ALMUSTAQBAL UNIVERSITY COLLEGE

Medical Laboratories Techniques Department

Stage : First year students

Subject : General chemistry 1 - Lecture 4 A

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Molality(m):

The Number of moles of solute per kilogram of **solvent**.

انتبه هنا استخدم وزن المذيب وليس المحلول

(المولاليه =عدد مولات المذاب في الكيلوغرام من المذيب)

Solute = المذاب و solution = المحلول و solvent = المذيب

Example

Determine the molality of a solution prepared by dissolving 75 g of solid KNO_3 (101 g/mol) into 374 gm of water at 25°C.

Solution:

Molality(m) $= \frac{number\ of\ moles(solute)x\ 1000}{mass\ of\ solvent(gm)}$

No of moles(solute) $= \frac{wt}{M.wt} = \frac{75\ gm}{101\ g/mol}$ **= 0.743 moles**

Molality(m) $= \frac{number\ of\ moles(solute)x\ 1000}{mass\ of\ solvent(gm)} = \frac{0.743\ mol\ x\ 1000}{374\ gm}$

Molality(m) = 1.987

Mole fraction:

The number of moles of one component relative to the total number of moles of all components in the solution.

Mole fraction of component 1(x_1)= $\dfrac{\textbf{moles of component 1}(n_1)}{\textbf{moles of component 1 }(n_1)+\textbf{moles of component 2 }(n_2)}$

Mole fraction of component 2(x_2)= $\dfrac{\textbf{moles of component 1}(n_2)}{\textbf{moles of component 1 }(n_1)+\textbf{moles of component 2 }(n_2)}$

$$\mathbf{X_1 + X_2 = 1}$$

$$\mathbf{X_1 = 1 - X_2}$$

$$\mathbf{X_2 = 1 - X_1}$$

$X1 = \dfrac{n1}{n1+n2}$	$X2 = \dfrac{n2}{n1+n2}$

Example:

Calculate the mole fraction for each of solute and solvent in a solution if the solute is (2 mole) and the solvent in (3 mole) .

Solution:

$$X_1 = \frac{n_1}{n_1+n_2} = \frac{2}{2+3} = \frac{2}{5} = 0.4$$

$$X_2 = \frac{n_2}{n_1+n_2} = \frac{3}{2+3} = \frac{3}{5} = 0.6$$

$X_1 + X_2 = 0.4 + 0.6 = 1$

For 3 components mixture we have X_1 , X_2 , and X_3 Then:

$$X_1 = \frac{n1}{n1+n2+n3}$$

$$X_2 = \frac{n2}{n1+n2+n3}$$

$$X_3 = \frac{n3}{n1+n2+n3}$$

<u>Example:</u>

Calculate the mole fraction for each component in a mixture that contains 1mole of A , 2 moles of B and 3 moles of C .

Total No of moles n_T = moles of A (n_A) + moles of B (n_B) + moles of C (n_C)

$$n_T = n_A + n_B + n_C$$

$$n_T = 1 + 2 + 3 = 6 \text{ moles}$$

$$X_A = \frac{n_A}{n_T} = \frac{1}{6} = 0.17$$

$$X_B = \frac{n_B}{n_T} = \frac{2}{6} = 0.33$$

$$X_C = \frac{n_C}{n_T} = \frac{3}{6} = 0.5$$

$$X_T = \sum X_i = 1$$

$$X_T = X_A + X_B + X_C$$

$$X_T = 0.17 + 0.33 + 0.5 = 1$$

Exercise:

The mass of an aqueous solution that contains 7.45 g of KCl (74.5 g/mol) is 151.45 g . Calculate :

1. The molality of the solution.

2. The mole fraction of each of the solute(KCl) and solvent (H_2O)(18 g/mol).

Part per million (ppm) :

It is a convenient way to express the concentration of the very dilute solution .

