1. Which of the following statements concerning equilibrium is *not* true?
   A) The equilibrium constant changes with temperature.
   B) At equilibrium, the concentrations of products and reactants are always equal.
   C) A system that is disturbed from an equilibrium condition responds in such a way as to restore equilibrium.
   D) The value of the equilibrium constant for a given reaction mixture is the same regardless of the direction from which equilibrium is attained.
   E) Equilibrium in molecular systems is dynamic, with two opposing processes balancing one another.

2. Indicate if the following matches $K = 1$, $K > 1$ or $K < 1$:
   a. reaction favors the products
   b. equilibrium lies on the left
   c. there are equal amounts of reactants and products at equilibrium
   d. weak electrolyte dissociation
   e. reaction goes to completion

3. The following reaction is at equilibrium at 25.0 °C: $2\text{NO}_\text{g} + \text{Cl}_2\text{g} \rightarrow 2\text{NOCl}_\text{g}$ $K_p = 50.8$
   a. If the partial pressures are 0.095 atm NO, 0.171 atm Cl$_2$, calculate partial pressure of NOCl.
   b. Calculate the value of $K$ at 25.0 °C.
4. The equilibrium constant for the reaction \(2\text{NO} (g) + \text{Br}_2(g) \rightarrow 2\text{NOBr}(g)\) is \(K = 1.3 \times 10^{-2}\). Calculate the value of \(K\) for:

a. \(2\text{NOBr} \rightarrow 2\text{NO} + \text{Br}_2\)

b. \(\text{NO} + \frac{1}{2} \text{Br}_2 \rightarrow \text{NOBr}\)

c. \(4\text{NOBr} \rightarrow 4\text{NO} + 2\text{Br}_2\)

5. Given the following equilibrium constants,

\[
\begin{align*}
\text{NaO} (g) & \rightarrow \text{Na}(l) + \frac{1}{2} \text{O}_2 (g) \quad K_1 = 2 \times 10^{-5} \\
\text{Na}_2\text{O}_2 (s) & \rightarrow 2\text{Na}(l) + \text{O}_2 (g) \quad K_2 = 5 \times 10^{-29}
\end{align*}
\]

Determine the value of the equilibrium constant for the reaction \(\text{Na}_2\text{O}_2 (s) \rightarrow 2\text{NaO} (g)\)

6. At a certain temperature, 10.0 mol of \(\text{SO}_3\) is placed into a 5.0 L container and the \(\text{SO}_3\) dissociates by the reaction: \(2\text{SO}_3 (g) \rightarrow 2\text{SO}_2 (g) + \text{O}_2 (g)\). At equilibrium, 4.0 mol of \(\text{SO}_2\) is present. Calculate \(K\) for this reaction.
7. At a certain temperature, \( K_p = 0.25 \) for the reaction: \( \text{N}_2\text{O}_4 (g) \rightarrow 2\text{NO}_2 (g) \). For the following, state whether the reaction is at equilibrium. If not, state in which direction the system will shift.

a. A flask containing \( \text{N}_2\text{O}_4 \) at a pressure of 1.00 atm and \( \text{NO}_2 \) at a pressure of 0.50 atm.

b. A flask containing \( \text{N}_2\text{O}_4 \) at pressure 0.60 atm and \( \text{NO}_2 \) at a pressure of 3.20 atm.

8. For the following reaction, \( K = 51 \). Determine the concentrations of all species at equilibrium for each of the following cases.

\[ \text{H}_2 (g) + \text{I}_2 (g) \rightarrow 2\text{HI}(g) \]

a. 1.0 mol of \( \text{HI} \) is placed in a 2.5 L flask.

b. 1.0 mol each of \( \text{H}_2 \), \( \text{I}_2 \) and \( \text{HI} \) are placed in a 1.00 L flask.
9. At 25 °C, \( K_p = 1.89 \times 10^{-6} \) for the following reaction: \[ 2 \text{NH}_3 (g) \rightarrow \text{N}_2 (g) + 3 \text{H}_2 (g) \]
If ammonia is placed into an evacuated flask at an initial pressure of 0.88 atm, calculate the total pressure at equilibrium.

10. Consider the following reaction, which is endothermic: \[ 2\text{SO}_3 (s) \rightarrow 2\text{SO}_2 (g) + \text{O}_2 (g) \]
How will the position of the equilibrium be shifted for each of the following changes?

   a. \( \text{O}_2 (g) \) is added
   b. \( \text{SO}_2 (g) \) is removed
   c. \( \text{SO}_3 (s) \) is added
   d. The volume of the container is decreased
   e. \( \text{Ne} (g) \) is added, increasing the total pressure
   f. The temperature is raised

11. For the reaction below, in which direction will the equilibrium be shifted for each of the following?
\[ \text{Ni}^{2+} (aq) + 4 \text{Cl}^- (aq) \rightarrow \text{NiCl}_4^{2-} (aq) \]

   a. Water is added, increasing the volume
   b. \( \text{NaCl} \) is added
   c. \( \text{AgNO}_3 \) is added