Equilibrium.

1. Write the equilibrium-constant expression (Kc) for each of the following reactions.
   a. SO_2Cl_2 (g) ⇌ SO_2 (g) + Cl_2 (g)
   b. 2 H_2O_2 (g) ⇌ 2 H_2O (l) + O_2 (g)

2. Consider the chemical equilibrium described below. Predict the way in which the equilibrium will shift in response to each of the following changes.

   C (s) + 2 H_2 (g) ⇌ CH_4 (g)

   a. Decrease in the pressure of H_2
   b. Increase in the pressure of CH_4
   c. Adding C (s) to the flask
   d. The volume is decreased

3. Sodium bicarbonate decomposes according to the equation below. Given that Kp = 0.26 atm^2 at 125 °C, calculate the partial pressures of CO_2 (g) and H_2O (g) at equilibrium when $NaHCO_3$ (s) is heated to 125 °C in a closed vessel. *(CO_2 = 0.51 atm H_2O = 0.51 atm)*

   2 $NaHCO_3$ (s) ⇌ Na_2CO_3 (s) + CO_2 (g) + H_2O (g)

4. If 0.20 atm H_2 and 3.0 atm CH_4 (g) are mixed in the presence of 4 grams of carbon at 500 °C, determine if the reaction is at equilibrium. If it is not, determine if products or reactants will be formed. *(Products form)*

   C (s) + 2 H_2 (g) ⇌ CH_4 (g)   Kp = 2.69 x 10^3 atm^{-1} (at 500 °C)

5. Given that [$Ni(CO)_4$] = 0.85 M at equilibrium for the reaction below, calculate the concentration of CO (g) at equilibrium. *([CO] = 0.0642 M)*

   Ni(s) + 4 CO (g) ⇌ $Ni(CO)_4$ (g)   Kc = 5.0 x 10^4 M^{-3}

6. Phosgene, $COCl_2$ (g), a toxic gas used in the synthesis of a variety of organic compounds, decomposes according to

   $COCl_2$ (g) ⇌ CO (g) + Cl_2 (g)

   A sample of phosgene gas at an initial concentration of 0.500 M is heated at 527 °C in a reaction vessel. At equilibrium, the concentration of CO (g) was found to be 0.046 M. Calculate the equilibrium constant for the reaction at 527 °C. *(Kc = 0.00466 M)*

7. Nitrogen dioxide decomposes at high temperatures according to the equation:

   2 NO_2 (g) ⇌ 2 NO (g) + O_2 (g)

   Suppose initially we have pure NO_2 (g) at 1000 K and 0.500 atm. If the total pressure is 0.732 atm when equilibrium is reached, what is the value of Kp (make sure to include the correct units)? *(38.54 atm)*

8. For the reaction below, calculate the equilibrium concentrations of ICl (g), I_2 (g), and Cl_2 (g) when 0.65 moles of ICl (g) is to a 1.5 liter reaction vessel. *(I_2 = 0.0875 M Cl_2 = 0.0875 M   ICl = 0.258 M)*

   2 ICl (g) ⇌ I_2 (g) + Cl_2 (g)   Kc = 0.11