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Volumetric Analysis

1) Different ways of expressing concⁿ of solution.
i) Molarity ii) Normality iii) Gram percentage

2) Titration
i) acid base titration ii) Redox titration.

3) primary Standard substance, primary standard solⁿ, secondary solⁿ, end point, equivalence point, neutral points, Indicators

4) Derivation of Normality equation

5) Relation between Normality and Molarity

6) Selection of Indicators in acid-base titration and its curve.

Equivalent weight of an element (E):

It ~~is~~ can be defined as the number of parts by weight of an element which combine or displace directly or indirectly 1.008 parts by weight of hydrogen or 8 parts by wt. of oxygen or 35.5 parts by weight of chlorine. It is also called combining weight.

i.e Equivalent weight (E) = $\frac{\text{Atomic weight}}{\text{Valency}}$

Equivalent weight of acid:

It is defined as the number of parts by weight of an acid which supplies 1.008 parts by weight of hydrogen.

i.e equivalent wt. of acid = $\frac{\text{Molecular weight}}{\text{Basicity}}$

Where,
Basicity of an acid is defined as the number of replaceable hydrogen ions (H^+) in an acid molecule.

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Equivalent weight of a base :

The equivalent weight of base is defined as the number of parts by weight of base which is neutralized by one gram equivalent of an acid.

$$\text{Equivalent wt of base} = \frac{\text{Molecular weight}}{\text{Acidity}}$$

where,

Acidity of a base is defined as the number of replaceable hydroxide ion (OH^-) present in a molecule of base.

Equivalent weight of a salt :

It can be defined as the number of parts by weight of it which is formed by the neutralization of one gram equivalent of an acid by base.

ie

$$\text{Equivalent wt of Salt} = \frac{\text{Molecular weight}}{\text{Charge on cation per molecule}}$$

Equivalent weight of compound :

It is defined as the number of part by weight of it that react with one gram equivalent of another compound.

ie $$\text{Eq. wt. of compound} = \frac{\text{Molecular weight}}{\text{Charge on cation per molecule}}$$

Equivalent weight of oxidizing or reducing agent

It is defined as the ratio of molecular weight of it to the change in oxidation number per molecule during redox ~~most~~ reaction.

$$\text{Equivalent weight} = \frac{\text{Molecular wt. of an oxidizing and reducing agent}}{\text{change in oxidation No. of molecule}}$$

Equivalent weight of radical:

It is defined as the ratio of the ionic weight to the total number of positive or negative charge.

$$\text{Eq. weight of radical} = \frac{\text{Ionic weight}}{\text{Total no. of +ve or -ve charge}}$$

Gram equivalent weight:

The equivalent wt. of any substance expressed in gram is called gram equivalent weight.

$$\text{No. of gram equivalent weight} = \frac{\text{wt. of substance (in gm)}}{\text{Equivalent weight}}$$

Gram molecular weight (mole)

The molecular weight of any substance expressed in gram is called a gram molecular weight or mole.

No. of gram mol. weight or No. of mole = $\frac{\text{wt. of substance (in gm)}}{\text{Molecular weight}}$

= calculate the No. of gram equivalent of

a) 5 gm of HCl
b) 16 gm of H_2SO_4
c) 5 gm of oxalic acid
d) 103 gm of Al_2O_3
e) 105 gm of $NaOH$
f) 103 gm of Na_2SO_4

a) 5 gm of HCl
soln
Molecular wt = 1 + 35.5
= 36.5

Basicity = 1

Now
Equivalent weight = $\frac{\text{Molecular weight}}{\text{Basicity}}$

Gulmil

$= \frac{36.5}{1}$

$= 36.5$

Now,

Gram equivalent $= \frac{\text{wt. in gm}}{\text{Equivalent wt}}$

$= \frac{5}{36.5}$

$= 0.136986$

b) 36 gm of H_2SO_4

Soln

Molecular wt $= (1 \times 2) + (32) + (16 \times 4)$

$= 2 + 32 + 64$

$= 98$

Basicity = 2

Now,

Equivalent wt $= \frac{\text{Molecular wt}}{\text{Basicity}}$

$= \frac{98}{2}$

$= 49$

Gram equivalent $= \frac{\text{wt. in gm}}{\text{eq. weight}}$

$= \frac{36}{49}$

$= 0.734694$

c) 5gm of oxalic acid $(COOH)_2$

Given.

