Chapter 18 WS

K_{sp}, Gibbs, Order of Reactions

Name: ______________________________

Period: _______ Date: ____________________

Answer each of the following questions. Be specific and thorough.

1) Write the equilibrium dissociation equation as well as the solubility product equation for each of the following:

   a. Calcium Sulfide $CaS_{(aq)} \rightarrow Ca^{+2}_{(aq)} + S^{-2}_{(aq)}$ $K_{sp} = [Ca^{+2}][S^{-2}]$

   b. Lead (II) Sulfate $PbSO_{4\,(aq)} \rightarrow Pb^{+2}_{(aq)} + SO^{-2}_{4\,(aq)}$ $K_{sp} = [Pb^{+2}][SO_4^{-2}]$

   c. Silver Phosphate $Ag_3PO_{4\,(aq)} \rightarrow 3Ag^{+}_{(aq)} + PO^{-3}_{4\,(aq)}$ $K_{sp} = [Ag^{+}]^3[PO_4^{-3}]$

   d. Mercury (I) Iodide $HgI_{(aq)} \rightarrow Hg^{+}_{(aq)} + I^{-}_{(aq)}$ $K_{sp} = [Hg^{+}][I^{-}]$

   e. Iron (III) Hydroxide $Fe(OH)_{3\,(aq)} \rightarrow Fe^{+3}_{(aq)} + 3OH^{-}_{(aq)}$ $K_{sp} = [Fe^{+3}][OH^{-}]^3$

2) Use your understanding of solubility products and solubility to answer each of the following questions:

   a. If the K_{sp} of nickel (II) sulfide is $4.0x10^{-20}$, what is the concentration of each at equilibrium?

   $K_{sp} = [Ni^{+2}][S^{-2}]$ $4.0 \times 10^{-20} = x \cdot x$ $x^2 = 4.0 \times 10^{-20}$ $x = 2.0 \times 10^{-10}\ M$

   b. If the K_{sp} of silver sulfide is $8.0x10^{-51}$, what is the concentration of each ion at equilibrium?

   $K_{sp} = [Ag^{+}]^2[S^{-2}]$ $8.0 \times 10^{-51} = (2x)^2 \cdot x$ $4x^3 = 8.0 \times 10^{-51}$

   $x^3 = 2.0 \times 10^{-51}$ $x = 1.3 \times 10^{-17}\ M$ $[S^{-2}] = 1.3 \times 10^{-17}, [Ag^{+}] = 2.6 \times 10^{-17}$

   c. Based on the solubility products, which substance is more soluble in water? Why?

   In a, the K_{sp} is 10^{-20} which is much larger than the K_{sp} in b, which is 10^{-51}. That indicates that there are more ions in solution for a than there are in b

   d. Does your answers for a and b verify your answer for c? Why or why not?

   The concentration of ions in a is 10^{-10}, which is much larger than the concentration of ions in b which are 10^{-17}. This verifies the answer in c, that the nickel (II) sulfide is more soluble than the silver sulfide.

3) The K_{sp} of silver bromide is $5.00x10^{-13}$, what would be the bromide-ion concentration of a 1.00 L saturated solution of silver bromide if 0.0400 mol of silver nitrate is added to the solution?

   Since the concentration of silver in the solution is so small, assume the 0.040 mol of silver nitrate is the $[Ag^{+}]$

   Since it is a 1 L solution, the concentrations are equal to the moles (M = mol/1L)

   $K_{sp} = [Ag^{+}][Br^{-}]$ $5.00 \times 10^{-13} = [0.0400]x$ $x = 1.25 \times 10^{-11}\ M$

4) What symbol do we use for entropy and what does it measure?

   ΔS Entropy measures the disorder of the system

   a. What does a negative entropy mean?

   $\Delta S<0$ is less disorganized (more organized)

   b. What does a positive entropy mean?

