Solubility Calculations

1. Concentration Calculations

- Concentration refers to the amount of solute per unit volume.

c - concentration
n - number of moles
V - volume

$$c = \frac{n}{V}$$

- When dealing with solutions, chemists express concentration as molarity (M), the number of moles of solute dissolved in one litre of solution.

$$M = \frac{moles\ of\ solute}{liters\ of\ total\ solution}$$

Example: If 0.750 L of a saturated AgCl solution contains 2.50 g AgCl, what is the molar solubility of AgCl? (aka molarity)

need: $M = \frac{mol}{L}$

need moles first $\frac{2.50\,g}{143.4\,g/mol} = 0.0174\,mol$

Given: 0.750 L = V
2.50 g AgCl

$= \frac{0.0174\,mol}{0.750\,L}$

$= 0.0232\,M$

Example: What mass of potassium chloride would be required to make 400 mL of 2.85 M solution?

Given: V = 400 mL (400.0) → convert 1 L = 1000 mL
2.85 M

need: g KCl

need moles first

$M = \frac{mol}{L}$

$mol = M \cdot L$

$= 2.85\,M \cdot 0.4\,L$

$= 1.14\,mol$

$1.14\,mol \times \frac{74.6\,g}{mol}$

$= 85.0\,g\ KCl$

2. Calculating Ion Concentrations

- When an ionic compound dissolves, it dissociates into ions. After writing the balanced dissociation equation, we can calculate the concentrations of ions in solution using the equation ratio.

Example: What are the concentrations of ions in 0.25 M $Na_3PO_{4\,(aq)}$?

(1) Write the balanced dissociation eqn $Na_3PO_{4(aq)} \rightarrow 3Na^+_{(aq)} + PO_4^{-3}_{(aq)}$

(2) use ratio to find concentrations

$0.25\,M\ Na_3PO_4 \times \frac{3\,mol\ Na^+}{1\,mol\ Na_3PO_4} = 0.75\,M\ Na^+$

$0.25\,M\ Na_3PO_4 \times \frac{1\,mol\ PO_4^{-3}}{1\,mol\ Na_3PO_4} = 0.25\,M\ PO_4^{-3}$

Example: Calculate the ionic concentration for each ion when 85.6 g $Al_2(SO_4)_3$ is dissolved in 100.0 mL of water.

(1) $Al_2(SO_4)_{3(aq)} \rightarrow 2Al^{+3}_{(aq)} + 3SO_4^{-2}{}_{(aq)}$

(2) find Molarity first, since not given

$$\frac{85.6\,g}{342.3\,g/mol} = \frac{0.25\,mol}{0.1\,L} = 2.5\,M$$

(3) use equation ratios

$$2.5\,M\ Al_2(SO_4)_3 \times \left(\frac{2\,mol\ Al^{+3}}{1\,mol\ Al_2(SO_4)_3}\right) = \boxed{5.00\,M}\ Al^{+3}$$

$$2.5\,M \times \left(\frac{3}{1}\right) = \boxed{7.50\,M}\ SO_4^{-2}$$

Example: Calculate the concentrations of ions when 25.7 g $(NH_4)_3PO_{4(aq)}$ is dissolved in 250.0mL H_2O.

$(NH_4)_3PO_{4(aq)} \rightarrow 3NH_4^{+}{}_{(aq)} + PO_4^{-3}{}_{(aq)}$

$$\frac{25.7\,g}{149\,g/mol} = \frac{0.1725\,mol}{0.25\,L} = 0.690\,M$$

$$0.690\,M \times \left(\frac{3\,mol}{1\,mol}\right) = \boxed{2.01\,M}\ NH_4^{+}$$

$$0.690\,M \times \left(\frac{1\,mol}{1\,mol}\right) = \boxed{0.690\,M}\ PO_4^{-3}$$