Volumetric Analysis

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Gravimetric analysis Versus Volumetric analysis

Gravimetric analysis	Volumetric analysis
Gravimetric analysis is a process of measuring the amount of an analyte by its mass.	Volumetric analysis is a process used to determine the amount of a desired constituent by its volume.
Mass of the analyte is determined.	Volume of the analyte is determined.
Involves the formation of a solid mass known as a precipitate, which can be separated from the sample solution.	Done via a titration, in which the volume of analyte is determined by adding portions of a reagent that can react with the analyte.
Generally gives the final result in grams.	Gives the final result in milliliters.

Introduction

It is a process of determining the strength of unknown solution with the help of standard solution.

Acidimetry: It is process of determining the strength of an acid solution with the help of standard alkali solution in presence of indicator is called acidimeter.

Alkalimetry: It is a process of determining the strength of alkali solution with the help of standard acid solution in presence of indicator is called alkalimetry.

Redox reaction (or Titration)

The process of determining the strength of reducing agent with the help of standard oxidizing agent and vice-versa is known as redox rxn (or titration).

Ex: Titration between oxalic acid with potassium permaganate

$$2KMnO_4 + 5\begin{matrix}COOH\\|\\COOH\end{matrix} + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$$

Equivalent weight

Equivalent weight of a substance is the number of parts by weight of it which combines or displaces directly or indirectly 1.008 parts by weight of hydrogen or 8 parts by weight of oxygen or 35.5 parts by wt of chlorine.

It is unit less but when expressed in gram, it is known as gram equivalent weight.

$$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2\uparrow$$

2×1.008 parts of H_2 is displaced by 24 parts of Mg.

1 parts of H_2 is displaced by $\frac{24}{1.008}$ parts of Mg.

Equivalent weight of Acid

Equivalent weight of acid is that weight which is obtained by dividing its molecular weight by number of replaceable hydrogen atoms present in 1 mole of acid.

i.e., $\text{Eq. wt. of acid} = \dfrac{\text{Molecular wt. of acid}}{\text{Basicity}}$

Ex: Equivalent wt. of HCl

Molecular wt. of HCl = 1 + 35.5 = 36.5

Basicity = 1

$\therefore \text{Eq. wt.} = \dfrac{\text{Molecular wt.}}{\text{Basicity}}$

$= \dfrac{36.5}{1}$

$= 36.5$

Equivalent wt. of H_2SO_4

Molecular wt. of $H_2SO_4 = (1 \times 2) + 32 + (4 \times 16) = 98$

Basicity = 2

$\therefore \text{Eq. wt.} = \dfrac{\text{Molecular weight}}{\text{Basicity}}$

$= \dfrac{98}{2} = 49$

Equivalent weight of base

It is defined as the weight of the base which is neutralalise by 1gm of equivalent of acid.

Mathematically, $\text{Eq. wt. of base} = \dfrac{\text{Molecular wt. of base}}{\text{acidity}}$

where, acidity is the number of replaceable OH^- present in base.

In case of Metallic Oxide

Eq. wt. of base = $\frac{\text{Molecular wt. of base}}{2 \times \text{no. of oxygen atom}}$

Ex: Equivalent wt. of NaOH

Molecular wt. of NaOH = 23 + 16 + 1 = 40

Acidity = 1

∴ Eq. wt. of NaOH = $\frac{40}{1}$ = 40

Equivalent weight of $Ca(OH)_2$

Molecular wt. of $Ca(OH)_2$ = 40 + (2×16) + (2×1)

= 74

Acidity = 2

∴ Eq. wt. of $Ca(OH)_2$ = $\frac{74}{2}$ = 37

Equivalent weight of CaO

Molecular wt. of CaO = 40 + 16 = 56

∴ Eq. wt. of CaO = $\frac{\text{molecular wt.}}{2 \times \text{no. of oxygen atoms}}$

= $\frac{56}{2}$ = 28

Equivalent weight of salt

Eq. wt. = $\frac{\text{molecular wt. of salt}}{\text{no. of charge on cation or anion}}$

or

no. of metal × valency

Ex: For NaCl

Molecular weight = 23 + 35.5 = 58.5

$\therefore$ Eq. wt. of NaCl $= \dfrac{\text{Molecular weight}}{\text{no. of metal} \times \text{valency}} = \dfrac{58.5}{1 \times 1} = 58.5$

