Fundamentals of Analytical Chemistry

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What is Solubility Product, K_{sp}?

The solubility product constant is the equilibrium constant for the dissolution of a solid substance into an aqueous solution

Dissolution reaction:

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

Reverse of the dissolution reaction:

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

Ultimately, dynamic equilibrium is reached

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

$$K_{sp} = [Ca^{2+}][F^-]^2$$

Solubility Product Constant

Another example : The solubility equilibrium law equation is ,

$$Ba(IO_3)_{2\,(s)} \rightleftharpoons Ba^{+2}{}_{(aq)} + 2IO_3^-{}_{(aq)}$$

$$k = \frac{[Ba^{+2}]\,[IO_3]^3}{Ba(IO_3)_2}$$

Which simplifies to :

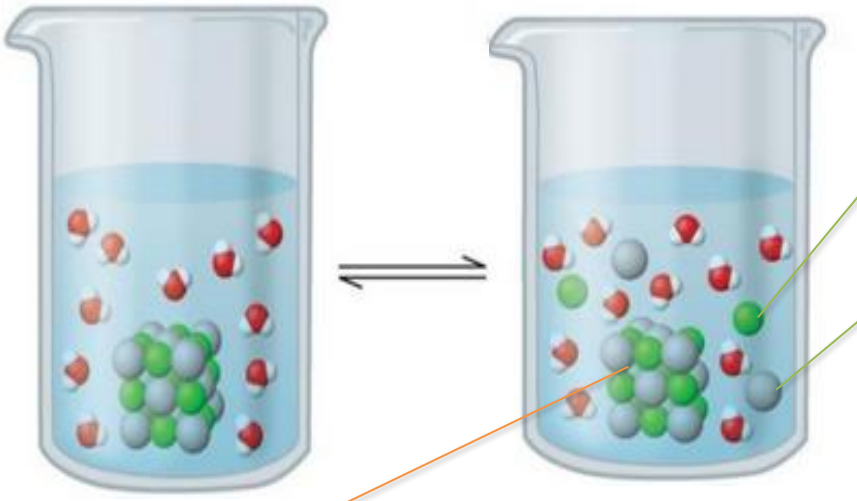
$$ksp = [Ba^{+2}]\,[IO_3]^2$$

What is Solubility Product, K_{sp}?

Solubility Equilibrium for AgCl •

Silver chloride, AgCl, is only **slightly** soluble in water. When it is added to water, it dissolves slightly and forms a saturated solution containing a very dilute Ag+ and Cl– ions in equilibrium with undissolved

$$AgCl_{(s)} \rightleftharpoons Ag^{+}_{(aq)} + Cl^{-}_{(aq)}$$



$K_{sp} = [Ag^{+}][Cl^{-}]$

smaller K_{sp} = lower solubility

$K_{sp} = 10^{-30}$

Solubility and Ksp

Three important definitions:

Solubility

quantity of a substance that dissolves to form a saturated solution

Molar solubility

the number of moles of the solute that dissolves to form a liter of saturated solution

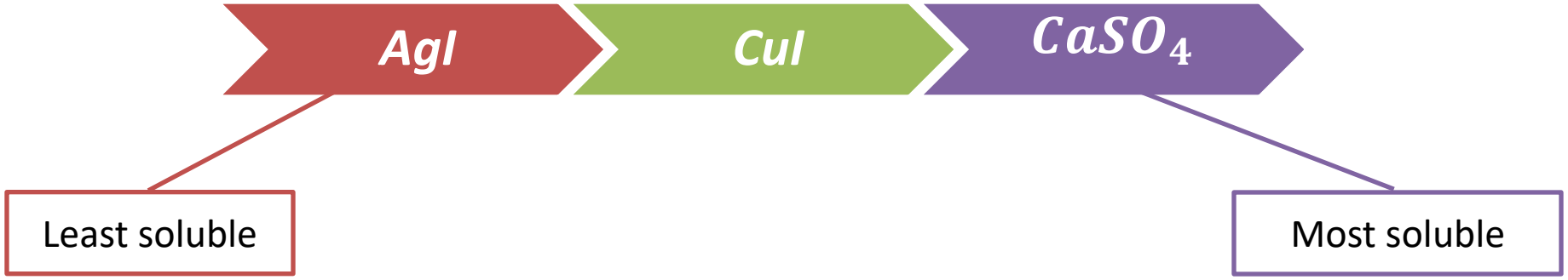
Ksp (solubility product

the equilibrium constant for the equilibrium between an ionic solid and its saturated solution

