

ALMUSTAQBAL UNIVERSITY COLLEGE

Medical Laboratories Techniques Department

Stage : First year students

Subject : General chemistry – part A - Lecture 3

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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 .

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

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

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 .

$$\text{Normality (N)} = \frac{\text{Number of equivalents(solute)}}{V(\text{solution})}$$

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

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

$$V(\text{liter}) = \frac{V_{ml}}{1000}$$

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

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

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

الجواب : نكتب الاشتقاق (الخطوات الاربعه اعلاه)

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

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

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

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

$\text{Normality (N)} = \text{Molarity (M)} \cdot \eta$, or $\text{Molarity (M)} = \text{Normality (N)} / \eta$
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e.g: $\text{Normality (N)} \text{ of } 1M \text{ KCl} = M \cdot \eta = 1 \times 1 = 1 N \text{ KCl} ,$

$\text{Normality (N)} \text{ of } 1M \text{ HCl} = M \cdot \eta = 1 \times 1 = 1N \text{ HCl},$

$\text{Normality (N)} \text{ of } 1 M \text{ H}_2\text{SO}_4 = M \cdot \eta = 1 \times 2 = 2 N \text{ H}_2\text{SO}_4 ,$

$\text{Normality (N)} \text{ of } 1 M \text{ Na}_2\text{CO}_3 = M \cdot \eta = 1 \times 2 = 2N \text{ Na}_2\text{CO}_3$

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.

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

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

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

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

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

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

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

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

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

B) Equivalent mass of Bases:

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

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

1. Mono hydroxy base ($\eta=1$)

e.g: NaOH

for KOH

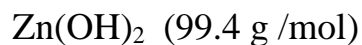
$$Eq. = \frac{Mwt}{1} = \frac{40}{1} = 40$$

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

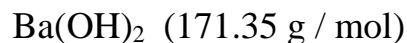
2. Di hydroxy base ($\eta=2$)

e.g: Ca(OH)₂ (74 g / mol)

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



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



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

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:

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

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



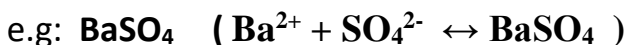
$$(\eta = \text{Ag}^+ (1) \times 1 = 1)$$

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



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

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



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

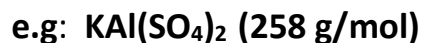
Mwt for $\text{BaSO}_4 = 233 \text{ g/mol}$

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



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

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



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

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

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

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

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 $\text{Na}^+ = 1$,

Then (η) = $2 \times 1 = 2$

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

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

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

Second method:

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

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

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).

(المولاليه = عدد مولات المذاب في الكيلوغرام من المذيب)

المذيب = solvent و المحلول = solution والمذاب = Solute

Molality is calculated by the following mathematical relationship:

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

انتبه هنا استخدم وزن المذيب وليس المحلول

Example

Determine the molality of a solution prepared by dissolving 75 g of solid $\text{Ba}(\text{NO}_3)_2$ (261.32 g /mol) into 374 g of water.

Solution:

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

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

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

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

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 ;

$$\text{Mass of solution} = \text{mass of solute} + \text{mass of solvent}$$

$$\text{Mass of solution} = \text{mass of solute (NaCl)} + \text{mass of solvent (H}_2\text{O)}$$

$$\text{Mass of solvent (H}_2\text{O)} = \text{Mass of solution} - \text{mass of solute(NaCl)}$$

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

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

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

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

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

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 (C₂H₆O₂)(62 g/mol) is dissolved in 400 g of distilled water to prepare an antifreeze solution . Calculate the concentration of the solution in molality.

Mole fraction:

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

$$\text{Mole fraction of solute}(X_1) = \frac{\text{No.of moles of solute (n}_1\text{)}}{\text{mole of solute (n}_1\text{)} + \text{moles of solvent (n}_2\text{)}}$$

$$\text{Mole fraction of solvent}(X_2) = \frac{\text{No.of moles of solvent (n}_2\text{)}}{\text{moles of solute (n}_1\text{)} + \text{moles of solvent (n}_2\text{)}}$$

$$1 = \text{مجموع الكسور المولية في المحلول}$$

$$X_T = \sum X_i = 1$$

$$\boxed{X_1 + X_2 = 1}$$

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 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:

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

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

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

Example: Calculate the mole fraction for each component in a mixture that contains 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).