

Uses, Applications, Occurrences of K_{sp} Equilibria

Geology

- caves, caverns, sinkholes - carbonates dissolving, $[CO_2]$ high (low pH)
- stalactites, stalagmites - carbonates precipitating, $[CO_2]$ low (high pH)
- mid-oceanic ridges and vents - Cu, Fe sulfides
- formation of gemstones - zircons, pearls

Biology

- low solubility - $BaSO_4$ used in X-rays
- sea shells
- kidney stones
- dissolving of teeth governed by K_{sp}
- precipitation of calcium phosphate as bone

Technology

- photography
- separation of metals from ores
- scale deposits
- paint pigments

Solubility Equilibria

solubility

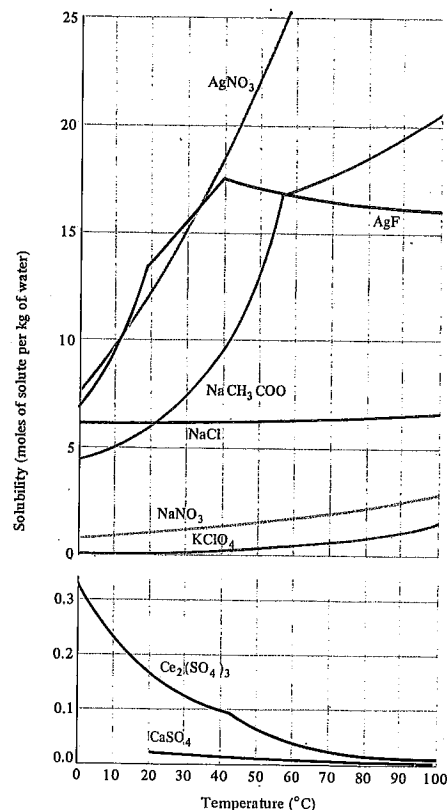
concentration of a **saturated** solution

solubility equilibrium

solubility product constant, K_{sp}

generally endothermic

FIG I - Effect of Temperature on Solubility



Relation of Solubility to K_{sp}

molar solubility

mass solubility

assumptions of equilibrium calculations

ideal solution

ions solvated

system at **equilibrium**

EX 1. Given the K_{sp} of AgCl, express the solubility of AgCl in terms of its K_{sp} .

EX 2. Given the K_{sp} of Bi_2S_3 , express the solubility of Bi_2S_3 in terms of its K_{sp} .

EX 3. If the solubility of lead(II) fluoride is 0.064 g/100 mL, what is the value of its K_{sp} ?

Comparing Relative Solubilities Given K_{sp}

The compounds on the right have solubilities and K_{sp} values that can be directly compared.

compound	solubility product constant, K_{sp}
AgI	1.5×10^{-16}
CuI	5.1×10^{-12}
CaSO ₄	2.4×10^{-5}

EX 4. What are the solubilities of the following compounds?

compound	K_{sp}	solubility
CuS	8.5×10^{-45}	
Ag ₂ S	1.6×10^{-49}	
Bi ₂ S ₃	1.1×10^{-73}	

Precipitation from Solution

When will a precipitate form?

Use of Q , **product quotient**

Criteria for Precipitate Formation: Comparison of Q to K_{sp}

$Q < K_{sp}$ no precipitate forms
unsaturated solution

$Q = K_{sp}$ no precipitate forms (just a trace)
saturated solution

$Q > K_{sp}$ precipitate forms
may be temporarily **supersaturated - unstable**

EX 5. 0.4 mol of MgCl₂ is added to 1 L of a 5×10^{-5} M solution of Na₂CO₃. Will a precipitate form?

Will a precipitate form if 0.9 mol of MgCl₂ is added?

EX 6. 400 mL of 0.20 M BaCl_2 is mixed with 100 mL of 0.50 M Na_2CO_3 . Give the concentration of all ions and the amount of precipitate. $K_{\text{sp}} \text{BaCO}_3 = 8.1 \times 10^{-9}$

Common-Ion Effect

decreased solubility of an ionic solid in a solution that contains a dissolved ion that is present in the ionic solid

Le Châtelier's principle

EX 7. $K_{\text{sp}} \text{PbI}_2 = 1.4 \times 10^{-10}$. What is the solubility of PbI_2 in pure water?

What is the solubility of PbI_2 in 0.10 M NaI ?