Molecular wt $= (12 + 16 + 16 + 1)_2$

$= 90$

Basicity $= 2$

Now,

Eq. weight $= \frac{\text{molecular wt.}}{\text{Basicity}}$

$= \frac{90}{2}$

$= 45$

Again,

Gram equivalent $= \frac{\text{wt. in gram}}{\text{Eq. weight}}$

$= \frac{5}{45}$

$= 0.111$

d) 703 gm of Al_2O_3

soln

Molecular weight $= 27 \times 2 + 16 \times 3$

$= 102$

Acidity = 3

Now

~~Om~~ →

$$\text{Eq. weight} = \frac{\text{molecular wt.}}{\text{Acidity}}$$

$$= \frac{103}{3}$$

$$= 34$$

$$\text{Gram equivalent} = \frac{\text{Wt. in gm}}{\text{Eq. weight}}$$

$$= \frac{103}{34}$$

$$= 3.0294$$

e) 10.5 gm of NaOH

Sol

$$\text{molecular weight} = (23+16+1)$$

$$= 40$$

Acidity = 1

$$\text{Eq. weight} = \frac{\text{molecular wt.}}{\text{Acidity}}$$

$$= \frac{40}{1}$$

$$= 40$$

Gram equivalent weight $= \frac{\text{wt in gm}}{\text{Eq. weight}}$

$= \frac{105}{40}$

$= 2.625$

f) 103 gm of Na_2SO_4

Here,

molecular weight $= (23 \times 2) + (32) + (16 \times 4)$

$= 46 + 32 + 64$

$= 142$

Charge on cation per molecule $= 1 \times 2 = 2$

Equivalent weight $= \frac{\text{molecular wt.}}{\text{charge on cation per molecule}}$

$= \frac{142}{2}$

$= 71$

Gram equivalent $= \frac{\text{wt in gm}}{\text{Eq. weight}}$

$= \frac{103}{71}$

$= 1.4507$

Q) 105 of $Al(OH)_3$

Here.

Molecular mass = 27 + (16 + 1) × 3

= 78

Acidity = 3

Now

Eq. weight = $\frac{\text{molecular wt}}{\text{Acidity}}$

= $\frac{78}{3}$

= 26

Gram equivalent wt = $\frac{\text{wt in gm}}{\text{Eq. weight}}$

= $\frac{105}{26}$

= 4.038

Calculate the no. of moles of

a) 5gm of H_2SO_4

b) 10.6 gm of NaOH

a) 5 gm of H_2SO_4

molecular wt = 98

we know,

98 gm of H_2SO_4 contains 6.023×10^{23} molecules

~~1 gm~~ g H

weight of molecule = 5gm

Now,

No. of moles $= \frac{n}{N} = \frac{5}{98}$

$= 0.051020$

b) 106 gm of NaOH

Here,

Molecular wt (NaOH) = 40.

Given mass (n) = 106 gm

Now,

No. of moles $= \frac{n}{N} = \frac{106}{40}$

$= 2.65$

Concentration of solution

concentration of solution is defined as the amount of solute present in definite volume of solution.

The concn of solution is generally expressed as the no. of grams of solute dissolve per lit of solution.

For eg: If 10 gm of a substance is dissolve in 1 l of solution, Concn of solution is 10 gm/l.

Thus, the concentration of solution is expressed in any one of the following units.

1) Normality (N)

Normality of a solution is defined as the no. of gram equivalents of solute dissolve in 1 lit of solution.

It is denoted by N.

$$\therefore \text{Normality (N)} = \frac{\text{No. of gram equivalent}}{\text{Volume of solution in lit}}$$

we have,

$$\text{No. of Gram equivalent} = \frac{\text{wt in gm}}{\text{Equivalent wt}}$$

Now,

$$\text{Normality} = \frac{\text{wt in gm / eq. wt}}{\text{Volume of soln in lit}}$$

or, $\text{Normality} = \frac{\text{gm/lit}}{\text{Eq. weight}}$

or, $\text{gm/lit} = \text{Normality} \times \text{eq. wt}$

1 N or Normal Solution

If one gram equivalent of solute is dissolve in 1 lit of Solution, It is called Normal solution.