(1 **ppm** = 1 **mg / liter**) or (1 **ppm** = 1 **µg /mL**)

ppm: is a mass ratio of grams of solute to one million grams of sample or solution.

$$C_{ppm} = \frac{mass\ of\ solute(g)}{mass\ of\ solution\ (g)} \times 10^6$$

also

$$\mathbf{Cppm} = \frac{\boldsymbol{mass\ of\ solute(mg)}}{\boldsymbol{volume\ of\ solution(liter)}}$$

$$\mathbf{Cppm} = \frac{\boldsymbol{wt(mg)}}{\boldsymbol{V\ (liter)}} = \frac{\frac{\boldsymbol{wt(\mu g)}}{\mathbf{1000}}}{\frac{\boldsymbol{VmL}}{\mathbf{1000}}}$$

$$\mathbf{Cppm} = \frac{\boldsymbol{wt(\mu g)}}{\boldsymbol{VmL}} \quad (\mu g / mL)$$

1 g =1000 mg , 1mg = 1000 µg , 1 g = 10^6µg

$$\mathbf{Cppm} = \frac{wt(g)}{VmL} \, x \, 10^6$$

Example: Prepare (500mL) of (1000 ppm) KCl aqueous solution .

solution :

$$\mathbf{Cppm} = \frac{wt(g)}{VmL} \, x \, 10^6$$

$$\text{wt}_{\text{g}} = \frac{C_{ppm} \, x \, V_{mL}}{10^6} \quad \text{(By rearrangement)}$$

$$\text{wt (g)} = \frac{1000 \, x \, 500}{10^6} = 0.5 \text{ g}$$

Then 0.5 g of KCl is to be dissolved in water and the volume is completed to 500 mL in a volumetric flask to get(1000 ppm) solution.

Relationship of ppm with Molarity(M) and Normality (N)

ppm = M x M.Wt x 1000

ppm = N x Eq.Wt x 1000

$$\textbf{Molarity(M)} = \frac{PPm}{Mwt \, x1000}$$

يستخدم هذا القانون لتحويل التركيز من PPm الى المولاريه(M)

$$\textbf{Or} \quad Normality(N) = \frac{PPm}{Eq.wt \, x1000}$$

يستخدم هذا القانون لتحويل التركيز من PPm الى التركيز النورمالي (N)

Example:

Calculate the molarity of K^+ (39.1 g/ mol) for the $K_3Fe(CN)_6$ aqueous solution of (63.3 ppm) concentration?

Solution **:**

$$K_3Fe(CN)_6 \longrightarrow 3K^+ + Fe(CN)_6^{3-}$$

1mole → 3mole

63.3ppm $k_3Fe(CN)_6$ → 3x 63.3ppm K^+ = 189.9 ppm K+

Molarity(M) $= \frac{PPm}{Mwt\ x1000} = \frac{189.9PPm}{39.1\ x1000}$ = 4.86 x 10^{-3} M (molarity of K^+)

Molarity of K^+ (M_{k+}) = 4.86 x 10^{-3} M

Example:

The maximum allowed concentration of chloride (35.5 g/mol) in drinking water supply is (2500 ppm) . express this concentration in terms of mole/liter (M) ?

ppm = mg/L

Solution:

$$Molarity(M) = \frac{PPm}{Mwt\ x1000}$$

$$Molarity(M) = \frac{PPm}{Mwt\ x1000} = \frac{2500}{35.5\ x\ 1000} = 7.05 \times 10^{-3}\ M$$

Second method:

$$2500 \text{ ppm} = \frac{2500 \text{ mg}}{\text{liter}}$$

$$\text{Molarity (M)} = \frac{\text{wt}_{\text{g}}}{\text{M.wt } x \text{ V}_{\text{L}}}$$

$$\text{Molarity(M)} = \frac{(2500\ x\ 10^{-3})\text{ g}}{35.5\ x\ 1}$$

Molarity (M) = 7.05 x 10^{-3} M