Name: _____

Chemistry 30

Unit 4: Solutions

Assignment 4 - The Solubility Product Constant, K_{sp}

1. Write the balanced equation **and** the solubility product constant expression, K_{sp}, for the each of the following dissociation reactions. All compounds are solids. One has been given as an example.

   An important reminder – the seven diatomic molecules (H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2) **ARE NOT** diatomic as ions!

   Reminders – ion charges MUST BE included.
   – solids (and liquids) are NOT included in the equilibrium expression
   – don't forget to include exponents when needed
   – polyatomic ions (e.g. CO_3^-) do not break apart

Compound	Equation	K_{sp}
$(NH_4)_2S$	$(NH_4)_2S\ (s) \rightleftharpoons 2\ NH_4^+(aq) + S^{2-}(aq)$	$K_{sp} = [NH_4^+]^2[S^{2-}]$
CaS	**$CaS(s) \rightleftharpoons Ca^{2+}(aq) + S^{2-}(aq)$**	**$K_{sp} = [Ca^{2+}][S^{2-}]$**
K_2SO_4	**$K_2SO_4\ (s) \rightleftharpoons 2\ K^+\ (aq) + SO_4^{2-}(aq)$**	**$K_{sp} = [K^+]^2[SO_4^{2-}]$**
$Mg(OH)_2$	**$Mg(OH)_2\ (s) \rightleftharpoons Mg^{2+}(aq) + 2\ OH^-(aq)$**	**$K_{sp} = [Mg^{2+}][OH^-]^2$**

2. Consider the K_{sp} values for the following substances, all measured at 25°C

   $PbCrO_4$ $\quad 2.0 \times 10^{-16}$

   $PbSO_4$ $\quad 1.3 \times 10^{-8}$

   $PbCO_3$ $\quad 7.4 \times 10^{-14}$

   Which substance is MOST soluble (dissolves the best) **$PbSO_4$**

   Which substances is LEAST soluble (dissolves the worst) **$PbCrO_4$**

Name: _____

3. Solutions are prepared by dissolving a sulfate salt (an ionic compound containing the sulfate ion) in water. Which one of the compounds listed would we use in order to get the highest concentration of sulfate ion, SO_4^{2-}?

   (a salt is an ionic compound that contains a positive ion other than hydrogen and a negative ion other than hydroxide).

   A. $CaSO_4$ $K_{sp} = 2.6 \times 10^{-4}$

   B. $SrSO_4$ $K_{sp} = 7.6 \times 10^{-7}$

   C. $BaSO_4$ $K_{sp} = 1.5 \times 10^{-9}$

   D. $RaSO_4$ $K_{sp} = 4.0 \times 10^{-11}$

4. Calculate K_{sp} for a saturated nickel(II) sulfide, NiS, solution with a molar concentration of 3.27×10^{-11}

   Begin with a balanced dissociation equation:

   $NiS \rightleftharpoons Ni^{2+}(aq) + S^{2-}(aq)$

   From information provided in the question and the balanced equation, determine the concentration of the ions Ni^{2+} and S^{2-}:

   $[Ni^{2+}]$ = $1 \times 3.27 \times 10^{-11}$ **$= 3.27 \times 10^{-11}$ M**

   $[S^{2-}]$= $1 \times 3.27 \times 10^{-11}$ **$= 3.27 \times 10^{-11}$ M**

   Write the K_{sp} expression for this reaction:

   $K_{sp} = [Ni^{2+}][S^{2-}]$

   Substitute values into the equation and solve for the unknown, K_{sp}:

   K_{sp} = $(3.27 \times 10^{-11})(3.27 \times 10^{-11})$ **$= 1.07 \times 10^{-21}$**

5. At 25°C, the concentration of $Ce(OH)_3$ in a saturated solution is 5.1×10^{-6} M. Calculate K_{sp}.

Begin with a balanced equation:

$$Ce(OH)_3 \rightleftharpoons Ce^{3+}(aq) + 3\ OH^-(aq)$$

Determine the concentration of the ions in the solution. Be careful with $[OH^-]$.

$[Ce^{3+}]$ = $1 \times (5.1 \times 10^{-6})$ = **5.1×10^{-6}**

$[OH^-]$ = $3 \times (5.1 \times 10^{-6})$ = **1.53×10^{-5}**

Write the K_{sp} expression, then substitute values into the equation and solve for the unknown, K_{sp}.

$K_{sp} = [Ce^{3+}][OH^-]^3$

$= (5.1 \times 10^{-6})(1.53 \times 10^{-5})^3$

$= (5.1 \times 10^{-6})(3.58 \times 10^{-15})$

$= 1.8 \times 10^{-20}$

6. Calculate the concentration of ions in a saturated solution of $CaCO_3$ in water at 25°C. K_{sp} for $CaCO_3$ is 4.8×10^{-9}.

$$CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$$

$[Ca^{2+}] = x$ (Let the unknown concentration = x)

$[CO_3^{2-}] = x$ (the concentrations of Ca^{2+} and CO_3^{2-} will be the same)

Next substitute in the known and unknown values

$K_{sp} = [Ca^{2+}][CO_3^{2-}]$

$4.8 \times 10^{-9} = x^2$

$\sqrt{4.8 \times 10^{-9}} = x = 6.9 \times 10^{-5}$

$x = [Ca^{2+}] = 6.9 \times 10^{-5}$ M

$x = [CO_3^{2-}] = 6.9 \times 10^{-5}$ M