WKS Name _____

Solubility Product Equilibrium-- K_{sp} Period _____ Date_____

Writing out K_{sp} expressions: A K_{sp} expression is just a specific type of equilibrium expression. K_{sp} expressions are only used for relatively insoluble solids in water. Every saturated solution must satisfy its K_{sp} expression because every saturated solution is at equilibrium. *(Ion concentrations are constant because rate of dissolving = rate of crystallization.)*

1) Write the balanced chemical equations for the following solids dissolving in water. Then, write the K_{sp} expression for each. *Remember: Pure solids are never written in equilibrium expressions. Don't forget exponents*.

   a) Sb_2S_3 (s) $\rightleftharpoons$ b) $MnCO_3$ (s) $\rightleftharpoons$

   K_{sp} = K_{sp} =

First Type of K_{sp} Calculation: Determining a K_{sp} value from concentrations.

2) A sample of $Ba(OH)_2$(s) is added to pure water and allowed to come to equilibrium. A saturated solution forms. The concentration of Ba^{+2} (aq) in this saturated solution is 0.108 M. What is K_{sp} of $Ba(OH)_2$?

   a) Write the balanced equation for the $Ba(OH)_2$ solid in water : $Ba(OH)_2$ (s) $\rightleftharpoons$

   b) Since $[Ba^{2+}]$ = 0.108 M. What must be the concentration of the OH^- ions? *(Use balanced eq.)*_____

   c) Write the K_{sp} expression (no numbers.) Then, plug in $[Ba^{2+}]$ and $[OH^-]$ values and solve for the K_{sp}.

3) A sample of $AgIO_3$ (s) is dissolved in water and a saturated solution is formed. The $[IO_3^-] = 1.7 \times 10^{-4}$ M. Answer these questions to find the K_{sp} of $AgIO_3$.

   a) Write the balanced equation for the dissolving process: $AgIO_3$ (s) $\rightleftharpoons$

   b) What is $[Ag^+]$? _____

   c) Write the K_{sp} expression (no numbers.) Then, plug in $[Ag^+]$ and $[IO_3^-]$ values and solve for the K_{sp}.

Second type of K_{sp} calculations: Solving for an unknown ion concentration in a saturated solution.

4) Determine the equilibrium concentrations of Pb^{2+} and SO_4^{2-} in a saturated solution of $PbSO_4$.
   Given: K_{sp} of $PbSO_4 = 1.3 \times 10^{-8}$ To do so, follow these steps:

   a) Write balanced equation for $PbSO_4$ (s) in water: $PbSO_4$ (s) $\rightleftharpoons$

   b) Suppose $[Pb^{2+}]$ = x. Then, $[SO_4^{2-}]$ = _____

   c) Write K_{sp} expression and then plug in K_{sp} value and concentration values in terms of "x's". Solve for x.

   d) Thus, $[Pb^{2+}]$ = _____ and $[SO_4^{2-}]$ = _____

5) Follow these steps to find the equilibrium concentrations of Ni^{2+} and OH^- in a saturated solution of $Ni(OH)_2$?
Given: K_{sp} of $Ni(OH)_2 = 1.6 \times 10^{-16}$

a) Write balanced equation for $Ni(OH)_2$ solid in water : $Ni(OH)_2$ (s) $\rightleftharpoons$

b) Suppose $[Ni^{2+}] = x$. Then, $[OH^-] =$ _____

c) Write K_{sp} expression and then plug in K_{sp} value and concentration values in terms of "x's". Solve for x.

d) Thus, $[Ni^{2+}] =$ _____ and $[OH^-] =$ _____

Third type of K_{sp} calculation: **Determining if precipitate will form. Solve for Q. (You're not at equil**.)

6) A solution is prepared by dissolving 9.2×10^{-4} moles of $PbCl_2$ (s) into 100. mL of hot water. Should a precipitate form if the solution is cooled to 25°C? *(Assume it is cooled too quickly for a supersaturated solution to form)*. Given: *K_{sp} of $PbCl_2$ at 25°C = 1.6×10^{-5}* To answer this question, follow these steps:

a) Write the balanced equation for $PbCl_2$ (s) in water: $PbCl_2$ (s) $\rightleftharpoons$

b) Write the Q expression-- no numbers. *(same as K_{sp} expression -- you are just not at equilibrium)*

c) Determine the concentrations of the ions in the hot solution.

d) Plug in concentrations and solve for Q.

e) Q is **(greater than, less than)** the K_{sp}.

f) Thus, there are **(more, fewer)** ions dissolved in the hot solution than at the saturation point at 25°C.

g) Thus, if the solution is cooled to 25°C would solid precipitate? _____ *(Assume one would disturb the solution if it were supersaturated.)* Thus, the resulting solution at 25°C is **(unsaturated, saturated**).

7) Suppose 7.5×10^{-13} moles of $Bi(NO_3)_3$ solid and 1.3×10^{-13} moles of Na_2S solid are added to 500 mL of water at 25°C. Does Bi_2S_3 solid precipitate? (K_{sp} of $Bi_2S_3 = 1.1 \times 10^{-73}$) To answer, follow these steps:

a) What is the initial concentration of Bi^{3+} ions in the 500 mL solution? (assume no reaction yet)

b) initial $[NO_3^-]$? initial $[Na^+]$? initial $[S^{2-}]$?

c) Write the balanced equation for Bi_2S_3 solid in water: Bi_2S_3 (s) $\rightleftharpoons$

d) Write the Q expression-- no numbers. *(same as K_{sp} expression -- you are just not at equilibrium)*

e) Plug in the initial concentrations of the ions involved and solve for Q.

f) Q is **(greater than, less than)** the K_{sp}. Thus, there are **(more, fewer)** ions than at saturation pt.

g) Would a precipitate form? _____ The resulting solution is **(unsaturated, saturated)**

Answers: 2) 5.04×10^{-3}; 3b) 1.7×10^{-4} M; 3c) 2.9×10^{-8}; 4c) 1.1×10^{-4} M; 4d) both 1.1×10^{-4} M; 5c) 3.4×10^{-6} M; 5d) 3.4×10^{-6} M, 6.8×10^{-6} M; 6c) 9.2×10^{-3} M; 1.8×10^{-2} M; 6d) 3.0×10^{-6}; 7a) 1.5×10^{-12} M; 7b) 4.5×10^{-12} M, 5.2×10^{-13} M, 2.6×10^{-13} M; 7e) 4.0×10^{-62}