ALMUSTAQBAL UNIVERSITY

College of Health and Medical Techniques
Medical Laboratory Techniques Department

Stage   : First year students
Subject : General Chemistry 1 - Lecture 4

Lecturer: Assistant professor Dr. SADIQ . J. BAQIR

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.

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

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

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

also

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

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

$Cppm = \dfrac{wt(\mu g)}{VmL}$ (**µg / mL**)

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

 1 g =1000 mg   ,   1mg = 1000 µg   1 g = 10⁶µg

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

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

solution :

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

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

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

   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)

$$ppm = M \ x \ M.Wt \ x \ 1000$$

$$ppm = N \ x \ Eq.Wt \ x \ 1000$$
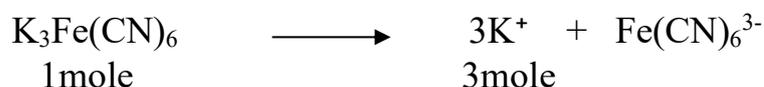
$$Molarity(M) = \frac{PPm}{Mwt \ x 1000}$$

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

$$Or \quad Normality(N) = \frac{PPm}{Eq.wt \ x 1000}$$

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 :

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

$\text{Molarity(M)} = \frac{PPm}{Mwt \; x1000} = \frac{63.3.9PPm}{329 \; x1000} = 1.92 \times 10^{-4} M$ (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) ?

$$\boxed{\textbf{ppm = mg/L}}$$

Solution:

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

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

Second method:

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

$$\text{Molarity (M)} = \frac{wt_g}{M.\,wt \; x \; V_L}$$

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

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) = $\frac{V(\mu L)}{1000}$ = $\frac{25(\mu L)}{1000}$ = 25x10⁻³ mL

$$\text{Cppm} = \frac{wt(\mu g)}{VmL} = \frac{26.7}{25 \times 10^{-3}} = 1068 \text{ ppm}$$

1 dL = 100 mL

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

V(dL) = $\frac{V(mL)}{100}$ = $\frac{25 \times 10^{-3}\,mL}{100}$ = **25x10⁻⁵ 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) = $\frac{wt(mg)}{V(dL)}$ = $\frac{26.7 \times 10^{-3}}{25 \times 10^{-5}}$ = **106.8 mg/dL**

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

Then C (mg/dL) = $\dfrac{Molarity(M) \times M.wt \times 1000}{10}$

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

<div dir="rtl">

طريقه ثانيه:

</div>

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

$(\frac{w}{V})\% = \frac{weight\ of\ solute(g)}{volume\ of\ solution(mL)}$ **x 100%**

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

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

0.1068 x 1000 = 106.8 mg/ dl

Molality(m):

The number of moles of solute per kilogram of solvent.

<div dir="rtl">

انتبه هنا استخدم وزن المذيب وليس المحلول

(المولاليه =عدد مولات المذاب في الكيلوغرام من المذيب)

المذيب = solvent و المحلول = solution والمذاب = Solute

</div>

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

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

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:

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

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

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

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

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

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

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

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

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:

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

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

$$density \; (\frac{g}{mL}) = \frac{mass \; (g)}{Volume \; (ml)}$$

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

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

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

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

Mass of solvent (H_2O) = 100 g

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

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 $= \dfrac{wt \; x1000}{Mwt \; x \; V(mL)}$

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

$density \; (\dfrac{g}{mL}) = \dfrac{mass \; (g)}{Volume \; (ml)}$

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

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

Molality(m) $= \dfrac{number \; of \; moles(solute)x1000}{mass \; of \; solvent \; (g)}$

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

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

Molality(m) $= \dfrac{0.1342 \; x1000}{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) $= \dfrac{\text{No.of moles of solute } (n_1)}{\text{mole of solute } (n_1)+\text{moles of solvent } (n_2)}$

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

مجموع الكسور الموليه في المحلول = 1

$X_T = \sum X_i = 1$

$X_1 + X_2 = 1$

Then $\boxed{X_1 = 1 - X_2}$

and $\boxed{X_2 = 1 - X_1}$

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:

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

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

$X_1 + X_2 = 0.4 + 0.6 = 1$

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

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

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

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

Example: 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)

$n_T = n_A + n_B + n_C$

$n_T = 1 + 2 + 3 = 6$ **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 $(X_1) = \dfrac{n_1}{n_1+n_2}$

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

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

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

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:

$pH= -\log[H_3O^+]$ $[H_3O^+] = 10^{-pH}$

$pOH = - \log[OH^-]$ $[OH^-] = 10^{-pOH}$