Chapter 15 – Precipitation Equilibrium

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March 24, 2021

- Example Decomposition: $NaCl(s) \rightleftharpoons Na^+(s) + Cl^-(s)$

  1. $K_{sp} = \left[Na^+\right]\left[Cl^-\right]$

- Solutions can only hold a set number of ions, over that solid forms
- Ion Product (P) — Concentration not necessarily at equilibrium

  1. $P > K_{sp}$ then there is solid
  2. $P < K_{sp}$ then there is no solid
  3. $P = K_{sp}$ then there is no solid and it is at equilibrium

- Water Solubility — How much can dissolve

  1. Example: $Fe(OH)_2$ has a solution of $2.5 \cdot 10^{-5}$[M]

$$\begin{aligned} K_{sp} &= [Fe]\,[OH]^2 \\ &= \left(2.5 \cdot 10^{-5}\right)\left(2.5 \cdot 10^{-5}\right)^2 \\ &= 1.56 \cdot 10^{-14} \end{aligned}$$

  2. Example: 1[g] CaF_2 ($K_{sp} = 1.5 \cdot 10^{-10}$) is dissolved in 1[L] of water at 80[$^\circ$ C]. Calculate the mass precipitation at 25[$^\circ$ C]

$$\begin{aligned} CaF_2 &\rightleftharpoons Ca^{2+} + 2\,F^- \\ K_{sp} &= \left[Ca^{2+}\right]\left[F^-\right]^2 \\ 1.5 \cdot 10^{-10} &= (x)\,(2x)^2 \\ x &= .000347\,[\text{M}] \\ .000347 \cdot 78 &= .974[\text{g}] \text{ not dissolved} \\ 1 - .974 &= .026[\text{g}] \text{ dissolved} \end{aligned}$$

- Common Ion Effect — Dissolving an ionic compound in water that already has that ion in it (e.g. dissolving $CaCO_3$ in Na_2CO_3 — carbonate, ${CO_3}^{2-}$, is the common ion)

  1. Ionic solids are less soluble in a solution with a common ion
  2. Example: Calculate solubility of $CaCO_3$ ($K_{sp} = 5 \cdot 10^{-9}$) in pure water and in a .1[M] solution of $Fe(CO_3)_2$

     (a) Pure:

     $$\begin{aligned} 5 \cdot 10^{-9} &= (x)(x) \\ x &= 7.07 \cdot 10^{-5}\,[\mathrm{M}] \end{aligned}$$

     (b) .1[M]$Fe(CO_3)_2$

     $$\begin{aligned} 5 \cdot 10^{-9} &= (x)((.1)(2)) \\ x &= 2.5 \cdot 10^{-8}[\mathrm{M}] \end{aligned}$$