   $\Delta S>0$ is more disorganized (less organized)

5) Will the entropy for each of the following be positive or negative? Why?

   a. Sugar dissolving in tea

   \+ liquids more disorganized than solids

   b. Frost forming on a window pane

   – Gas is organizing into a solid

   c. Air pumped into a tire

   – Only able to move within tire now

   d. $CaCO_{3\,(aq)} \rightarrow CaO_{(aq)} + CO_{2\,(g)}$

   \+ Going from 1 mol to 2 moles

   e. $N_{2\,(g)} + 3H_{2\,(g)} \rightarrow 2NH_{3\,(g)}$

   – Going from 4 moles to 2 moles

6) What symbol do we use for enthalpy and what does it measure?
ΔH Enthalpy measures heat change

a. What does a negative enthalpy mean?
ΔH<0 means heat leaves (exothermic)

b. What does a positive enthalpy mean?
ΔH>0 means heat enters (endothermic)

7) What symbol do we use for free energy and what does it measure?
ΔG It measures energy available to do work

a. What does a negative free energy mean?
ΔG<0 means reaction is spontaneous

b. What does a positive free energy mean?
ΔG>0 means reaction is nonspontaneous

8) Calculate the free energy for each of the following reactions using the information given. Will the reaction occur at the temperature given?

a. $CH_3OH_{(l)} + \frac{3}{2}O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{(g)}$ $\Delta H = -638.4\ kJ$ $\Delta S = 1.56\ \frac{kJ}{K}$ 0°C

$\Delta G = \Delta H - T\Delta S$ $\Delta G = -638.4\ kJ - (273\ K)\left(1.56\ \frac{kJ}{K}\right)$ $\Delta G = -1064.3\ kJ$ $Spontaneous$

b. $C_2H_{4\,(g)} + H_{2\,(g)} \rightarrow C_2H_{6\,(g)}$ $\Delta H = -136.9\ kJ$ $\Delta S = -1.207\ \frac{kJ}{K}$ 25°C

$\Delta G = \Delta H - T\Delta S$ $\Delta G = -136.9\ kJ - (298\ K)\left(-1.207\ \frac{kJ}{K}\right)$ $\Delta G = +222.8\ kJ$ $Nonspontaneous$

+

Reaction #1			Reaction #2		
Initial [A]	**Initial [B]**	**Initial Rate**	**Initial [A]**	**Initial [B]**	**Initial Rate**
0.100	.200	5.4×10^{-7}	0.250	0.250	1.0×10^{-3}
0.200	.200	10.8×10^{-7}	0.250	0.500	4.0×10^{-3}
0.200	.400	21.6×10^{-7}	0.500	0.250	9.0×10^{-3}

9) Use the information from the table for Reaction #1 to answer each of the following:

a. What is the order of the reaction for A? Explain.
When [A] doubles from 0.100 to 0.200 the rate doubles from 5.4 to 10.8, making it 1st order for A

b. What is the order of the reaction for B? Explain.
When [B] doubles from 0.200 to 0.400 the rate doubles from 20.8 to 21.6 making it 1st order for B

c. What is the overall order of the reaction? Explain.
$$Order_{overall} = Order_A + Order_B = 1 + 1 = 2nd\ Order\ Overall$$

d. What is the rate equation for Reaction #1?
$$Rate = k[A]^1[B]^1$$

10) Use the information from the table for Reaction #2 to answer each of the following:

a. What is the order of the reaction for A? Explain.
When [A] doubles from 0.25 to 0.50 the rate multiplies by 9, making it 3rd order for A ($2^3 = 9$)

b. What is the order of the reaction for B? Explain.
When [B] doubles from 0.25 to 0.50 the rate multiplies by 4, making it 2nd order for B ($2^2 = 4$)

c. What is the overall order of the reaction? Explain.
$$Order_{overall} = Order_A + Order_B = 3 + 2 = 5th\ Order\ Overall$$

d. What is the rate equation for Reaction #2?
$$Rate = k[A]^3[B]^2$$