UNIT 7 STUDY GUIDE

Match each statement with the appropriate letter. Each letter can be used once, more than once, or not at all.

1. The equilibrium concentration of products is much greater than that of reactants
2. The equilibrium concentration of products is much less than that of reactants
3. There is considerable amount of both reactants and products at equilibrium

a. K_{eq} is much greater than 1

b. K_{eq} is about equal to 1

c. K_{eq} is much less than 1

4. Complete the chart below

$NaOH(s) \leftrightarrows Na^+(aq) + OH^-(aq) + 10.6\ kcal$

Stress	Equilibrium Shift	Amount NaOH(s)	$[Na^+]$	$[OH^-]$	K
Add NaOH(s)		-------			
Add NaCl (adds Na^+)			-------		
Add KOH (Adds OH^-)				-------	
Add H^+ (Removes OH^-)				-------	
Increase Temperature					
Decrease Temperature					
Increase Pressure					
Decrease Pressure					

5. For the reaction $NH_3\ (aq) + H_2O\ (l) \rightleftharpoons NH_4^+\ (aq) + OH^-\ (aq)$, $K_c = 1.8 \times 10^{-5}$
   a. Write the expression for K_c.

   b. NH_3 is added to water. If the initial concentration of NH_3 is 0.75 M, calculate the equilibrium concentrations of NH_3, NH_4^+, and OH^-.

   $[NH_3] = 0.75\ M$; $[NH_4^+] = [OH^-] = 0.0037\ M$

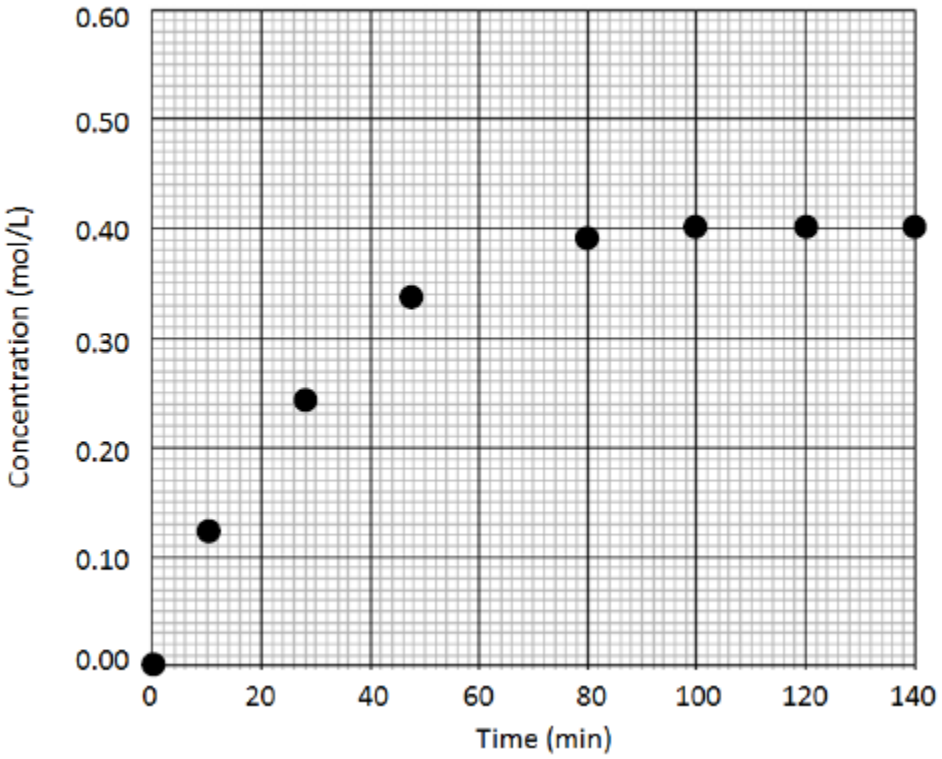
   c. In another experiment, NH_3 is added to a solution containing NH_4^+ and OH^-. If $[NH_3]$ = 0.50 M, $[NH_4^+]$ = 0.0025 M, and $[OH^-]$ = 0.0025 M, is the system at equilibrium? If not, how will the reaction shift? Explain.

   d. What type of reaction is this? How can you tell?

6. A chemist was studying the reaction below at room temperature.

$$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g)$$

She placed 3.0 mol of SO_2 and 2.0 mol of O_2 into a 5.0 L container. During the reaction, she measured the change in $[SO_3]$ over time and obtained the following graph.



a. At what time does it appear that the system reached equilibrium?

b. Based on the information above, calculate $[SO_2]$ and $[O_2]$ at equilibrium.

$[SO_2] = [O_2] = 0.20\ M$

c. Sketch and label two additional curves on the graph above showing the change in $[SO_2]$ and $[O_2]$ during the experiment.

d. Write the expression for K_c.

e. Calculate the value of K_c at the temperature for this experiment. *20.*

f. The same reaction has been balanced in different ways below. Calculate K_c for the reaction as balanced below for the temperature for this experiment.

i. $2\ SO_3\ (g) \rightleftharpoons 2\ SO_2\ (g) + O_2\ (g)$ *0.050*

ii. $4\ SO_2\ (g) + 2\ O_2\ (g) \rightleftharpoons 4\ SO_3\ (g)$ *4.0×10^2*

iii. $SO_3\ (g) \rightleftharpoons SO_2\ (g) + \frac{1}{2}\ O_2\ (g)$ *0.22*

g. Is this an example of homogeneous or heterogeneous equilibrium? Explain.

h. What would be the effect on K_c if the reaction was repeated with the addition of a catalyst? Explain.

i. What would be the effect on K_c if the experiment was repeated at the same temperature but with the initial concentration so the reactants double what they were in this experiment? Explain.

