Exercise 16.1
Solubility & K_{sp}

Name: _____

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The dissolution of an ionic compound may be described by a dissociation equation representing the formation of ions from the ionic solid. Molecular substances forming ions during dissolution go through a process called ionization. These dissolution processes usually do not go to completion and achieve an equilibrium that may be described using a special equilibrium expression called a solubility product expression.

	$AgC_2H_3O_2$	$Al(OH)_3$
Dissociation Equation:	$AgC_2H_3O_2(s) \rightleftharpoons Ag^+(aq) + C_2H_3O_2^-(aq)$	$Al(OH)_3(s) \rightleftharpoons Al^{3+}(aq) + 3\ OH^-(aq)$
Ksp Expression:	$K_{sp} = [Ag^+][\ C_2H_3O_2^-]$	$K_{sp} = [Al^{3+}][\ OH^-]^3$

DIRECTIONS: *Write balanced equations for the dissolution reactions and the corresponding expressions for the solubility products of the following:*

1. MnS
2. $Ca_3(PO_4)_2$
3. $Ca_5(PO_4)_3(OH)$
4. PbI_2
5. Cu_2S
6. $Ni(OH)_2$

DIRECTIONS: *Calculate values of K_{sp} for the following salts using the information given.*

Calculate the K_{sp} of calcium oxalate if 4.8×10^{-5} mol dissolves in 1.0 L of water to produce a saturated solution.

$CaC_2O_4(s) \rightleftharpoons Ca^{2+}(aq) + C_2O_4^{2-}(aq)$

$[Ca^{2+}] = [C_2O_4^{2-}] = 4.8 \times 10^{-5}\ M$; $K_{sp} = [Ca^{2+}][C_2O_4^{2-}] = (4.8 \times 10^{-5})^2 = 2.3 \times 10^{-9}$

7. The concentration of Mg^{2+} is 6.3×10^{-3} *M* at 25°C in a solution of $MgCO_3(s)$ at equilibrium. Calculate K_{sp}.
8. Determine the solubility product constant for $PbBr_2$ if the concentration of Pb^{2+} in a saturated solution is 2.14×10^{-2} M.
9. Find K_{sp} for a saturated solution of aluminum chromate if the concentration of the chromate ion is 0.0990 M.
10. The molar solubility of BiI_3 is 1.32×10^{-5} mol/L. Calculate K_{sp}.
11. Calculate K_{sp} if the solubility of iron(II) oxalate is 65.9 mg/L, at 25°C.

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DIRECTIONS: *Calculate the solubility of each of the following compounds in moles per liter and grams per liter.*

$Fe(OH)_2$ ($K_{sp} = 1.20 \times 10^{-5}$)

$Fe(OH)_2(s) \rightleftharpoons Fe^{2+}(aq) + 2OH^-(aq) \quad \rightarrow \quad K_{sp} = [Fe^{2+}][OH^-]^2$

Setting $[Fe^{2+}]$ to *x*, and the $[OH^-]$ to *2x*, (the mole ratio of Fe^{2+} to OH^- is 1:2), we get:

$1.2 \times 10^{-5} = [x][2x]^2 \quad \rightarrow \quad 1.2 \times 10^{-5} = 4x^3 \quad \rightarrow \quad 3.0 \times 10^{-6} = x^3 \quad \rightarrow \quad 0.014 = x$

So, $[Fe^{2+}]$ is 0.0144 *M* and $[OH^-]$ would be twice that or 0.0288 *M*.

Since the concentration of $[Fe^{2+}]$ produced = $[Fe(OH)_2]$ consumed, the solubility of $Fe(OH)_2$ = 0.014 M

12. $Be(IO_4)_2$, $K_{sp} = 1.57 \times 10^{-9}$

13. $CaSO_4$, $K_{sp} = 6.1 \times 10^{-5}$

14. Hg_2Cl_2, $K_{sp} = 1.1 \times 10^{-18}$

15. Ag_2CrO_4, $K_{sp} = 9.0 \times 10^{-12}$

16. Use the following data to calculate K_{sp} values for each solid.
    a. The solubility of CaC_2O_4 is 4.8×10^{-5} mol/L.

    b. The solubility of BiI_3 is 1.32×10^{-5} mol/L

17. The concentration of Ag^+ in a solution saturated with $Ag_2C_2O_4(s)$ is 2.2×10^{-4} M. Calculate K_{sp} for $Ag_2C_2O_4$.

18. Calculate the molar solubility of $Al(OH)_3$, $K_{sp} = 2 \times 10^{-32}$.

19. The solubility of $Ce(IO_3)_3$ in a 0.20 M KIO_3 solution is 4.4×10^{-8} mol/L. Calculate K_{sp} for $Ce(IO_3)_3$.

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20. The K_{sp} for silver sulfate, (Ag_2SO_4) is 1.2×10^{-5}. Calculate the solubility of silver sulfate in each of the following.
    a. Water

    b. 0.10 M $AgNO_3$

    c. 0.20 M K_2SO_4

21. A solution is 1×10^{-4} M in NaF, Na_2S, and Na_3PO_4. What would be the order of precipitation as a source of Pb^{2+} is added gradually to the solution? The relevant K_{sp} values are $K_{sp}(PbF_2) = 4x\ 10^{-8}$, $K_{sp}(PbS = 7 \times 10^{-29}$, and $K_{sp}(Pb_3(PO_4)_2) = 1 \times 10^{-54}$.