ALMUSTAQBAL UNIVERSITY COLLEGE

Medical Laboratories Techniques Department

Stage : First year students

Subject : General chemistry 1 - Lecture 2A

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Normality (N)

Represents the Number of milli equivalents of solute contained in one milliter of solution or Number of equivalents contained in one liter.

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

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

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

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

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

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

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

N = M η , or M = N / η

e.g: Normality(N) of 1M KCl = 1x1 = 1 N KCl ,

Normality(N) of 1M HCl = 1x1 = 1N HCl,

Normality(N) of 1 M H_2SO_4 = 2x1= 2 N H_2SO_4 ,

Normality(N) of 1 M Na_2CO_3 = 2x1 = 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.

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 e.g: (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: $Ca(OH)_2$ $Zn(OH)_2$ $Ba(OH)_2$

Eq. = $\frac{Mwt}{2} = \frac{74}{2} = 37$ Eq. = $\frac{Mwt}{2} = \frac{99.4}{2}$ =49.7 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 electrons.

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

η= change in oxidation state number

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

Example :

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

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

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

Fe^{2+} → Fe^{3+} (1 e loss – oxidation)

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

3. Equivalent mass in salts:

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

(η) =$\sum$(No. of cations x its valency)

e.g: **$BaSO_4$ (233 g/mol)**

$BaSO_4 \rightarrow Ba^{2+} + SO_4^{2-}$

η = Ba^{2+} (1) x (2+) =2

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

Example

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

Solution:

$Na_2CO_3 \rightarrow 2Na^{+} + CO_3^{2-}$

(η) =$\sum$(No. of cations x its valency)

(η) = 2 x 1 = 2

Eq. of $Na_2CO_3 = \frac{Mwt}{2} = \frac{106}{2} =$ **53 g**

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

Normality = $\frac{5.3gm}{53\ x\ 1L} = 0.1$

Second method:

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

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

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

(η) =∑(No. of cations x its valency)

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

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

e.g :

$AgNO_3$ (170 g/mol) **,** **Na_2CO_3** (106 g/mol) **,** **$La(IO_3)_3$ (663.6g/mol)**

$AgNO_3$ (η = Ag^+ (1) x 1= 1)

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

Na_2CO_3 (η= Na^+ (2) x 1= 2)

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

$La(IO_3)_3$ (η = La^{3+} (1) x 3 = 3)

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

Molarity of liquids:

The molarity of liquids Can be determined by applying the following formula:

$$\textbf{Molarity of liquid(M)} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x1000}{Mwt}$$

Specific gravity (Sp.gr) $= \frac{density\ of\ substance}{density\ of\ water}$

Specific gravity (Sp.gr) $= \frac{d_{substance}}{d_{H_2O}}$

(**sp.gr** $\approx$ $d_{substance}$) as $d_{H_2O} = 1$

Example:

Calculate the molarity of the solution of 70.5 % HNO_3 (w/w) (63.0 g /mol) that has specific gravity of (1.42) .

Solution:

$$\textbf{Molarity(M)} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x\ 1000}{Mwt}$$

$$M = \frac{1.42\ x\ \left(\frac{70.5}{100}\right)x\ 1000}{63.0} = \frac{1.42\ x\ 70.5x\ 10}{63.0} = 15.9\ M$$

Dilution:

Molarity (M) = $\frac{No.of\ moles\ (solute)}{Volume\ of\ solution(L)}$

No. of moles solute = Molarity(M) x V(L) (by rearrangement)

The amount of solute does not change during dilution . The number of moles of solute before and after dilution is unchanged, because dilution involves only the addition of extra solvent:

No. of moles (concentrated solution) = No. of moles (diluted solution)

$$M_{conc.} V_{conc.} = M_{dil.} V_{dil.}$$

The dilution equation is valid with any concentration units, such as (w/v)% as well as molarity, which are used in Examples However, the same units for both initial and final concentration values must be used.

$$N_{conc.} \times V_{conc.} = N_{dil.} \times V_{dil.}$$

$$(w/w)\%_{conc.} \times V_{conc.} = (w/w)\%_{dil.} \times V_{dil.}$$

$$(v/v)\%_{conc.} \times V_{conc.} = (v/v)\%_{dil.} \times V_{dil.}$$

$$(w/v)\%_{conc.} \times V_{conc.} = (w/v)\%_{dil.} \times V_{dil.}$$

Example:

Describe the preparation of (100 mL) of (6.0 M) HCl from its concentrated solution that is 37.1 % (w/w) HCl (36.5 g /mole) and has specific gravity (sp.gr) of (1.181) .

