*. Solubility Equilibria —

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Salts like NaCl, KCl, $CuSO_4$, $AgNO_3$ etc are highly soluble in water. Salts like LiF, AgCl, $BaSO_4$, CaF_2 etc are so little soluble in water that they are commonly called insoluble salts.

On the basis of their solubility, salts are classified into three ~~categories~~ types —

type - I	soluble salt	solubility > 0.1 M
type - II	slightly soluble salt	0.01 M < solubility < 0.1 M
type - III	sparingly soluble salt	solubility < 0.01 M.

When a sparingly soluble salt like AgCl, $BaSO_4$, CaF_2, LiF etc are shaken with water, only a small amount of it dissolved while most of the salts remains undissolved.

Thus there exists an equilibrium between the undissolved solid salt and the ions in the solution.

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Solubility Products —

let us consider a general sparingly salt dissolved in water.

$$AB(s) \underset{}{\overset{H_2O}{\rightleftharpoons}} A^+(aq) + B^-(aq)$$

$$K_c = \frac{[A^+][B^-]}{[AB]} \quad \text{—} (1)$$

The molar concentration of solid is taken as constant.

$$K_c = \frac{[A^+][B^-]}{K}$$

or $K_c \times K = [A^+][B^-] = K_{sp}$ —(2)

The constant K_{sp} is known as solubility product constant or simply solubility product.

In general we can write —

$$A_xB_y \rightleftharpoons xA^{y+} + yB^{x-}$$

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

Where A^{y+} & B^{x-} denote the positive and negative ions respectively.

* <u>Calculation of solubility & solubility products</u> –

① $AgCl(s) \rightleftharpoons Ag^+ + Cl^-$

$\quad\quad\quad\quad\quad\quad\quad\quad S \quad\quad S$

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

$$S \times S$$

$$K_{sp} = S^2$$

$$S = (K_{sp})^{1/2}$$

where, S = solubility

K_{sp} = solubility product

② $Al(OH)_3 \rightleftharpoons Al^{3+} + 3OH^-$

$\quad\quad\quad\quad\quad\quad\quad\quad S \quad\quad 3S$

$$K_{sp} = [Al^{3+}][OH^-]^3$$

$$= S \times 3S^3$$

$$K_{sp} = 27S^4$$

or $S = \left(\frac{K_{sp}}{27}\right)^{1/4}$.

(3) $BaSO_4 \rightleftharpoons Ba^{++}\ SO_4^{--}$

$K_{sp} = [Ba^{++}]\ [SO_4^{--}]$
$\quad\quad\quad\quad S \quad\quad S$

$= S^2$

$K_{sp} = S^2$

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

(4) $Ca_3(PO_4)_2 \rightleftharpoons 3Ca^{++} + 2PO_4^{3-}$
$\quad\quad\quad\quad 3S \quad\quad 2S$

$K_{sp} = [Ca^{++}]^3\ [PO_4^{3-}]^2$

$= (3S)^3 \times (2S)^2$

$= 27S^3 \times 4S^2$

$K_{sp} = 108S^5$

$S = \left(\frac{K_{sp}}{108}\right)^{1/5}$

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Application :-

(1) Calculation of Solubility -

Q. Calculate the solubility of AgCl in H_2O at room temperature if solubility product of AgCl is 1.6×10^{-10}.

$$AgCl \rightleftharpoons Ag^+ + Cl^-$$

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

$$S \times S$$

$$K_{sp} = S^2$$

$$S = \sqrt{1.6 \times 10^{-10}}$$

$$\boxed{S = 1.26 \times 10^{-5} \text{ mol/L}}$$

Mass of AgCl = 143.5 g

$$\therefore S = 1.26 \times 10^{-5} \times 143.5 \text{ g/L}$$

$$\boxed{S = 0.0018 \text{ g/L}}$$

(2) Predicting the precipitation of reaction :-

(a) When ionic product is greater than Ksp.

→ Precipitation formed.

(b) When ionic product is equal to Ksp

→ Solution is saturated.

(c) When ionic product is less than Ksp.

→ Solution is unsaturated & no. ppt is formed.

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