**ALMUSTAQBAL UNIVERSITY COLLEGE**

***Medical Laboratories Techniques Department***

**Stage : First year students**

**Subject : General chemistry – part A - Lecture 3**

**Lecturer: Assistant professor Dr. SADIQ . J. BAQIR**

# Normality (N)

**Represents the number of equivalents contained in one liter solution or the number of milli equivalents of solute contained in one milliliter of solution .**

$$\textbf{Normality(N)} = \frac{\textbf{Number of equivalents of solute}}{\textbf{volume of solution(liter)}}$$

$$\textbf{Normality(N)} = \frac{\textbf{Number of milli equivalents of solute}}{\textbf{volume of solution( mL)}}$$

**e.g:** 0.2 N HCl solution contains 0.2 equivalents (eq) of HCl in liter solution or 0.2 milli equivalent (meq) of HCl in each mL of solution .

$$\textbf{Normality (N)} = \frac{\boldsymbol{Number\ of\ equivalents(solute)}}{\boldsymbol{VL(solution)}}$$

$$\textbf{Number of equivalents (eq)} = \frac{\boldsymbol{wt\ (g)}}{\boldsymbol{eq.wt(g)}}$$

$$\textbf{Normality (N)} = \frac{\frac{\boldsymbol{wt}}{\boldsymbol{eq.wt}}}{\boldsymbol{V(liter)}} \qquad \textbf{V(liter)} = \frac{\boldsymbol{V_{ml}}}{\textbf{1000}}$$

**Normality (N)** = $\dfrac{\dfrac{wt}{eq.wt}}{\dfrac{V(mL)}{1000}}$

**Normality (N)** = $\dfrac{wt\ x\ 1000}{eq.wt\ \ x\ \ V(mL)}$

Exercise: proof that **Normality (N)** = $\dfrac{wt\ x\ 1000}{eq.wt\ \ x\ \ V(mL)}$

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Eq.wt = $\dfrac{Mwt}{\eta}$

**Normality (N)** = $\dfrac{wt\ x\ 1000}{\frac{Mwt}{\eta}\ x\ V(mL)}$

**Normality (N)** = $\dfrac{wt\ x\ 1000}{\frac{Mwt\ x\ V(mL)}{\eta}}$

**Normality (N)** = $\left(\dfrac{wt\ x1000}{Mwt\ x\ V(mL)}\right)\ \eta$

| **Normality (N) = Molarity (M) . η , or Molarity(M) = Normality(N) / η** |
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**e.g: Normality(N) of 1M KCl = M . η = 1 x 1 = 1 N KCl ,**

**Normality(N) of 1M HCl = M . η =1 x 1 = 1N HCl,**

**Normality(N) of 1 M $H_2SO_4$ = M . η = 1 x 2 = 2 N $H_2SO_4$ ,**

**Normality(N) of 1 M $Na_2CO_3$ = M . η = 1 x 2 = 2N $Na_2CO_3$**

## I. Equivalent mass in neutralization reaction:

### A) Equivalent mass of acids (Eq):-

Is the mass that either contribute or reacts with one mole of hydrogen ion in the reaction.

$$Eq = \frac{Mwt}{number\ of\ H}$$

1. Mono protic acid e.g: ( HCl , $HNO_3$ , $CH_3COOH$ ) η=1

$$Eq = \frac{Mwt}{1}$$

$$Eq = \frac{36.5}{1} = 36.5\ for\ HCl$$

$$Eq = \frac{63}{1} = 63\ for\ HNO_3$$

2. Diprotic acid e.g: ($H_2SO_4$, $H_2S$, $H_2SO_3$) η= 2

$Eq = \frac{Mwt}{2} = \frac{98}{2} = 49$ for $H_2SO_4$

$Eq = \frac{34}{2} = 17$ for $H_2S$

$Eq = \frac{82}{2} = 41$ for $H_2SO_3$

### B) Equivalent mass of Bases:

Is the mass that either contribute or reacts with one mole of OH in the reaction.

$$Eq = \frac{Mwt}{number\ of\ OH}$$

1. Mono hydroxy base (η=1)

**e.g: NaOH** **for KOH**

**Eq.** $= \frac{Mwt}{1} = \frac{40}{1} = 40$ **Eq.** $= \frac{Mwt}{1} = \frac{56}{1} = 56$

**2.** Di hydroxy base (η=2)

e.g: $Ca(OH)_2$ (74 g / mol)

Eq. = $\frac{Mwt}{2} = \frac{74}{2} = 37$

$Zn(OH)_2$ (99.4 g /mol)

Eq. = $\frac{Mwt}{2} = \frac{99.4}{2} = 49.7$

$Ba(OH)_2$ (171.35 g / mol)

Eq. = $\frac{Mwt}{2} = \frac{171.35}{2} = 85.67$

## II. Equivalent mass in (oxidation – reduction) reaction (Redox):

The equivalent mass of a participant in an (oxidation–reduction) reaction is that mass which directly produce or consume one mole of electron.

