ALMUSTAQBAL UNIVERSITY COLLEGE

Biomedical Engineering Department

Stage : Second year students

Subject : Chemistry 1 - Lecture 5

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 milliter of solution .

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 .

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

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

Normality (N) = $\frac{\frac{wt}{eq.wt}}{V(liter)}$

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

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

$$\text{Eq.wt} = \frac{Mwt}{\eta}$$

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

Normality (N) $= \frac{\boldsymbol{wt\ x\ 1000}}{\frac{\boldsymbol{Mwt\ xV(mL)}}{\boldsymbol{\eta}}}$

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

Normality (N) = Molarity (M) . η ,
or Molarity(M) = Normality(N) / η

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. <u>Equivalent mass in neutralization reaction:</u>

A) Equivalent mass of acids (Eq):-

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

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

1. Mono protic acid e.g: (**H**Cl , **H**NO_3 , CH_3COO**H**) η=1

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

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

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

2. Diprotic acid e.g: ($\mathbf{H_2}SO_4$, $\mathbf{H_2}S$, $\mathbf{H_2}SO_3$) 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 e.g: (η=1)

e.g: NaOH

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

for KOH

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

2. Di hydroxy base (η=2)

e.g: Ca$\mathbf{(OH)_2}$ (74 g / mol)

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

Zn$\mathbf{(OH)_2}$ (99.4 g /mol)

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

Ba$\mathbf{(OH)_2}$ (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: Na_2CO_3 ($Na_2CO_3 \rightarrow 2Na^+ + CO_3^-$)

(η= Na^+ (2) x 1= 2)

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

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

$\eta = Ba^{2+} (1) \times (2+) = 2$

Mwt for $BaSO_4$ = 233 g/mol

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

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

($\eta = La^{3+} (1) \times 3 = 3$)

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

e.g: $KAl(SO_4)_2$ (258 g/mol)

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

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

$\eta = K^+ (1) \times (1+) + Al^{3+}(1) \times (3+) = 4$

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

Example

Find the Normality of the solution containing 5.300 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) = $\left(\frac{wt\ x1000}{Mwt\ x\ V(mL)}\right)$ **η**

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

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

Example

Determine the molality of a solution prepared by dissolving 75.0 gm of solid $Ba(NO_3)_2$ (261.32 g/mol) into 374.00 gm of water.

Solution:

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

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

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

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

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

مجموع الكسور الموليه في المحلول = ١

$X_T = \sum X_i = 1$

$X_1 + X_2 = 1$ **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 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:

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

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

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

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)

$\mathbf{n_T = n_A + n_B + n_C}$

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

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

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

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

$\mathbf{X_T = \sum X_i = 1}$

$\mathbf{X_T = X_A + X_B + X_C}$

$\mathbf{X_T = 0.17 + 0.33 + 0.5 = 1}$

Exercise:

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

1. The molality of the solution.

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