It is denoted by 1 N or N.

Semi Normal solution :

If half gram equivalent of solute is present in 1 lit of Solution, then it is called semi Normal Solution.

It is denoted by $N/_2$.

Deci Normal Solution :

If $\frac{1}{10}$ th (one tenth) gram equivalent of solute is present in one lit of solution, it is called Deci Normal Solution.

It is denoted as $N/_{10}$.

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Centi ~~Number~~ Normal solution:

~~If 100th(~~

If one hundredth $\left(\frac{1}{100}\right)^{th}$ gm equivalent of

solute is present in 1 lit of solution. Then it is called Centi Normal solution.

It is denoted ~~to~~ as $N/100$.

2. Molarity (M)

Molarity of a solution is defined as the no. of moles of solute dissolve in 1 lit of solution. It is denoted by M

$\therefore$ Molarity(M) $= \frac{\text{No. of moles}}{\text{volume of sol}^n \text{ in lit}}$

we have,

$$\text{No. of moles} = \frac{\text{wt in gm}}{\text{Molecular wt.}}$$

Now, $\frac{\text{Molarity}}{~~\text{Normality}~~} = \frac{\text{wt in gm / molecular wt.}}{\text{volume of sol}^n \text{ in lit.}}$

or, $\frac{\text{Molarity}}{~~\text{Normality}~~} = \frac{\text{gm / lit}}{\text{molecular wt.}}$

$\therefore$ gm/lit = Molarity X molecular wt.

1 M or Molar solution:
If a solution contains 1 mole of solute in 1 lit of solution, it is called molar solution. It is denoted by 1 'M' or 'M'.

Semi Molar solution
If $\frac{1}{2}^{th}$ (half) a mole of solute contains in 1 lit of solution, it is called semi Molar solution. It is denoted by $M/2$.

Deci Molar solution
If one tenth ($1/10^{th}$) mole of solute contains in 1 litre of solution, it is called Deci molar solution. It is denoted by $M/10$.

Centi Molar solution
If one hundreth $\left(\frac{1}{100}^{th}\right)$ a mole of solute contains in 1 litre of solution, it is called centi molar solution.
It is denoted by $M/100$.

Relation betⁿ Normality and Molarity

we have,

g/l = Normality × equivalent wt. —(i)

Again,

g/l = Molarity × molecular wt. —(ii)

from eqⁿ (i) and (ii), we get

Normality × eq. weight = molarity × molecular wt

or, Normality = molarity × $\frac{\text{molecular wt.}}{\text{Eq. weight}}$

or, $\boxed{\text{Normality} = \text{Molarity} \times \text{Acidity or Basicity}}$

Since $\boxed{\frac{\text{mol. wt}}{\text{eq. wt}} = \text{Acidity or basicity}}$

3) Percentage:

It is the number of part of a substance dissolve in 100 parts of solution. It is represented by %.

It can be expressed as weight by weight (w/w), weight by volume (w/v) and volume by volume (v/v)

For examples:

i) 5% (w/v) NaCl solution means 5g NaCl is dissolve in 100ml of its solⁿ.

ii) 5% (w/w) NaCl solution means 5g NaCl is dissolve in 100g of its solution
iii) 5% (V/V) alcohol soln means 5ml alcohol is dissolve in 100ml of its solution.

4) Gram per litre

It is defined as the amount of substance in gram dissolve in 1 litre of its solution.

It is denoted as gL^{-1} (g/L)

Now,

$$\text{Gram per litre} = \frac{\text{wt. of substance in gm}}{\text{wt. of solution in litre}}$$

5) Molality (m)

It is defined as the number of mole of substance dissolve in 1 kg of its solution.

It is denoted by 'm'.

$$\text{Molality (m)} = \frac{\text{No. of mole of substance}}{\text{wt. of solvent in kg}}$$

6) Mole fraction

The mole fraction of component is defined as the fraction of total no. of moles of the one component present out of total no. of moles of solution. It is denoted by (X).

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Titration

The process in which the concn of unknown solution is determined with the help of standard solution by using indicator is called titration.

Unknown solution is that solution whose strength is not known, is to be determined.

