \text{N}_2\text{O}_3\text{(g)} \) \( R \)

b. Adding more \( \text{NO}_2\text{(g)} \) \( L \)

c. Increasing the volume of the reaction flask. \( R \)

d. Lowering the temperature. \( L \)
3. At 1800 K, oxygen molecules dissociate very slightly into atoms:

\[ \text{O}_2(\text{g}) \rightarrow 2 \text{O} (\text{g}) \quad \text{K}_p = 1.2 \times 10^{-10} \]

If you place 1.0 mol of O\(_2\) in a 10.0 L vessel and heat it to 1800K, how many O atoms are present in the flask?

Since \( K_p \) is very small, then \( x \approx 0.10 \)

\[ \text{K}_c = \frac{K_p}{RT} = 8.12 \times 10^{-13} \]

\[ x = 1.4 \times 10^{-7} \]

\[ 2.8 \times 10^{-7} \text{ mol} \cdot \text{L}^{-1} \times 10.0 \text{ L} = 2.8 \times 10^{-6} \text{ mol O} \]

\[ 2.8 \times 10^{-6} \text{ mol O} = \frac{0.02 \times 10^{-3} \text{ mol}}{1 \text{ mol}} \]

4. Two molecules of gaseous acetic acid can form a dimer through hydrogen bonds. The equilibrium constant \( K_c \) at 25°C is 3.2 \times 10^4. Assume that acetic acid is present initially at a concentration of 5.4 \times 10^{-4} \text{ mol/L} at 25°C and that no dimer is present initially.

- a. What percentage of acetic acid is converted to dimer?
- b. As the temperature goes up, in which direction does the equilibrium shift? (Recall that hydrogen-bond formation is an exothermic process.)

\[ \text{2 HOAc} \rightarrow \text{dimer} \]

\[ \text{Init} \quad 5.4 \times 10^{-4} \quad 0 \]

\[ \Delta \text{C} \quad -2x \quad x \]

\[ \text{eq} \quad 5.4 \times 10^{-4} - 2x \quad x \]

\[ 8.4 \times 10^{-5} \quad 2.28 \times 10^{-4} \text{ M} \]

\[ \frac{8.4 \times 10^{-5}}{5.4 \times 10^{-4}} \times 100 = 15.9 \% \text{ remains} \]

\[ 84.9 \% \text{ converted} \]

As \( T \) goes up, the equilibrium shifts to left for exothermic reactions.