Solution:

١. نحسب تركيز الحامض الاصلي (المركز) من القانون التالي:

$$M_{HCl} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x\ 1000}{Mwt}$$

$$M_{HCl} = \frac{1.18\ x\ \frac{37.1}{100}\ x\ 1000}{36.5} = \frac{1.18\ x\ 37.1\ x\ 10}{36.5} = 12.0\ M$$

The Molarity of the concentrated acid is 12.0M

الان نذهب الى قانون التخفيف لحساب الحجم المطلوب اخذه من الحامض المركز وتخفيفه الى الحجم المطلوب (١٠٠ مللتر في هذا المثال) وكمايلي:

$$M_{conc.}\ V_{conc.} = M_{dil.}\ V_{dil.}$$

$$12.0\ x\ V_{conc} = 6.0\ x\ 100$$

$$V_{conc} = \frac{6.0\ x\ 100}{12} = 50\ mL.$$

Then 50 mL of concentrated acid is to be diluted to 100 mL to give 6 M solution

Exercise:

Describe the preparation of 500 mL of 3.00 M H_2SO_4 (98 g /mol) from the commercial reagent that is 93% H_2SO_4 (w/w) and has a specific gravity of 1.830.

Calculation of Normality of liquids

$$\text{Normality of liquid (N)} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x\ 1000}{eq.wt}$$

Example:

Describe the preparation of 500 mL of 3.00 N H_2SO_4(98 g /mol) from the commercial reagent that is 96% H_2SO_4 (w/w) and has a specific gravity of 1.840.

Solution:

$$\mathbf{M}_{\mathbf{H2SO4}} = \frac{\boldsymbol{sp.gr\ x\ \%\ x\ 1000}}{\boldsymbol{eq.wt}}$$

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

For H_2SO_4 **η=2 then**

$$\text{eq.wt} = \frac{98}{2} = 49$$

$$\textbf{Normality } (\mathbf{N}_{\mathbf{H2SO4}}) = \frac{\mathbf{1.840}\ x\ \frac{\mathbf{96}}{\mathbf{100}}\ x\ \mathbf{1000}}{\mathbf{49}}$$

$$\textbf{Normality } (\mathbf{N}_{\mathbf{H2SO4}}) = \frac{\mathbf{1.840}\ x\ \mathbf{96}\ x\ \mathbf{10}}{\mathbf{49}} = \mathbf{36.04\ N}$$

The Normality of the concentrated acid is 36.04 N

لحساب الحجم المطلوب اخذه من الحامض المركز وتخفيفه الى الحجم المطلوب (٥٠٠ مللتر في هذا المثال) نطبق قانون التخفيف التالي:

$$\mathbf{N_{conc.}\ V_{conc.} = N_{dil.}\ V_{dil.}}$$

$$\mathbf{36.04\ x\ V_{conc} = 3.0\ x\ 500}$$

$$\mathbf{V_{conc}} = \frac{\mathbf{3.0}\ x\ \mathbf{500}}{\mathbf{36.04}} = \mathbf{41.62\ mL.}$$

Then 41.62 mL of concentrated acid is to be diluted to 500 mL to give 3 N solution.

Example:

A 12.5% (w/w) aqueous solution of $NiCl_2$ (129.61 g/mol) has specific gravity of 1.149. Calculate:

(a) the Molarity of $NiCl_2$ in this solution.

(b) the molar concentration of Cl^- in the solution.

(c) the mass in grams of $NiCl_2$ contained in 500 mL of this solution.

solution:

(a) the Molarity of $NiCl_2$ in this solution

$$M_{NiCl2} = \frac{sp.gr\ x\ \%\ x\ 1000}{Mwt}$$

$$M_{NiCl2} = \frac{1.149\ x\ \frac{6.42}{100}\ x\ 1000}{129.61} = 0.569\ M$$

(b) the molarity of Cl^- concentration in the solution.

$$NiCl_2 \longrightarrow Ni^{2+} + 2Cl^-$$

Each 1 mole gives 1 mole 2 mole

Molarity of Cl^- = 2 x Molarity of $NiCl_2$

Molarity of Cl^- = 2 x 0.569 = 1.138 M

(a) the mass in grams of $NiCl_2$ contained in 500 mL of this solution.

Weight (g) = Molarity x volume(liter) x M.wt

Weight = 0.569 x ($\frac{500}{1000}$) L x 129.61 = 36.87 g

Second method:

$$\textbf{Molarity(M)} = \frac{wt_{(g)} \times 1000}{M.wt \times V_{mL}}$$

$$\textbf{wt(g)} = \frac{Molarity(M) \times M.wt \times V_{mL}}{1000}$$

$$\textbf{wt(g)} = \frac{0.569 \times 129.6 \times 500_{mL}}{1000} = 36.87 \text{ g}$$

Exercise:

A solution of 6.42 (w/w)% of $Fe(NO_3)_3$ (241.86 g/mol) has a specific gravity of 1.059. Calculate:

A) The Molarity and Normality of the solution

B) The mass in grams of $Fe(NO_3)_3$ contained in each liter of this solution