

ALMUSTAQBAL UNIVERSITY COLLEGE

Biomedical Engineering Department

Stage : Second year students

Subject : General chemistry - 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 milliliter 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 .

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

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

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

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

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

Exercise: proof that $\text{Normality (N)} = \frac{\text{wt} \times 1000}{\text{eq.wt} \times V(\text{mL})}$

الجواب : نكتب الاشتقاق (الخطوات الاربعه اعلاه)

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

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

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

$$\text{Normality (N)} = \left(\frac{\text{wt} \times 1000}{Mwt \times V(\text{mL})} \right) \eta$$

$\text{Normality (N)} = \text{Molarity (M)} \cdot \eta$, or $\text{Molarity(M)} = \text{Normality(N)} / \eta$
--

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 H₂SO₄ = M . η = 1 x 2 = 2 N H₂SO₄ ,

Normality(N) of 1 M Na₂CO₃ = M . η = 1 x 2 = 2N Na₂CO₃

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.

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

1. Mono protic acid e.g: (HCl , HNO₃ , CH₃COOH) $\eta=1$

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

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

$$\text{Eq} = \frac{63}{1} = 63 \text{ for HNO}_3$$

2. Diprotic acid e.g: (H₂SO₄, H₂S, H₂SO₃) $\eta=2$

$$\text{Eq} = \frac{Mwt}{2} = \frac{98}{2} = 49 \quad \text{for H}_2\text{SO}_4$$

$$\text{Eq} = \frac{34}{2} = 17 \text{ for H}_2\text{S}$$

$$\text{Eq} = \frac{82}{2} = 41 \text{ for H}_2\text{SO}_3$$

B) Equivalent mass of Bases:

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

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

1. Mono hydroxy base e.g: ($\eta=1$)

e.g: NaOH

for KOH

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

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

2. Di hydroxy base ($\eta=2$)

e.g: Ca(OH)₂ (74 g / mol)

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

Zn(OH)₂ (99.4 g / mol)

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

Ba(OH)₂ (171.35 g / mol)

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

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.

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

$\eta = \text{change in oxidation state number}$

$\eta =$ numbers of electrons participate in oxidation - reduction processes (Redox)

Example :



$$\text{Eq. of KMnO}_4 = \frac{Mwt}{5} = \frac{157.9}{5} = 31.6$$

III. Equivalent mass for salts:

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

$$(\eta) = \Sigma [\text{no. of cations} \times \text{its valency}(\text{cation charge})]$$



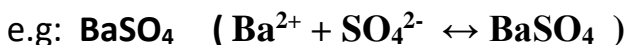
$$(\eta = \text{Ag}^+ (1) \times 1 = 1)$$

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



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

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



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

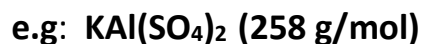
Mwt for $\text{BaSO}_4 = 233 \text{ g/mol}$

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



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

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



$$(\eta) = \sum [\text{no. of cations} \times \text{its valency(cation charge)}]$$

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

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

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

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 ($\eta) = \sum [\text{no. of cations} \times \text{its valency(cation charge)}]$

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

$$\text{Then}(\eta) = 2 \times 1 = 2$$

$$\text{Eq. of Na}_2\text{CO}_3 = \frac{Mwt}{2} = \frac{106}{2} = 53.0 \text{ gm}$$

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

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

Second method:

$$\text{Normality (N)} = \left(\frac{wt \times 1000}{Mwt \times V(mL)} \right) \eta$$

$$\text{Normality (N)} = \left(\frac{5.3 \times 1000}{106 \times 1000(mL)} \right) 2 = 0.1 \text{ N}$$

Molality(m): The number of moles of solute per **kilogram of solvent**.

انتبه هنا استخدم وزن المذيب وليس المحلول

(المولاليه = عدد مولات المذاب في الكيلو غرام من المذيب)

Solute = المذاب solution = المحلول solvent = المذيب

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

Example

Determine the molality of a solution prepared by dissolving 75.0 gm of solid Ba(NO₃)₂ (261.32 g/mol) into 374.00 gm of water.

Solution:

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

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

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

$$\text{Molality(m)} = \mathbf{0.76}$$

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 (H₂O)

Mass of solvent (H₂O) = Mass of solution - mass of solute(NaCl)

$$\text{Mass of solvent (H}_2\text{O)} = 551.7 \text{ g} - 11.7 \text{ g} = \mathbf{540 \text{ g}}$$

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

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

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

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

Mole fraction:

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

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

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

مجموع الكسور المولية في المحلول = 1

$$X_T = \sum X_i = 1$$

$$X_1 + X_2 = 1 \quad \text{Then} \quad X_1 = 1 - X_2 \quad \text{and} \quad X_2 = 1 - X_1$$

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:

$$X_1 = \frac{n_1}{n_1 + n_2 + n_3}$$

$$X_2 = \frac{n_2}{n_1 + n_2 + n_3}$$

$$X_3 = \frac{n_3}{n_1 + n_2 + n_3}$$

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)

$$n_T = n_A + n_B + n_C$$

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

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

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

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

$$X_T = \sum X_i = 1$$

$$X_T = X_A + X_B + X_C$$

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

Exercise:

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

154.1 g . Calculate :

1. The molality of the solution.

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