Standard soln is that solution whose strength is known i.e contains a known wt. of solute in known volume

Terms used in Titration

a) Titrant :

The solution of known concentration is known as Titrant

b) Titrand (Titrate)

The solution of unknown concentration in which is being titrated is called titrand.

Types of titration :

Based on nature of reaction, there are two different types of titration.

1) Acid-base titration

2) Redox titration

1) Acid-base titration (Neutralization titration)

These titrations in which the concn of acid is determined by neutralizing it completely with standard alkali solution in the presence of indicators, or vice versa are called Acid based titration.

For eg :- Acidimetry and Alkalimetry.

$HCl\,(aq.) + NaOH\,(aq.) \longrightarrow NaCl\,(aq.) + H_2O$

2) Redox titration.

Those titration in which the strength of oxidizing agent is determined by using standard soln of reducing agent or vice versa are called redox titration.

This titration involve change in oxidation number between the reacting substances

For eg. Titration of $KMnO_4$ soln in acidic medium against oxalic acid soln.

In this titration $KMnO_4$ acts as self indicator due to its pink colour.

$2K\overset{+7}{Mn}O_4 + 3H_2SO_4 + 5H_2\overset{+6}{C_2}O_4 \xrightarrow{\Delta} K_2SO_4 + 2\overset{+2}{Mn}SO_4$ (colourless) $+ 8H_2O + 10\overset{+4}{CO_2}$

Define primary standard substance with examples. Also write the prerequisites of primary standard substance.

The substance which is used to prepare primary standard solution is called primary standard substance.

Examples:

1) Anhydrous Na_2CO_3
2) Crystals of oxalic acid
3) Powdered $CaCO_3$, etc

The prerequisites of primary standard substance are:

i) It should be available in highly pure and dry state
ii) It should be cheaper and should not be toxic.
iii) It should not be hygroscopic and deliquescent.
iv) It should have high equivalent weight so as to minimize titration error.
v) The composition of substance should not be changed in any state for long time.

~~Secondary~~

Primary standard substance

Those substances which can be obtained in pure and dry state and aren't affected by air during weighing is known as primary standard substance.

Secondary standard substance

Those substance which are not available in pure form, dry state and are affected by air during weighing are called secondary standard substance.

The soln of this substance cannot be prepared by direct weighing. So their soln is called secondary standard solution.

For eg: $CuSO_4$, HNO_3, $NaOH$, $KMnO_4$, $FeSO_4$, etc

Normality Factor (f):

It is very difficult to weigh out the required amount of substance accurately. Therefore, actual concn of the soln differs from its expected concn. Therefore, normality factor is calculated.

It is the ratio of weight of solute taken to the weight of solute to be taken

i.e Normality factor $= \frac{\text{wt. of solute taken}}{\text{wt. to be taken}}$

or $= \frac{\text{practical weight}}{\text{Theoritical weight}}$

The actual normality of solution,
i.e formed in the process can be obtained by multiplying normality factor and normality of soln to be prepared.

i.e actual normality = Normality of soln × Normality factor

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Practically, it is written with normality of $soln$

i.e. $\frac{N}{10}$ $(f = 0.4)$

or, 2N $(f = 0.35)$

$\therefore$ Actual normality $= \frac{1}{10} \times 0.4$
$=$

Standard solution

The solution whose concentration is known is called standard solution. The standard solution can be prepared by taking certain weight of solute and dissolving it in solvent to form definite volume of solution.

A standard $soln$ is titrated with unknown $soln$ to determine the strength of unknown $soln$. The $soln$ of secondary ~~Solution~~ secondary standard substances are called secondary ~~substance~~ standard solution. The $concn$ of secondary standard substance solution is determined by the titration of it with primary standard solution.

Chemical Analysis :

Basically it is of two types,

1) Quantitative analysis
2) Qualitative analysis.

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Q) 105 of $Al(OH)_3$

Here,

Molecular mass $= 27 + (16+1) \times 3$

$= 78$

Acidity $= 3$

Now

Eq. weight $= \dfrac{\text{molecular wt}}{\text{Acidity}}$

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Gram equivalent wt $= \dfrac{\text{wt in gm}}{\text{Eq. weight}}$

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calculate the no. of moles of

a) 5gm of H_2SO_4

b) 105 gm of $NaOH$

a) 5 gm of H_2SO_4