Relative Solubility

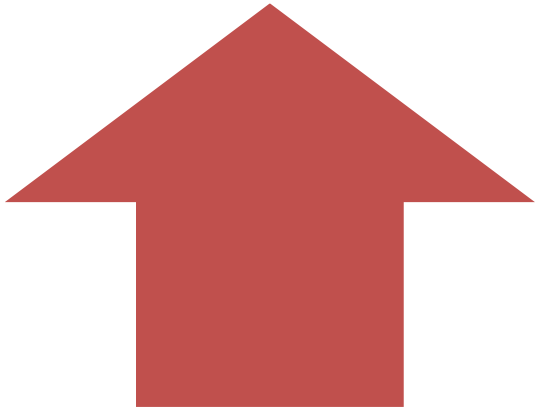
Salt	K_{sp}	K_{sp}	Calculated Solubility (mol/L)
AgI	$K_{sp} = [Ag^+][I^-]$	1.5×10^{-16}	1.2×10^{-8}
CuI	$K_{sp} = [Cu^+][I^-]$	5.0×10^{-12}	2.0×10^{-6}
$CaSO_4$	$K_{sp} = [Ca^{2+}][SO_4^{2-}]$	6.1×10^{-5}	7.8×10^{-3}

$$K_{sp} = s^2 \Rightarrow s = \sqrt{K_{sp}}$$



What is the Common Ion Effect?

A solution where in there are several species associating with each other via a chemical equilibrium process,



an increase in the concentration of one of the ions dissociated in the solution by the addition of another species containing the same ion will lead to an increase in the degree of association of ions.

The decrease in the solubility of the salt in a solution .

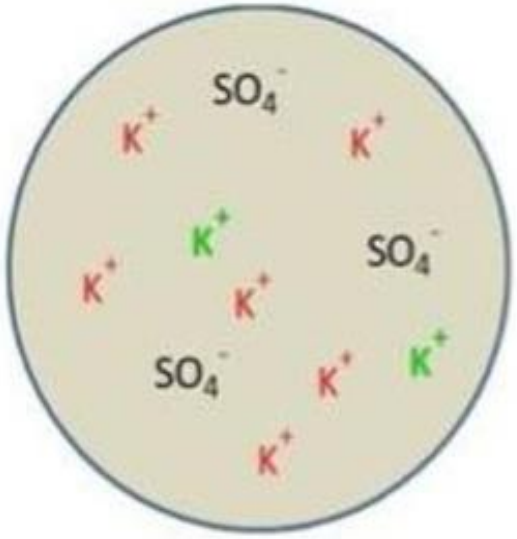
The lowering of the degree of discussion of weak electrolytes by adding a strong electrolyte having a common ion

What is the Common Ion Effect?

- The solubility of an ionic precipitate **decreases** when a soluble compound containing one of the ions of the precipitate is added to the solution.
- We can add KNO3 to the solution –KNO3 and K2SO4 both **contain** K^+ .
- The equilibrium will **shift left**.

$$KNO_{3\,(s)} \rightleftharpoons K^+_{(aq)} + NO_3^-{}_{(aq)}$$

$$K_2SO_{4\,(s)} \rightleftharpoons 2K^+_{(aq)} + SO_4^{-2}{}_{(aq)}$$



Le Châtelier's Principle states that if :

- an equilibrium becomes unbalanced.
- the reaction will shift to restore the balance.
- Control formation of a precipitate
- If a common ion is added to a weak acid or weak base equilibrium ,then the equilibrium will shift towards the reactants.

$$Ag_2CrO_{4(s)} \rightleftharpoons 2\,Ag^+_{(aq)} + CrO_4^{-2}{}_{(aq)}$$

$$AgNO_3 \rightleftharpoons Ag^+_{(aq)} + NO_3^-{}_{(aq)}$$