CHEM 1412 Problem Set #3a **Dr. Ya-Ping Huang**

Solubility Equilibrium

1. Calculate the molar solubility of CaF_2 at 25°C in:

a. pure water (2.1×10^{-4} M)

b. in 0.010M $Ca(NO_3)_2$ solution (3.1×10^{-5} M)

c. in 0.010M KF solution (3.9×10^{-7} M)

[Ans]: The 1st step is to write the equation for dissolution, and find the relationship between Ksp and molar solubility.

. a. R $CaF_{2(s)} \Leftrightarrow Ca^{2+}_{(aq)} + 2F^-_{(aq)}$ Let S represent the molar solubility

E S → S 2S

$Ksp = [Ca^{2+}]_{eq}[F^-]_{eq}^2 = (s)(2s)^2 = 4S^3 = 3.9x10^{-11}$

$$S = \sqrt[3]{\frac{K_{sp}}{4}} = \sqrt[3]{\frac{3.9x10^{-11}}{4}} = \sqrt[3]{9.75x10^{-12}} = 2.14x10^{-4}\,M$$

b. In 0.010M $Ca(NO_3)_2$ solution, there is the common –ion effect. The extra Ca^{2+} from $Ca(NO_3)_2$ will reduce the solubility of $CaF_{2(s)}$ (Le Chatelier's principle) –the common-ion effect

R $CaF_{2(s)} \Leftrightarrow Ca^{2+}_{(aq)} + 2F^-_{(aq)}$ Let S represent the molar solubility

E S → S 2S

+0.010

$[Ca^{2+}]_{eq} = 0.010 + S$ $[F^-]_{eq} = 2S$

$Ksp = [Ca^{2+}]_{eq}[F^-]_{eq}^2 = (S+0.010)(2S)^2 \cong (0.010)(2S)^2 = 0.04S^2 = 3.9x10^{-11}$

(s is dropped from s+0.010, because when there is common-ion effect , the solubility will be severely reduced such that the s term is negligible compared to the concentration of commen-ion)

$$S = \sqrt{\frac{Ksp}{0.04}} = \sqrt{\frac{3.9x10^{-11}}{0.04}} = 3.12x10^{-5}\,M$$

$Ksp = [Ca^{2+}]_{eq}[F^-]_{eq}^2 = (s)(2s)^2 = 4S^3 = 3.9x10^{-11}$

c. in 0.010M KF solution: there is the common –ion effect. The extra F^- from KF will reduce the solubility of $CaF_{2(s)}$ through common-ion effect (Le Chatelier's principle)

R $CaF_{2(s)} \Leftrightarrow Ca^{2+}_{(aq)} + 2F^-_{(aq)}$ Let S represent the molar solubility

E S → S 2S

+0.010

$[Ca^{2+}]_{eq} = S$ $[F^-]_{eq} = 0.010 + 2S$

$Ksp = [Ca^{2+}]_{eq}[F^-]_{eq}^2 = (S)(0.01+2S)^2 \cong (S)(0.01)^2 = 1.0x10^{-4}S = 3.9x10^{-11}$

$S = Ksp/1.0x10^{-4} = 3.9x10^{-7}$ M