Honors Chemistry

Chapter 13 Study Questions

1. For a system at equilibrium, which of the following are true?
   a) The rate of the reaction is zero.
   b) The concentrations of reactants and products are no longer changing.
   c) The value for the equilibrium constant, *K*, will change when temperature is changed.
   d) The rate of the forward reaction is equal to the rate of the reverse reaction.

2. The equilibrium constant for the following reaction is equal to 0.447 at 100°C:

   $$\tfrac{1}{2}\, N_2O_4(g) \rightleftarrows NO_2(g)$$

   a) What is the value for *K* for the following reaction: $2\ NO_2(g) \rightleftarrows N_2O_4(g)$?
   b) Write an expression for *K*, the equilibrium constant, for the reaction in (*a*).
   c) Find the concentration of N_2O_4 in a system at equilibrium (at 100°C) if the equilibrium concentration of NO_2 is 0.30 mol/L.

3. For each reaction below, write an expression for *K* and indicate what effect an increase in pressure would have on equilibrium.
   a) $H_2(g) + S(s) \rightleftarrows H_2S(g)$
   b) $N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$
   c) $H_2(g) + Br_2(l) \rightleftarrows 2\ HBr(g)$

4. For the equilibrium in *Question 3b*, *K* is 4.51×10^{-5} at 450°C. Is a mixture containing 100 atm NH_3, 30 atm N_2 and 500 atm H_2 at equilibrium? If not, will the mixture shift toward product or reactants to achieve equilibrium?

5. Consider the following system at equilibrium:

   $$2\ N_2O(g) \rightleftarrows 2\ N_2(g) + O_2(g) \qquad \Delta H = +\ 163\ kJ$$

   a) For each situation below, indicate whether more product or more reactant is produced in order to re-establish equilibrium.
      i) N_2 is added
      ii) O_2 is removed
      iii) the volume is increased
      iv) the temperature is increased
      v) the pressure is increased by compressing the mixture
   b) Which of the situations above will increase yield?
   c) What effect will an increase in temperature have on the value for *K*?

6. A mixture of 0.100 mol of NO, 0.050 mol of H_2, and 0.100 mol of H_2O are placed in a 1.00-liter flask. The following equilibrium is established:

   $$2\ NO(g) + 2\ H_2(g) \rightleftarrows N_2(g) + 2\ H_2O(g)$$

   At equilibrium, [NO] = 0.070 M.
   a) Calculate the equilibrium concentrations of H_2, N_2, and H_2O.
   b) Write an expression for K for this reaction.
   c) Calculate *K* for this reaction.
   d) At equilibrium, how will the concentrations of products compare to the concentrations of reactants?

7. At 1500 K, the equilibrium constant for the reaction, $N_2(g) + O_2(g) \rightleftarrows 2\ NO(g)$, is 1.0×10^{-5}. Calculate the equilibrium concentrations of N_2, O_2 and NO if, before any reaction, 0.500 mol of NO is placed in a 1.00-liter container. (Ignore significant digits for NO.)

8. Given the equilibrium constants for the following two reactions:

$$A(g) \rightleftarrows B(g) \qquad K = K_1$$
$$B(g) \rightleftarrows C(g) \qquad K = K_2$$

a) Derive the equilibrium constant for the reaction, $A(g) \rightleftarrows C(g)$ in terms of K_1 and K_2.

b) What general statement can be made about what happens to values for K when two reactions are added?

Summary of Chapter 13: Equilibrium

definition of equilibrium
factors affecting equilibrium: temperature
equilibrium constant, K
- expression for K from equation
- only gases and aqueous
- relate to extent of reaction

find K for a reaction from K of related reactions
Reaction quotient, Q, and its relationship to K
calculation of K from concentrations at equilibrium and vice versa
LeChatelier's Principle
- statement of principle
- effect of adding or removing product or reactant
- effect of changing volume or pressure
- effect of changing temperature

relationship between temperature and K for endothermic and exothermic reactions
effect of changes on yield and rate