1. Determine $\Delta G^0_{\text{rxn}}$ and $K_P$ at 298 K for each of the following reactions:
   a) $\text{N}_2\text{O}_4(\text{g}) \leftrightarrow 2 \text{NO}_2(\text{g})$
   b) $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \leftrightarrow 2 \text{HI}(\text{g})$
   c) $3 \text{H}_2(\text{g}) + \text{N}_2(\text{g}) \leftrightarrow 2 \text{NH}_3(\text{g})$

2. The synthesis of ammonia is given by the formula
   $$\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \leftrightarrow 2 \text{NH}_3(\text{g})$$
   a) If you begin the reaction with $n_0$ moles of $\text{N}_2(\text{g})$ and $3n_0$ moles of $\text{H}_2(\text{g})$, find an exact expression for $z_{eq}$. Use this expression to discuss how $z_{eq}$ varies with $P$ and relate your conclusions to Le Chatelier’s principle.

3. Sufuryl chloride, $\text{SO}_2\text{Cl}_2$, decomposes to sulfur dioxide and chlorine gas:
   $$\text{SO}_2\text{Cl}_2(\text{g}) \leftrightarrow \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$$
   $\Delta G^0_f (\text{SOCl}_2) = -371.3 \text{ kJ/mol}$, $\Delta G^0_f (\text{SO}_2) = -300.2 \text{ kJ/mol}$.
   a) Determine the equilibrium concentrations of each species if the system initially contains 1 mole of $\text{SO}_2\text{Cl}_2$ and 0 moles of $\text{SO}_2$ and $\text{Cl}_2$ at 1 bar
   b) Determine the equilibrium concentrations of each species if the system initially contains 1 mole of $\text{SO}_2\text{Cl}_2$, 1 mole of $\text{SO}_2$, and 0 moles of $\text{Cl}_2$ at 1 bar.
   c) Describe any differences according to Le Chatelier’s principle.

4. The water-gas shift reaction is an important industrial source of pure $\text{H}_2(\text{g})$ for ammonia synthesis:
   $$\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \leftrightarrow \text{H}_2(\text{g}) + \text{CO}_2(\text{g})$$
   What would happen to the equilibrium concentration of each species if you increase the total pressure of the system by a factor of 100?

5. Until recently, values of $K_P$ were reported assuming a standard state of 1 atm. Determine a general equation for converting $K_P$ values at 1 atm to 1 bar.

6. Under certain conditions, water vapor dissociates into $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$. At 2000 K and 1 bar, water vapor is 0.53% dissociated. At 2100 K and 1 bar, it is 0.88% dissociated. Determine the enthalpy of the dissociation reaction, assuming it is constant over this temperature range.