4. Solubility Equilibria

A. Solubility Product Constant, K_{sp}

- Consider the equilibrium that exists in a saturated solution of $BaSO_4$

$$BaSO_{4(s)} \rightleftharpoons Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$

$$K_{sp} = [Ba^{2+}][SO_4^{2-}]$$

- In general $A_aB_{b(s)} \rightleftharpoons aA^+_{(aq)} + bB^-_{(aq)}$, $K_{sp} = [A^+]^a[B^-]^b$

- K_{sp} is not the solubility
  - ↳ quantity of solute that dissolves in a given amount of solvent.
  - → solubility product constant for the equilibrium b/w an ionic solid and its saturated solution

Solubility of a compound (g/L) ⟷ Molar Solubility of a compound (mol/L) → Molar concentration of ions ⇄ K_{sp}

The smaller K_{sp} is, the less soluble the solid is.

5. Factors That Affect Solubility (of ionic compounds)

A. Common-Ion Effect - The solubility of a slightly soluble salt is decreased by the presence of a 2nd solute with a common ion.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2F^-(aq)$$

which way would equilibrium shift if NaF was added? shift left

Ex (17) The value for Ksp for $Mn(OH)_2$ is 1.6×10^{-13}. Calculate the molar solubility of $Mn(OH)_2$ in a solution that contains .020M NaOH

$$Mn(OH)_2(s) \rightleftharpoons Mn^{2+}(aq) + 2OH^-$$

I	0	.020 M
C	x	2x
E	x	.02 + 2x

$$1.6 \times 10^{-13} = (x)(.02+2x)^2$$

$$1.6 \times 10^{-13} = (x)(.0004)$$

$$4 \times 10^{-10} M = x$$

Ex (15) A saturated solution of $Mg(OH)_2$ in contact with undissolved solid is prepared at 25°C. The pH of the solution is 10.17. Assuming $Mg(OH)_2$ completely ionizes, calculate Ksp.

$$Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$$

7.40×10^{-5} M 1.48×10^{-4} M

pOH = 3.83

$[OH^-] = 10^{-3.83}$

$[OH^-] = 1.48 \times 10^{-4}$ M

$$K_{sp} = [Mg^{2+}][OH^-]^2$$

$$= [7.40 \times 10^{-5}][1.48 \times 10^{-4}]^2 = 1.62 \times 10^{-12}$$

Ex (16) The Ksp of LaF_3 is 2×10^{-19}. what is the solubility of LaF_3 in water in mol/L

$$LaF_3 \rightleftharpoons La^{3+} + 3F^- \qquad K_{sp} = [La^{3+}][F^-]^3$$

	LaF_3	La^{3+}	$3F^-$
I		0	0
C		+x	+3x
E		x	3x

$2 \times 10^{-19} = x(3x)^3$

$2 \times 10^{-19} = 27x^4$

$7.41 \times 10^{-21} = x^4$

9.28×10^{-6} M = x

$$9.28 \times 10^{-6} \frac{mol}{L} \left(\frac{196\ g}{1\ mol} \right) = 1.81 \times 10^{-3} \frac{g}{L}$$

B. Solubility and pH

- If a substance has a basic anion, it will be more soluble in an acidic solution
- substances with acidic cations are more soluble in basic solutions

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