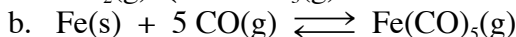
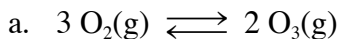


CH 223 Problem Set #1

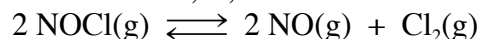
Covering: Chapter Fifteen and Chapter Guide One

Important Tables and/or Constants: none

1. Write equilibrium constant expressions for the following reactions. For gases use either pressures or concentrations.

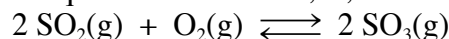


2. The equilibrium constant, K , for the reaction:

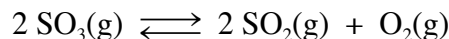


is 3.9×10^{-3} at 300°C . A mixture contains the gases at the following concentrations: $[\text{NOCl}] = 5.0 \times 10^{-3} \text{ M}$, $[\text{NO}] = 2.5 \times 10^{-3} \text{ M}$, and $[\text{Cl}_2] = 2.0 \times 10^{-3} \text{ M}$. Is the reaction at equilibrium at 300°C ? If not, in which direction does the reaction proceed to come to equilibrium?

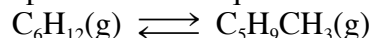
3. An equilibrium mixture of SO_2 , O_2 and SO_3 at 1000 K contains the gases at the following concentrations: $[\text{SO}_2] = 3.77 \times 10^{-3} \text{ M}$, $[\text{O}_2] = 4.30 \times 10^{-3} \text{ M}$, and $[\text{SO}_3] = 4.13 \times 10^{-3} \text{ M}$. Calculate the equilibrium constant, K , for the reaction:



4. You place 3.00 mol of pure SO_3 in an 8.00 L flask at 1150 K . At equilibrium, 0.58 mol of O_2 has formed. Calculate K for the reaction at 1150 K using the reaction:



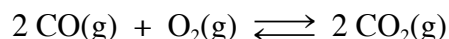
5. Cyclohexane, C_6H_{12} , a hydrocarbon, can isomerize or change into methylcyclopentane, $\text{C}_5\text{H}_9\text{CH}_3$, a compound of the same formula but with a different molecular structure. The equilibrium constant has been estimated to be 0.12 at 25°C . If you originally placed 0.045 mol of cyclohexane in a 2.8 L flask, what would be the concentrations of cyclohexane and methylcyclopentane when equilibrium is established? Use the equation:



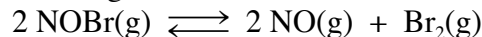
6. The equilibrium constant K for the reaction



is 6.66×10^{-12} at 1000 K . Calculate K for the reaction



7. K_p for the following reaction is 0.16 at 25°C :



The enthalpy change for the reaction at standard conditions is $+16.3 \text{ kJ}$. Predict the effect of the following changes on the position of the equilibrium; that is, state which way the equilibrium will shift (left, right, or no change) when each of the following changes is made.

- adding more $\text{Br}_2(\text{g})$
- removing some $\text{NOBr}(\text{g})$
- decreasing the temperature
- increasing the container volume

Problem Set #1 continues on the next page

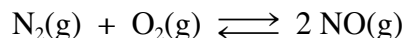
Problem Set #1, Continued from previous page

8. The decomposition of NH_4HS is an endothermic process:



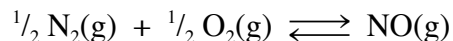
Using Le Chatelier's principle, explain how increasing the temperature would affect the equilibrium. What if some additional NH_3 is placed in the flask? What will happen to the pressure of NH_3 if some H_2S is removed from the flask

9. The equilibrium constant for the reaction

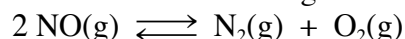


is 1.7×10^{-3} at 2300 K.

- a. What is K for the reaction when written as follows:



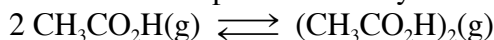
- b. What is K for the following reaction?



10. Ammonium iodide dissociates reversibly to ammonia and hydrogen iodide if the salt is heated to a sufficiently high temperature. Some ammonium iodide is placed in a flask, which is then heated to 400 °C. If the total pressure in the flask when equilibrium has been achieved is 705 mm Hg, what is the value of K_p (when partial pressures are in atmospheres)?



11. In the gas phase, acetic acid exists as an equilibrium of monomer and dimer molecules. The dimer consists of two molecules of acetic acid linked through hydrogen bonds. The equilibrium constant, K , for the monomer-dimer equilibrium shown below has been determined to be 3.2×10^4 . Assume that acetic acid is present initially at a concentration of 5.4×10^{-4} M at 25 °C and that no dimer is present initially.



- a. What percentage of the acetic acid is converted to the dimer?
b. As the temperature increases, in which direction does the equilibrium shift? (Recall that hydrogen bond formation is an exothermic process.)
12. At 450 °C, 3.60 mol of ammonia is placed in a 2.00 L flask and allowed to decompose into the elements. If the experimental value of K is 6.3 for this reaction at this temperature, calculate the equilibrium concentration of each reagent. What is the total pressure in the flask? The reaction:



13. K_c for the decomposition of ammonium hydrogen sulfide is 1.8×10^{-4} at 25 °C. The reaction:



- a. When the pure salt decomposes in a flask, what are the equilibrium concentrations of NH_3 and H_2S ?
b. If NH_4HS is placed in a flask already containing 0.020 M of NH_3 and then the system is allowed to come to equilibrium, what are the equilibrium concentrations of NH_3 and H_2S ?
14. The dissociation of calcium carbonate has an equilibrium constant $K_p = 1.16$ at 800 °C.



- a. What is K_c for the reaction?
b. If you place 22.5 g of CaCO_3 in a 9.56 L container at 800 °C, what is the pressure of CO_2 in the container?
c. What percentage of the original 22.5 g sample of CaCO_3 remains undecomposed at equilibrium?