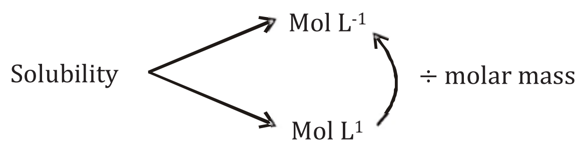
SOLUBILITY AND SOLUBILITY PRODUCT

Solubility Equilibria of Sparingly Soluble Salts

“The amount of a substance that has been dissolved in a solution, expressed in terms of moles per unit volume."



Classification of Salts:

If $S > 0.1$ M
⇒ Soluble Salts
If $0.01 \text{ M} < S < 0.1$ M
⇒ Partial Soluble salts
If $S < 0.01$ M
⇒ Sparingly soluble salts

Note: All salts of alkali metals and NH_4^+ ion is generally water soluble.

Examples of sparingly soluble salts are AgCl, $PbCl_2$, Hg_2Cl_2, $PbSO_4$, Ag_2CO_3, $CaSO_4$, AgCN, etc.

Process of Dissolution of Sparingly Soluble Salts

Let AB ⟶ Sparingly Soluble Salt

$$AB(s \underset{\text{Precipitation}}{\overset{\text{dissolution} \; H_2(\ell)}{\rightleftharpoons}} \overset{\oplus}{A}(aq) + \overset{\ominus}{B}(aq)$$

Initially, rate of dissociation > rate of ppt.

∴ more salt can be dissolved and solution is unsaturated.

But, when Saturated solution

rate of dissolution = rate of ppt ion

In a saturated solution, all the dissolved salt exists in the form of its ions. Consequently, the concentration of ions in a saturated solution serves as an indicator of the salt's solubility.

This principle is typically applied to salts with limited solubility, and we will be focusing on solubility in such solutions

Simple Solubility

Let the salt is $A_x B_y$, in solution in water, let the solubility in H_2O = 's' M, then

$$A_xB_y \longrightarrow xA^{y+} + yB^{-x}$$
$$-\,xs \qquad\qquad ys$$

∴ $$k_{sp} = (xs)^x \, (ys)^y = x^x, y^y.(s)^{x+y}$$

Different Cases of Calculating Solubilities

Solubility Product (K_{sp})

For a saturated solution,

$$AB \longrightarrow A^{\oplus} + B^{\ominus}$$

$$K_{eq.} = \frac{[A^+][B^-]}{[AB]} \quad \text{[concentration of solid is constant]}$$

$\therefore$

$$\underbrace{K_{eq.}[AB]}_{\downarrow} = [A]^+[B]^-$$

$$K_{sp} = [A^+][B^-]$$

Solubility product (K_{sp}) is a type of equilibrium constant, so will be dependent only on temperature for a particular salt.

Here different methods for writing K_{sp} for different types of salts are following:

(a) **AB Type Salt**

$$AB(s) \longrightarrow A^+(aq) + B^-(ag)$$

$$\quad s \qquad\qquad s$$

$$K_{sp} = [A^+][B^-] = s^2$$

$$s = \sqrt{K_{sp}}$$

(b) **A_2B Type Salt**

$$A_2\ B(\ s) \longrightarrow 2\ A^+(aq) + B^-(aq)$$

$$\quad 2s \qquad\qquad s$$

$$K_{sp} = [A^+]^2[B^-] = [2s]^2[s] = 4s^3$$

$$K_{sp} = 4s^3$$

(c) **AB_3 Type Salt**

$$AB_3(\ s) \longrightarrow A^{3+}(aq) + 3\ B^-(aq)$$

$$\quad s \qquad\qquad 3s$$

$$K_{sp} = [s][3s]^3 = 27s^4$$

(d) **A_2B_3 Type Salt**

$$A_2\ B_3(\ s) \longrightarrow 2\ A^{3+}(aq) + 3\ B^{2-}(aq)$$

$$\quad 2s \qquad\qquad 3s$$

$$K_{sp} = [2s]^2[3s]^3$$

$$K_{sp} = 108\ s^5$$

(e) **AxBy Type Salt**

$$AxBy \longrightarrow xA^{y+} + yB^{x-}$$

$$AxBy \longrightarrow xA^{y+} + yB^{x-}$$

xs ys

$$K_{sp} = (xs)^x (ys)^y$$

$$K_{sp} = x^x . y^y . s^{x+y}$$

The forthcoming examples will demonstrate various types of solubility and the influence of diverse factors or conditions on a salt's solubility.