Equivalent weight of oxidizing and reducing agents:

$$\text{Eq. wt.} = \frac{\text{molecular wt. of oxidizing or reducing agents}}{\text{change in oxidation no.}}$$

Ex: $KMnO_4$ (oxidizing):

In acidic medium,

change in O.N. = 5

$$\overset{+7}{KMnO_4} + H_2SO_4 \longrightarrow K_2SO_4 + \overset{+2}{Mn}SO_4 + H_2O + [O]$$

$\therefore$ Eq. wt. of $KMnO_4 = \dfrac{158}{5} = 31.6$

In basic medium,

change in O.N. = 1

$$\overset{+7}{KMnO_4} + H_2SO_4 \longrightarrow K_2\overset{+6}{Mn}O_4 + H_2O + [O]$$

$\therefore$ Eq. wt. of $KMnO_4 = \dfrac{158}{1} = 158$

In neutral medium,

change in O.N. = 3

$$\overset{+7}{KMnO_4} + H_2O \longrightarrow KOH + \overset{+4}{Mn}O_2 + [O]$$

$\therefore$ Eq. wt. of $KMnO_4 = \dfrac{158}{3} = 52.67.$

Equivalent weight of $K_2Cr_2O_7$

Acidic Medium

$$3H_2S + K_2\overset{+6}{Cr_2}O_7 + 8HCl \longrightarrow 3S + 2\overset{+3}{Cr}Cl_3 + 2KCl + 7H_2O$$

In above reaction, reduction of Cr from +6×2 = +12 (in $K_2Cr_2O_7$) to +3×2 = +6 (in $2CrCl_3$) takes place. Hence change in oxidation number is 6.

Hence, equivalent weight of $K_2Cr_2O_7$ = $\dfrac{\text{molecular weight}}{\text{change in oxidation number}}$

$$= \frac{2\times39+2\times52+7\times16}{6}$$

$$= \frac{249}{6} = 49$$

Equivalent weight of reducing agents

① Equivalent weight of oxalic acid

$$H_2\overset{+6}{C_2}O_4 \longrightarrow 2\overset{+4}{C}O_2 + 2H^+ + 2e^-$$

Change in oxidation number = 2

Equivalent weight of $H_2C_2O_4$ = $\dfrac{\text{molecular weight of } H_2C_2O_4 \text{ (anhydrous)}}{\text{total change in oxidation no.}}$

$$= \frac{90}{2} = 45$$

Note: $H_2C_2O_4.2H_2O$ (oxalic acid crystal)

Equivalent weight of $H_2C_2O_4.2H_2O$ (hydrated) = $\dfrac{\text{molecular wt. of } H_2C_2O_4.2H_2O}{\text{total change in oxidation number}}$

⑧ Equivalent weight of ferrous sulphate

$$FeSO_4 + \frac{1}{2} H_2SO_4 \longrightarrow \frac{1}{2} Fe_2(SO_4)_3 + H^+ + e^-$$

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

Change in oxidation number = 1

$\therefore$ Equivalent weight of $FeSO_4$ = $\frac{\text{molecular weight of } FeSO_4}{\text{change in oxidation number}}$

$$= \frac{56+32+4\times16}{1} = 152$$

Terms of express Concentration

1. gram/litre (gm/l): It is defined as the number of grams of solute present in 1 litre of solution.

$$gm/l = \frac{\text{grams of solute}}{\text{volume in litre of sol}^n}$$

$$= \frac{\text{grams of solute}}{\text{volume in ml of sol}^n} \times 1000$$

Ex: 40 gm/l of NaOH indicates that 40g of NaOH dissolved in 1 litre of solution.

2. Percentage (%): It is defined as the number of parts of solute present in 100 parts of solution.

* % (w/v): It is defined as the no. of grams of solute present in 100ml of solution.

Eg: 5% NaOH indicates that 5gm of NaOH dissolved in 100ml of solution.

* % (w/w) : It is defined as the no. of gram of solute present in 100 gram of solution.
Eg: 5% (w/w) NaOH indicates that 5 gram of NaOH dissolved in 100 gram of solution.

* % (v/v) : It is defined as the number of ml of solute dissolved in 100 ml of solution.
Eg: 5% (v/v) HCl indicates that 5ml of HCl dissolve in 100ml of solution.

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3) Normality (N)

It is defined as the number of gram equivalent of solute present in 1 litre of solution.
The number of gram equivalent weight of solute dissolved in one litre of the solution is known as normality of the solution. It is denoted by (N) and is very important term used in volumetric analysis.