7. Given the following equilibrium equations and their corresponding equilibrium constants:

$2\ O_2\ (g) + CH_2CO\ (g) \rightleftharpoons 2\ CO_2\ (g) + H_2O\ (g)$ $K_p = 1.6 \times 10^{-9}$
$CH_4\ (g) + 2\ O_2\ (g) \rightleftharpoons CO_2\ (g) + 2\ H_2O\ (g)$ $K_p = 1.2 \times 10^{14}$

a. Find K_p for the reaction $CH_4\ (g) + CO_2\ (g) \rightleftharpoons CH_2CO\ (g) + H_2O\ (g)$ *7.6×10^{22}*

b. Use the equation and K_p from part **a** to calculate the equilibrium pressures of all species if the reaction is performed with an initial CH_4 pressure of 0.30 atm and an initial CO_2 pressure of 0.50 atm. *$P_{CH2CO} = P_{H2O} = 0.30$ atm; $P_{CO2} = 0.20$ atm; $P_{CH4} \approx 0$ atm*

8. Barium carbonate is only slightly soluble in water.

a. Write the equation for the dissolution of barium carbonate.

b. If $K_{sp} = 5.0 \times 10^{-9}$, calculate the molar solubility of barium carbonate. *7.1×10^{-5} M*

9. Calcium fluoride is only slightly soluble in water.

a. Write the equation for the dissolution of calcium fluoride.

b. If $K_{sp} = 3.9 \times 10^{-11}$, calculate the solubility of calcium fluoride in mol/L and g/L.

2.1×10^{-4} M, 0.017 g/L

c. What is the molar solubility of solid calcium fluoride in a 0.025 M NaF solution.

6.2×10^{-8} M

d. Explain the difference in molar solubility in parts **b** and **c** using the common ion effect and Le Chatelier's principle.

e. Explain why calcium fluoride has a higher molar solubility than barium sulfate, even though the K_{sp} of calcium fluoride is smaller.

AP Problems

1. Answer the following questions relating to the solubilities of two silver compounds, Ag_2CrO_4 and Ag_3PO_4.

Silver chromate dissociates in water according to the equation shown below.

$$Ag_2CrO_4(s) \leftrightharpoons 2\ Ag^+(aq) + CrO_4^{2-}(aq) \qquad K_{sp} = 2.6 \times 10^{-12} \text{ at } 25°C$$

(a) Write the equilibrium-constant expression for the dissolving of $Ag_2CrO_4(s)$.
(b) Calculate the concentration, in mol L^{-1}, of $Ag_+(aq)$ in a saturated solution of Ag_2CrO_4 at 25°C.
(c) Calculate the maximum mass, in grams, of Ag_2CrO_4 that can dissolve in 100. mL of water at 25°C.
(d) A 0.100 mol sample of solid $AgNO_3$ is added to a 1.00 L saturated solution of Ag_2CrO_4 . Assuming no volume change, does $[CrO_4^{2-}]$ increase, decrease, or remain the same? Justify your answer.

In a saturated solution of Ag_3PO_4 at 25°C, the concentration of $Ag^+(aq)$ is 5.3×10^{-5} *M*. The equilibrium constant expression for the dissolving of Ag_3PO_4 (*s*) in water is shown below.

$$K_{sp} = [Ag^+]^3[PO_4^{-3}]$$

(e) Write the balanced equation for the dissolving of Ag_3PO_4 in water.
(f) Calculate the value of K_{sp} for Ag_3PO_4 at 25°C.
(g) A 1.00 L sample of saturated Ag_3PO_4 solution is allowed to evaporate at 25°C to a final volume of 500. mL. What is $[Ag^+]$ in the solution? Justify your answer.

$$C(s) + H_2O(g) \leftrightharpoons CO(g) + H_2(g) \qquad \Delta H° = +131 \text{ kJ}$$

A rigid container holds a mixture of graphite pellets ($C(s)$), $H_2O(g)$, $CO(g)$, and $H_2(g)$ at equilibrium. State whether the number of moles of $CO(g)$ in the container will increase, decrease, or remain the same after each of the following disturbances is applied to the original mixture. For each case, assume that all other variables remain constant except for the given disturbance. Explain each answer with a short statement.

(a) Additional $H_2(g)$ is added to the equilibrium mixture at constant volume.

(b) The temperature of the equilibrium mixture is increased at constant volume.

(c) The volume of the container is decreased at constant temperature.

(d) The graphite pellets are pulverized.

2000 A Required

1. $2\ H_2S_{(g)} \rightarrow 2\ H_{2(g)} + S_{2(g)}$

When heated, hydrogen sulfide gas decomposes according to the equation above. A 3.40 g sample of $H_2S_{(g)}$ is introduced into an evacuated rigid 1.25 L container. The sealed container is heated to 483 K, and 3.72×10^{-2} mol of $S_{2(g)}$ is present at equilibrium.

(a) Write the expression for the equilibrium constant, K_c, for the decomposition reaction represented above.

(b) Calculate the equilibrium concentration, in $mol \cdot L^{-1}$, of the following gases in the container at 483 K.

(i) $H_{2(g)}$

(ii) $H_2S_{(g)}$

(c) Calculate the value of the equilibrium constant, K_c, for the decomposition reaction at 483 K.

(d) Calculate the partial pressure of $S_{2(g)}$ in the container at equilibrium at 483 K.

(e) For the reaction $H_{2(g)} + S_{2(g)} \rightarrow H_2S_{(g)}$ at 483 K, calculate the value of the equilibrium constant, K_c.

(the coefficient for S2 in part (e) should be ½)