**Eq** = $\frac{Mwt}{\eta}$ **η= change in oxidation state number**

η= numbers of electrons participate in oxidation - reduction processes (Redox )

**Example :**

$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + 2MnSO_4 + K_2SO_4 + 8H_2O$

**$2MnO_4^- + 10Fe^{2+} + 8H^+ \rightleftharpoons 10Fe^{3+} + 2MnSO_4$ (acidic medium)**

**$Mn^{7+} \rightarrow Mn^{2+}$ ( 5 e gain – reduction)**

**$Fe^{2+} \rightarrow Fe^{3+}$ ( 1 e loss – oxidation)**

Eq. of $KMnO_4 = \frac{Mwt}{5} = \frac{157.9}{5} = 31.6$

### III. Equivalent mass for salts:

$$Eq = \frac{Mwt}{\eta}$$

**(η) = Σ [ no. of cations x its valency (cation charge)]**

**e.g:** $AgNO_3$ ($AgNO_3 \rightarrow Ag^+ + NO_3^-$)

( **η** = $Ag^+$ (1) x 1= 1)

**Eq.** $= \frac{Mwt}{1} = \frac{170}{1} = 170$

**e.g:** $\mathbf{Na_2CO_3}$ **(**$\mathbf{Na_2CO_3 \rightarrow 2\ Na^+ + CO_3^-}$ **)**

**(η=** $\mathbf{Na^+}$ **(2) x 1 = 2)**

**Eq.** $= \frac{Mwt}{2} = \frac{106}{2} = 53$

e.g: $\mathbf{BaSO_4}$ **(** $\mathbf{Ba^{2+} + SO_4^{2-} \leftrightarrow BaSO_4}$ **)**

**η** = $Ba^{2+}$ (1) x (2+) =2

Mwt for $BaSO_4$ = 233 g/mol

**Eq.** $= \frac{Mwt}{2} = \frac{233}{2} = 116.5$

**e.g:** $\mathbf{La(IO_3)_3}$ **(** $\mathbf{La(IO_3)_3 \rightarrow La^{3+} + 3\ IO_3^-}$ **)**

**(η =** $\mathbf{La^{3+}}$ **(1) x 3 = 3)**

**Eq.** $= \frac{Mwt}{3} = \frac{663.6}{3} = 221.1$

**e.g**: $\mathbf{KAl(SO_4)_2}$ **(258 g/mol)**

**(η) = Σ [ no. of cations x its valency (cation charge)]**

no. of cations = 1 $K^+$ + 1 $Al^{3+}$

**η** = $K^+$ (1) x (1+) **+** $Al^{3+}$(1) x (3+)= 4

**Eq.** $= \frac{M.wt}{4} = \frac{258}{4} = 64.5$

**Example**

**Find the Normality of the solution containing 5.3 g/L of $Na_2CO_3$ (106 g/mol).**

Solution:

To find η for $Na_2CO_3$ ( **η ) = Σ [ no. of cations x its valency(cation charge)]**

No. of cations =2Na+ while the cation charge for $Na^+$ = 1 ,

Then ( **η** ) = 2 x 1 = 2

Eq. of $Na_2CO_3$ = $\frac{Mwt}{2} = \frac{106}{2}$ =**53.0 gm**

Normality (N ) = $\frac{wt}{Eq.\ x\ VL}$

Normality (N) = $\frac{5.3gm}{53.0\ x\ 1L}$ = 0.1N

**Second method**:

**Normality (N)** = $(\frac{wt\ x1000}{Mwt\ x\ V(mL)})$ **η**

**Normality (N)** = $(\frac{5.3\ x1000}{106\ x\ 1000(mL)})$ **2 = 0.1 N**

## Molality (m) :

**Molality is the number moles of solute contained in one kilogram of solvent.**

e.g: If one mole of sugar is dissolved in one kg of distilled water then the concentration of solution is (1mol / kg) or one molali (1m ).

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Molality is calculated by the following mathematical relationship:

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

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**Example**

**Determine the molality of a solution prepared by dissolving 75 g of solid $Ba(NO_3)_2$ (261.32 g /mol) into 374 g of water.**

**Solution:**

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

$$\textbf{No of moles (solute)} = \frac{wt}{M.wt} = \frac{75.0\ g}{261.32\ g\ /mol} = 0.287\ \textbf{moles}$$

$$\textbf{Molality (m)} = \frac{Number\ of\ moles(solute)x\ 1000}{mass\ of\ solvent(g)} = \frac{0.287\ mol\ x\ 1000}{374\ g}$$

**Molality (m) = 0.76**

**Example:**

**The mass of an aqueous solution that contains 11.7 g of NaCl (58.5 g/mol) 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**

**Exercises:**

1. Calculate the molality of the solution prepared by dissolving 36 g of glucose (180 g / mol ) in 360 g of distilled water.

2. The mass of 620 g ethylene glycol ($C_2H_6O_2$)( 62 g/mol) is dissolved in 400 g of distilled water to prepare an antifreeze solution . Calculate the concentration of the solution in molality.

**<u>Mole fraction:</u>**

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

**Suppose : Component 1 = solute Component 2 = solvent**

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

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**$X_T = \sum X_i = 1$**

$X_1 + X_2 = 1$

**Then** $X_1 = 1 - X_2$ **and** $X_2 = 1 - X_1$

**Example: calculate the mole fraction for each of solute and solvent in a solution if the solute is (2 mole) and the solvent is (3 mole) .**

**Solution:**

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

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

$X_1 + X_2 = 0.4 + 0.6 = 1$

**Exercises:**

**1. A sucrose solution $C_{12}H_{22}O_{11}$ (342 g/mol) is prepared by dissolving 34.2 g of it in 180 g of distilled water(18 g/mol). Express the concentration of sucrose and water in the solution in terms of mole fraction for each one.**

**2. Calculate the mole fraction of water in a mixture consists of 9 g of water (18 g / mol) and 120 g of acetic acid ($CH_3COOH$)(60 g / mol) .**

**For 3 components mixture (1 , 2 and 3) 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 1 mole 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 10.1 g of $KNO_3$ (101 g /mol) is 154.1 g . Calculate :**

**a. The molality of the solution.**

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