ALMUSTAQBAL UNIVERSITY

College of Health and Medical Techniques

Medical Laboratories Techniques Department

Stage : First year students

Subject : General Chemistry 1 - Lecture 4

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Part per million (ppm) Concentration

It is a convenient way to express the concentration of the very dilute solution (by ppm or ppb).

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

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

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

or a mass ratio of grams of solute to one million grams of solution.

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

also

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

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

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

Then Cppm is measured by **mg / liter** or **µg /mL**

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

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

<u>Example:</u> What is the weight of KCl needed to Prepare 500 mL of (1000 ppm) aqueous solution ?.

<u>solution :</u>

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

$$wt_{g} = \frac{C_{ppm}\ x\ V_{mL}}{10^6}$$

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

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

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

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

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

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

Example: Calculate the molarity of K^+ for the $K_3Fe(CN)_6$ (329 g / mol) aqueous solution of (63.3 ppm) concentration.

Solution **:**

$$\underset{\text{1mole}}{K_3Fe(CN)_6} \longrightarrow \underset{\text{3mole}}{3K^+} + Fe(CN)_6^{3-}$$

$$\text{Molarity(M)} = \frac{PPm}{Mwt\ x1000} = \frac{63.3.9PPm}{329\ x1000} = 1.92 \text{ x } 10^{-4}\text{ M}$$ (molarity of $k_3Fe(CN)_6$)

Molarity of K^+ (M_{k+}) = 3 x 1.92 x 10^{-4}M = 5.77 x10^{-4} M

Exercise:

Calculate the molarity of (K^+) in 1740 ppm aqueous solution of K_2SO_4 (174 g / mole).

Example:

The maximum allowed concentration of chloride (35.5 g/mol) in drinking water supply is (2.50 x 10^2 ppm) . express this concentration in terms of mole/liter (M) ?

ppm = mg/L

Solution:

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

$$Molarity(M) = \frac{PPm}{Mwt\ x1000} = \frac{2.5\ x\ 10^2}{35.5\ x\ 1000} = 7.05 \text{ x } 10^{-3}\text{ M}$$

Second method:

$$2.5\ x10^2\text{ppm} = \frac{2.5\ x10^2\text{mg}}{\text{liter}}$$

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

$$\text{Molarity(M)} = \frac{(2.5 \; x \; 10^{2} x \; 10^{-3}) \text{ g}}{35.5 \; x \; 1}$$

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

Example :

A 25 µL serum sample was analysed for glucose content and found to contain 26.7 µg. Calculate the concentration of glucose in ppm and in mg/dL.

Solution:

1 mL = 1000 μL

V (mL) = $\frac{V(\mu L)}{1000} = \frac{25(\mu L)}{1000} = 25\text{x}10^{-3}$ mL

Cppm = $\frac{wt(\mu g)}{VmL} = \frac{26.7}{25x10^{-3}}$ = 1068 ppm

1 dL = 100 mL

V(dL) = $\frac{V_{mL}}{100}$

V(dL) = $\frac{V(mL)}{100} = \frac{25x10^{-3}\, mL}{100}$ = $25\text{x}10^{-5}$ dL

mg = 1000 μg

wt (mg) = $\frac{weight\ (\mu g)}{1000}$ = $weight\ (\mu g)$ x 10^{-3}

wt (mg) = 26.7 x 10^{-3}

Concentration (mg/dL) = $\frac{wt(mg)}{V(dL)} = \frac{26.7\ x\ 10^{-3}}{25x10^{-5}}$ = 106.8 mg/dL

**** Then C (mg/dL) = $\frac{C_{ppm}}{10}$**

Then C (mg/dL) = $\frac{Molarity(M) x M.wt\ x1000}{10}$

C(mg/dL) = Molarity(M) x M.wt x100

طريقه ثانيه:

$$mg/dL = \left(\frac{w}{v}\right)\%\ x1000$$

$$\left(\frac{w}{V}\right)\% = \frac{weight\ of\ solute(g)}{volume\ of\ solution(mL)} \times 100\%$$

$$\left(\frac{w}{V}\right)\% = \frac{26.7\ x\ 10^{-6}(g)}{25x10^{-3}(mL)} \times 100\% = 0.1068$$

$$mg/dL = \left(\frac{w}{v}\right)\%\ x\ 1000$$

0.1068 x 1000 = 106.8 mg/ dl

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

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

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

Example :

Determine the molality of a solution prepared by dissolving 25 g of solid KNO_3 (101.1 g/mole) into 500 g of water.

Solution:

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

No of moles(solute) = $\frac{wt}{M.wt}$ $=\frac{25\ g}{101.1\ g\ /mol}$ **= 0.247 moles**

Molality(m) = $\frac{number\ of\ moles(solute)x\ 1000}{mass\ of\ solvent(g)}$ $=\frac{0.247\ mol\ x\ 1000}{500\ \ g}$

Molality(m) = 0.494

Example:

The mass of an aqueous solution that contains 11.7 g of NaCl (58.5 g/mole) is 551.7 g . Calculate the molality of the solution.

