Practice Work: 17.1 Factors Affecting Chemical Equilibrium

1. If you wished to maximize the products of the following reactions, which concentrations would you lower or raise?
   a. \( \text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \leftrightarrow 2\text{HBr}(\text{g}) \)
   b. \( \text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \leftrightarrow \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \)
   c. \( \text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \leftrightarrow \text{SO}_3(\text{g}) + \text{NO}(\text{g}) \)
   d. \( \text{C}(\text{s}) + \text{CO}_2(\text{g}) \leftrightarrow 2\text{CO}(\text{g}) \)

2. For each reaction, state whether increasing or decreasing the volume of the reaction vessel would yield more product at equilibrium. Give the reason for your choice.
   a. \( \text{N}_2\text{O}_4(\text{g}) \leftrightarrow 2\text{NO}_2(\text{g}) \)
   b. \( 2\text{SO}_3(\text{g}) \leftrightarrow 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \)
   c. \( \text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \leftrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \)
   d. \( 2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \leftrightarrow 2\text{CO}_2(\text{g}) \)

3. What effect would an increase in temperature have on these reactions at equilibrium? Why?
   a. Heat + \( \text{H}_2(\text{g}) + \text{I}_2(\text{g}) \leftrightarrow 2\text{HI}(\text{g}) \)
   b. \( \text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \leftrightarrow \text{CO}(\text{g}) + 2\text{H}_2\text{O} + \text{heat} \)
   c. \( \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \leftrightarrow 2\text{NH}_3(\text{g}) + \text{heat} \)
   d. Heat + \( \text{CH}_4(\text{g}) \leftrightarrow \text{C}(\text{s}) + 2\text{H}_2(\text{g}) \)

4. Use Le Châtelier’s principle to predict how each of the following changes would affect this equilibrium.
   \( \text{C}_2\text{H}_4\text{O}(\text{g}) \leftrightarrow \text{CH}_4(\text{g}) + \text{CO}(\text{g}) \)
   a. adding \( \text{CH}_4(\text{g}) \) to the system
   b. removing \( \text{CO}(\text{g}) \) from the system
   c. removing \( \text{C}_2\text{H}_4\text{O}(\text{g}) \) from the system

5. How would decreasing the volume of the reaction vessel affect these equilibria?
   a. \( \text{CO}(\text{g}) + \text{H}_2(\text{g}) \leftrightarrow \text{H}_2\text{O}(\text{g}) \)
   b. \( \text{NH}_4\text{HS}(\text{s}) \leftrightarrow \text{NH}_3(\text{g}) + \text{H}_2\text{S}(\text{g}) \)
   c. \( 2\text{NbCl}_4(\text{g}) \leftrightarrow \text{NbCl}_3(\text{g}) + \text{NbCl}_5(\text{g}) \)
   d. \( 2\text{SO}_3(\text{g}) + \text{CO}_2(\text{g}) \leftrightarrow \text{CS}_2(\text{g}) + 4\text{O}_2(\text{g}) \)

6. Phosphorus pentachloride decomposes exothermically to form phosphorus trichloride and chlorine.
   \( \text{PCl}_5(\text{g}) \leftrightarrow \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) + \text{heat} \)
   How would you regulate the temperature of this equilibrium in order to do the following?
   a. increase the concentration of \( \text{PCl}_5 \)
   b. decrease the concentration of \( \text{PCl}_3 \)
   c. increase the amount of \( \text{Cl}_2 \) in the system
   d. decrease \( K_{\text{eq}} \)

7. Predict how this equilibrium would respond to a simultaneous decrease in both temperature and pressure.
   \( \text{N}_2\text{O}_4(\text{g}) \leftrightarrow 2\text{NO}_2(\text{g}) \quad \Delta H^\circ = +58 \text{ kJ} \)

Review

8. Is it possible to cause a shift in an equilibrium system without changing the equilibrium constant? Explain.

9. In a reversible endothermic reaction, four moles of gaseous reactants yield three moles of gaseous products. Describe four ways to shift this equilibrium toward the products.