

Topic  $\Rightarrow$  Solubility Product and its applications.

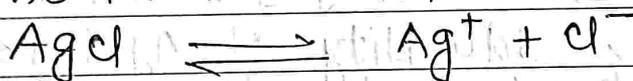
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## Solubility Product

In a saturated solution of a salt, there exists a dynamic equilibrium between the excess of the solute and the ions furnished by that part of the solute which has gone in solution.

e.g.

Consider, the case when a sparingly soluble salt, like silver chloride, is added to water. A very small amount dissolves and the rest of it remains in the solid state.



Applying the law of chemical equilibrium,

$$K = \frac{a_{\text{Ag}^+} \times a_{\text{Cl}^-}}{a_{\text{AgCl}}}$$

Since activity of a solid is taken as unity by convention, the above expression may be put as

$$K_{sp} = a_{\text{Ag}^+} \times a_{\text{Cl}^-}$$

$K_{sp}$  is called solubility product of AgCl.

It is constant at a given temperature. It is more convenient to use concentration terms instead of activities. The constant is then known

as concentration solubility product denoted by  $K'_{sp}$ .

$$\therefore K'_{sp} = [Ag^+][Cl^-]$$

Where the square brackets represents the concentrations of the entities enclosed within.

In the case of sparingly soluble salts since the ionic concentrations are very low, activity of each ion is almost equal to its concentration. Hence,

$$K_{sp} = K'_{sp}$$

i.e. Solubility product is almost equal to concentration solubility product.

### Applications of solubility product

#### 1. Determination of solubilities of sparingly soluble salts. $\Rightarrow$

Let, solubility of a sparingly soluble salt  $AgCl$  is  $s$  mole per litre. The concn. of both silver and chloride ion will be  $s$  mole per litre each.

$$\therefore K_{sp} = [Ag^+][Cl^-] = s^2$$

Hence, solubility of  $AgCl$  is related to the solubility product by the expression.

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

The solubility product of  $AgCl$  at a given temp. is determined by adding  $AgCl$  in a solution of  $KCl$  of a known concentration say  $b$  moles per litre. The concentration of  $Ag^+$  is  $a$  moles per litre.

So, the concentration of chloride ion in solution will be  $(a+b)$  moles per litre due to  $NaCl$  and  $KCl$  both.

Thus solubility product of silver chloride,

$$K_{sp} = a(a+b)$$

Since, both  $a$  and  $b$  are known. The solubility

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of AgCl can easily be calculated.

Hence, solubility of AgCl =  $\sqrt{K_{sp}}$  mole per litre.

- (ii) Predicting precipitation reactions.
- (iii) fractional precipitation
- (iv) Precipitation of soluble salts
- (v) Dissolution of precipitates of phosphates, carbonates and sulphide etc. in Acid solution.

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S.M.