

Mo Tu We Th Fr Sa Su

# \* Solubility Equilibria

By: A. K. Gupta (chem.)

Salts like NaCl, KCl,  $\text{CuSO}_4$ ,  $\text{AgNO}_3$  etc are highly soluble in water. Salts like LiF,  $\text{AgCl}$ ,  $\text{BaSO}_4$ ,  $\text{CaF}_2$  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 -

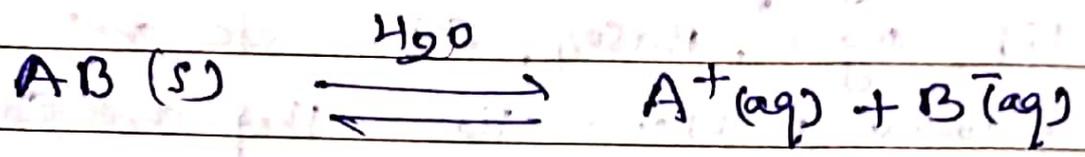
- |            |                        |   |
|------------|------------------------|---|
| type - I   | soluble salt           | solubility $> 0.1 \text{ M}$                    |
| type - II  | slightly soluble salt  | $0.01 \text{ M}$ (solubility) $< 0.1 \text{ M}$ |
| type - III | sparingly soluble salt | solubility $< 0.01 \text{ M}$                   |

When a sparingly soluble salt like  $\text{AgCl}$ ,  $\text{BaSO}_4$ ,  $\text{CaF}_2$ , LiF etc are shaken with water, only a small amount of it dissolved while most of the salt remains undissolved.

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

# Solubility Products

Let us consider a general sparingly salt dissolved in water.



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

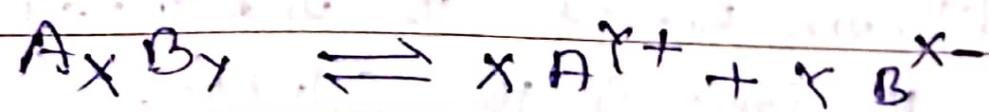
The molar concentration of solid is taken as constant.

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

$$\text{or } K_c \times K = [A^+][B^-] = K_{sp}$$

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

In general we can write -

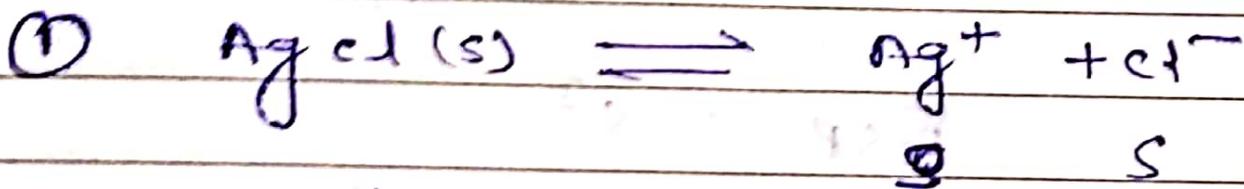


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$$K_{sp} = [A^{Y+}]^x [B^{X-}]^y$$

where  $A^{Y+}$  &  $B^{X-}$  denote the positive and negative ions respectively.

\* Calculation of solubility & solubility products



~~K<sub>sp</sub>~~

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

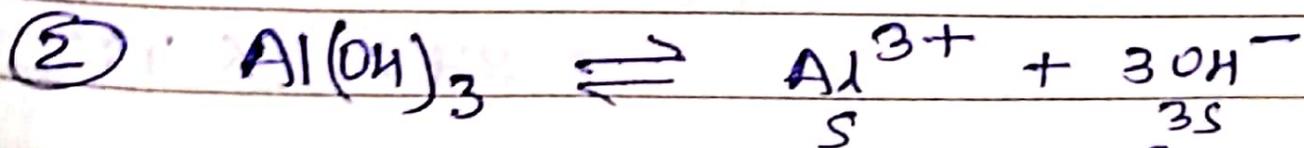
$$S \times S$$

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

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

where,  $S =$  solubility

$K_{sp} =$  solubility product

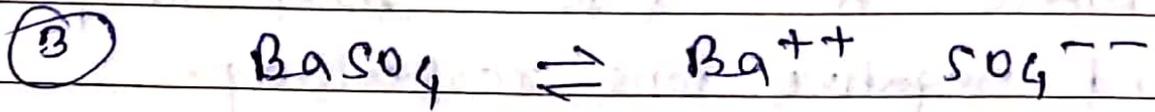


$$K_{sp} = [Al^{3+}] [OH^-]^3$$

$$S \times 3S^3$$

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

$$s = \left( \frac{K_{sp}}{27} \right)^{1/3}$$



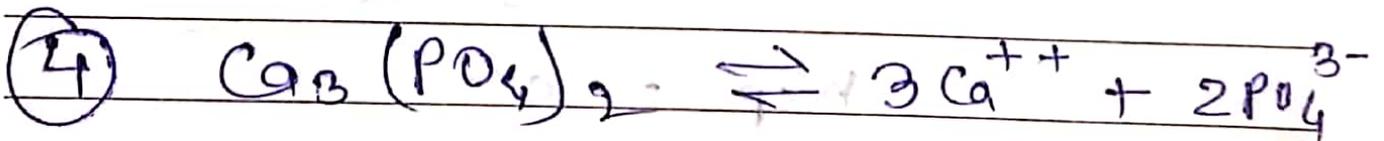
$$K_{sp} = [Ba^{++}] [SO_4^{--}]$$

$$s \quad s$$

$$= s^2$$

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

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



$$3s \quad 2s$$

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

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

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

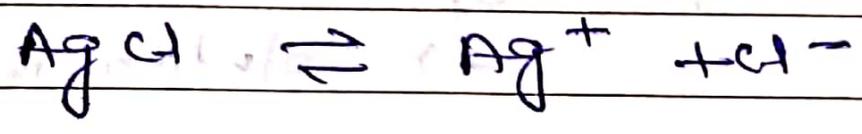
$$K_{sp} = 108s^5$$

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

Application :-

① calculation of solubility -

D. calculate the solubility of AgCl in H<sub>2</sub>O at room temperature  
K<sub>sp</sub> of solubility product of AgCl is  $1.6 \times 10^{-10}$ .



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

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

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

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

Mass of AgCl = 143.5 g

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

$$s = 0.0018 \text{ g/L}$$

# 2 Predicting the precipitation of reaction :-

(a) When ionic product is greater than  $K_{sp}$ .  
→ Precipitation formed.

(b) When ionic product is equal to  $K_{sp}$ .  
→ Solution is saturated.

(c) When ionic product is less than  $K_{sp}$ .  
→ Solution is unsaturated & no. ppt is formed.



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