Solution :

Mass of solution = mass of solute + mass of solvent

Mass of solution = mass of solute (NaCl) + mass of solvent (H_2O)

Mass of solvent (H_2O) = Mass of solution - mass of solute(NaCl)

Mass of solvent (H_2O) = 551.7 g – 11.7 g = 540 g

No . of moles of NaCl = $\frac{mass(\ g)}{M.wt}$

No . of moles of NaCl = $\frac{11.7}{58.5}$ **= 0.2 mole**

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

Molality (m) $= \frac{0.2\ mol\ x\ 1000}{540\ g} =$ **0.37**

Exercise:

7.45 g of potassium chloride KCl (74.5 g/ mole) was dissolved in 100 g of water. Calculate the molality of the solution.

Example :

A 18 g of urea NH_2CONH_2 (60 g/ mole) was dissolved in 100 g of water (d= 1 g /mL). Calculate the molarity and molality of the solution.

Solution:

No . of moles of urea = $\frac{mass(\ g)}{M.wt}$

No . of moles of urea = $\frac{18(\ g)}{60}$ **= 0.3 mole**

Volume of water = $\frac{mass\ of\ water(g)}{density\ (\frac{g}{mL})}$

Volume of water = $\frac{100(g)}{1\ (\frac{g}{mL})}$ **= 100 mL**

Molarity (M) = $\frac{wt\ x\ 1000}{Mwt\ x\ V(mL)} = \frac{18x\ 1000}{60\ x\ 100(mL)}$ **= 3 M**

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

Density of water = 1 g /mL

Mass of solvent (H_2O) = 1 g /mL x volume of water (mL)

= 1 g/mLx100 mL = 100 g

Molality (m) = $\frac{0.3\ molx1000}{100\ g}$ **= 3**

Example:
The weight of 10 g KCl (74.5 g / mol) is dissolved in 1000 g of water. If the density of the prepared solution is 0.997 g mL^{-1}, calculate :

a) molarity

b) molality of the solution.

Solution:

Molarity = $\frac{wt\ x 1000}{Mwt\ x\ V(mL)}$

Mass of solution = 10 g + 1000 g = 1010 g

Volume of solution = $\frac{mass\ of\ solution}{density} = \frac{1010\ g}{0.997}$ **= 1013 mL**

Molarity = $\frac{10\ x\ 1000}{74.5\ x\ 1013(mL)}$ **= 0.1325 M**

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

No . of moles of KCl = $\frac{mass(\ g)}{M.wt}$

No . of moles of KCl = $\frac{10}{74.5}$ **= 0.1342**

Molality(m) = $\frac{0.1342\ x 1000}{1000}$ **= 0.1342**

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 solute(X_1) = $\frac{\text{No.of moles of solute } (n_1)}{\text{mole of solute } (n_1)+\text{moles of solvent } (n_2)}$

Mole fraction of solvent(X_2) = $\frac{\text{No.of moles of solvent } (n_2)}{\text{moles of solute } (n_1)+\text{moles of solvent } (n_2)}$

مجموع الكسور الموليه في المحلول = 1

$X_T = \sum X_i = 1$

$X_1 + X_2 = 1$

Then $X_1 = 1 - X_2$

and $X_2 = 1 - X_1$

<u>Example:</u> 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)

$$n_T = n_A + n_B + n_C$$

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

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

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

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

$$X_T = \sum X_i = 0.17 + 0.33 + 0.5 = 1$$

Example:

A 4.6 mL of methanol (32 g/mol , d= 0.7952 g/mL) is dissolved in 25.2 g of water(18 g/mol). Calculate the mole fraction of methanol and water.

Solution:

Mass of methanol (g)= Volume x density
Mass of methanol (g) = 4.6 mL x 0.7952 g mL^{-1} = 3.658 g
No . of moles of methanol = $\frac{mass(g)}{M.wt}$

No . of moles of methanol (n_1)= $\frac{3.658(g)}{32}$ **=0.1143**

No . of moles of water(n_2) = $\frac{25.2(g)}{18}$ **=1.4**

Total number of moles = n_1+ n_2 = 0.1143 + 1.4 = 1.5143 mole

Mole fraction of methanol (X_1) = $\frac{n_1}{n_1+n_2}$

Mole fraction of methanol (X_1) = $\frac{0.1143}{1.5143}$ = 0.0755

Mole fraction of water(X_2) = $\frac{n_2}{n_1+n_2}$

Mole fraction of solvent (water) = X_2 = $\frac{1.4}{1.5143}$ = 0.9245

Exercise:

The mass of an aqueous solution that contains 10.1 g of KNO_3 (101 g/mol) is 154.1 g . Calculate :

1. The molality of the solution.

2. The mole fraction of each of the solute(KNO_3) and solvent (H_2O)(18 g/mol).

P- fuctions:

pX = - log [X]

Examples:

pH= –log[H_3O^+] **[H_3O^+] = 10^{-pH}**

pOH = - log[OH^-] **[OH^-] = 10^{-pOH}**