

CHEM 1412 Problem Set #3a

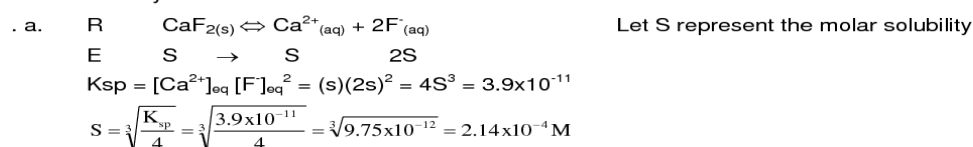
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Solubility Equilibrium

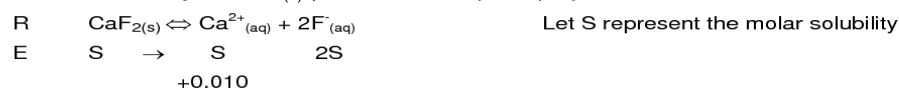
1. Calculate the molar solubility of CaF_2 at 25°C in:

- a. pure water (2.1×10^{-4} M)
- b. in 0.010M $\text{Ca}(\text{NO}_3)_2$ 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 K_{sp} and molar solubility.



b. In 0.010M $\text{Ca}(\text{NO}_3)_2$ solution, there is the common -ion effect. The extra Ca^{2+} from $\text{Ca}(\text{NO}_3)_2$ will reduce the solubility of $\text{CaF}_{2(s)}$ (Le Chatelier's principle) –the common-ion effect



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

$$K_{sp} = [\text{Ca}^{2+}]_{eq} [\text{F}^{-}]_{eq}^2 = (S + 0.010)(2S)^2 \cong (0.010)(2S)^2 = 0.04S^2 = 3.9 \times 10^{-11}$$
 (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 common-ion)

$$S = \sqrt{\frac{K_{sp}}{0.04}} = \sqrt{\frac{3.9 \times 10^{-11}}{0.04}} = 3.12 \times 10^{-5} \text{ M}$$

$$K_{sp} = [\text{Ca}^{2+}]_{eq} [\text{F}^{-}]_{eq}^2 = (s)(2s)^2 = 4S^3 = 3.9 \times 10^{-11}$$

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



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

$$K_{sp} = [\text{Ca}^{2+}]_{eq} [\text{F}^{-}]_{eq}^2 = (S)(0.010 + 2S)^2 \cong (S)(0.010)^2 = 1.0 \times 10^{-4} S = 3.9 \times 10^{-11}$$

$$S = K_{sp} / 1.0 \times 10^{-4} = 3.9 \times 10^{-7} \text{ M}$$