01

Ⓐ Explain Solubility and different factors affecting Solubility.

Answer:

A solution that can not dissolve any more solute at a given temperature is called saturated solution. If it can dissolve more, it is unsaturated.

Solubility:

Solubility is the amount of substance needed to make a solution saturated at a fixed temperature. For example the solubility of Cobalt (II) Chloride at 25°C is 78g per 100 mL of water.

It is generally expressed as amount of solute in grams needed to saturate

100 g of solvent.

$$\text{Solubility} = \frac{\text{Mass of solute in gram} \times 100}{\text{mass of solvent}}$$

Factors affecting solubility:

Solubility depends on:

i) Nature of solvent
ii) Nature of solute
iii) Temperature
iv) Pressure

i) Nature of solvent:

Generally organic compounds are dissolved in organic solvents and for inorganic compounds, they generally dissolve in inorganic solvents. It depends on polarity of solvent. Terpin oil dissolve dye needed to color doors and windows while water dissolves NaCl.

ii) Nature of Solute:

Same solvent can not dissolve all Solutes equally. For example, in water at 30°C, at best 37g of NaCl or, 50g of Na_2SO_4 or 45g of KNO_3 can be dissolved in 100 mL solution.

iii) Effect of temperature:

Generally solubility increases with the increase of temperature. But if the dissolving becomes exothermic, the solubility decreases. Solubility of KNO_3, KI, $AgNO_3$ increase with increase of temperature but for $Na_2SO_4 \cdot 10H_2O$, it increases upto 32.4°C and then decreases as it converts into dry Na_2SO_4. It decreases for gaseous solute in liquid solvent.

iv) Pressure:

It mainly affects gasses. When pressure goes up, it increases collision frequency and thus solubility increases.

(B) Derive the equation of solubility product of some sparingly soluble salt.

Answer:

Let AB be a sparingly soluble salt with solubility S mol L^{-1}

$$AB \rightleftharpoons A^+ + B^-$$

So, In solⁿ, the concentration of $[A^+] = S\ mol L^{-1}$

" " $[B^-] = S\ mol L^{-1}$

$\therefore$ Solubility product of AB

$$K_{sp} = [A^+] \times [B^-]$$
$$= s \times s = s^2 \text{ mol}^2 L^{-2}$$

For AB_2

If AB_2 is salt with solubility s molL^{-1}

$$AB_2 \rightleftharpoons A^{2+} + 2B^-$$

In Sol^n, $[A^{2+}] = s$ molL^{-1}

$[B^-] = 2s$ mol L^{-1}

$\therefore$ Ksp of AB_2

$$K_{sp} = [A^{2+}][B^-]^2$$
$$= s \times (2s)^2$$
$$= 4s^3 \text{ mol}^3 L^{-3}$$

For A_2B Let solubility be $s \text{ mol } L^{-1}$

$$A_2B \rightleftharpoons 2A^+ + B^{2-}$$

In solution, $[A^+] = 2s \text{ mol } L^{-1}$

$[B^{2-}] = s \text{ mol } L^{-1}$

$\therefore$ Ksp of A_2B

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

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

$$= 4s^3 \text{ mol}^3 L^{-3}$$

For AB_3:

If solubility is $s \text{ mol } L^{-1}$

$$AB_3 \rightleftharpoons A^{3+} + 3B^-$$

So, in solution $[A^{3+}] = s \text{ mol } L^{-1}$

$[B^-] = 3s \text{ mol } L^{-1}$

∴ Ksp of AB_3

$$K_{sp} = [A^{3+}] \times [B^-]^3$$
$$= S \times (3S)^3$$
$$= 27 S^4 \ mol^4 L^{-4}$$

Ⓒ Calculate the solubility product of a saturated solution of A_2B salt in water at 25°C temperature in which the concentration of B^{2-} ion is 6.4×10^{-5} M.

Answer:

Let the solubility of A_2B salt be S $molL^{-1}$

So, $A_2B \rightleftharpoons 2A^+ + B^{2-}$

$\quad S \qquad\quad 2S \quad\ S$

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As at saturated solution the con-centration of $[B^{2-}]$ is $S = 6.4 \times 10^{-5} M$

So, solubility of A_2B will be $S = 6.4 \times 10^{-5}$ mol L^{-1}

So, Solubility product of A_2B,

$$K_{sp} = [A^+]^2 \times [B^{2-}]$$
$$= (2S)^2 \times S$$
$$= 4S^3$$
$$= 4 \times (6.4 \times 10^{-5})^3$$
$$= 1.048 \times 10^{-12} \text{ mol}^3 L^{-3}$$

(Answer)

(D) 2mL 0.25M NH_4OH solution is added in 10mL 0.30M AB_3 solution. If the solubility product of $A(OH)_3$ at 25°C is 3.98×10^{-38} then justify the probability of getting precipitation in solution.

Answer:

$$AB_3 + 3NH_4OH \rightarrow A(OH)_3 + 3NH_4B$$

Here, 2mL 0.25M NH_4OH is added in a solution of 10mL 0.30M AB_3 solution.

So total volume of solution $= (10+2)\,mL$
$= 12\,mL$

concentration of A^{3+} $[A^{3+}] = \frac{10 \times 0.3}{12} M$
$= 0.25M$

Concentration of OH^-, $[OH^-] = \frac{2 \times 0.25}{12}$

$= 0.04167\ M$

So, $A(OH)_3 \rightleftharpoons A^{3+} + 3OH^-$

$Kip = [A^{3+}] \times [OH^-]^3$

$= 0.25 \times (0.04167)^3$

$Kip = 1.8 \times 10^{-5}\ mol^4 L^{-4}$

And $Ksp = 3.98 \times 10^{-38}\ mol^4 L^{-4}$

So, $Kip > Ksp$

So, precipitation of $A(OH)_3$ will be produced here.