Mathematically,

$$\text{Normality (N)} = \frac{\text{number of gram equivalent weight of solute}}{\text{volume of sol}^n \text{ in litre}} \quad \ldots (1)$$

or, $$\text{Normality} = \frac{\text{number of gram equivalent weight of solute}}{\text{volume of solution in ml}} \times 1000$$

When the equivalent weight is expressed in gram, the amount is called one gram equivalent weight.

$$\text{Number of gram equivalent} = \frac{\text{weight of solute in gm}}{\text{equivalent weight}} \quad \ldots (2)$$

From equation (1) and (2) (01

$$\text{Normality} = \frac{\text{weight of solute in gm}}{\text{equivalent weight}} \times \frac{1}{\text{volume of solution in litre}}$$

$$= \frac{\text{weight of solute in gram}}{\text{equivalent weight} \times \text{volume of solution in ml}} \times 1000$$

$$\text{so, } N = \frac{W \times 1000}{E \times V \text{ in ml}} \quad \dots (3)$$

where, N = Normality of solution
W = Weight of solute
E = Equivalent weight of solute
V = Volume of solution in ml

$$\text{Normality } (N) = \frac{\text{Weight of solute in gm/litre}}{\text{Equivalent wt. of solute}} \quad \dots (4)$$

Weight of solute in gm/litre = Normality x equivalent weight ...(5)

Normality of solute changes with temp.

$$W = \frac{NEV\text{ml}}{1000}$$

(i) Normal solution (1N)

It is solution obtained by dissolving 1gm equivalent of solute in 1 litre solution.

(ii) Seminormal solution (N/2)

It is solution obtained by dissolving half gram of equivalent of solute in 1 litre of solution.

#(iii) Decinormal solution (N/10):
It is solution obtained by dissolving 1/10 gm of equivalent of solute in 1 litre of solution.

(iv) Centinormal solution (N/100)
It is solution obtained by dissolving 1/100 gm of equivalent of solute in 1 litre of solution.

Molarity (M):
It is defined as the number of moles of solute present in one litre of solution. It is denoted by M.
Mathematically,

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{\text{volume in litres}} \quad \ldots (1)$$

We know,

$$\text{No. of moles} = \frac{\text{Wt. of solute in gram}}{\text{Molecular wt.}}$$

$$\therefore \text{Molarity} = \frac{\text{Wt. of solute in gram}}{\text{Molecular wt.}} \times \frac{1}{\text{Volume in litre}} \quad \ldots (2)$$

$$\text{or, Molarity} = \frac{\text{Wt. of solute in gram}}{\text{Volume in litre}} \times \frac{1}{\text{molecular wt.}}$$

$$\text{Molarity} = \frac{g/l}{\text{molecular wt.}}$$

$$\therefore g/l = \text{Molarity} \times \text{Molecular wt.} \quad \ldots (3)$$

Relationship between Normality (N) and Molarity (M)

$$\text{Normality} = \frac{\text{no. of gram equivalent}}{\text{volume in litre}}$$

Also, g/l = Normality x Equivalent wt. ... (1)

And, $$\text{Molarity (M)} = \frac{\text{no. of moles}}{\text{volume in litre}}$$

Also, g/l = Molarity x Molecular wt. ... (2)

Eqⁿ (1) and (2),

Normality x Equivalent wt. = Molarity x Molecular wt.

$$\text{Normality} = \text{Molarity} \times \frac{\text{Molecular wt.}}{\text{Equivalent wt.}}$$

∴ Normality = Molarity x ~~acidity or basicity~~

Molality

It is defined as the number of moles of solute dissolved in 1kg of solvent.

Molar solution

It is defined as the solution in which 1 mole of solute is dissolved in 1 litre of solution. It is denoted by 1M.

* Semimolar solution (M/2)

* Decimolar solution (M/10)

* Centimolar solution (M/100)

Standard solution:

Those solution whose concentration is low i.e., known weight of solute is dissolved in certain values of solution is called standard solution.

It is of two types:

i) Primary standard solution

Those solution which can be obtained by dissolving definite wt. of substance in water for making definite volume of solution is known as primary standard solution.

Primary standard substance is used to produce primary standard solution.

Na_2CO_3 # Primary standard substances are those substance which can be obtained in pure and dry state, non-toxic and which is not affected by air during weighing.

The pre-requisties for a substances to be primary standard are:-

i. It should be easily available in pure state.
ii. It must be easily soluble in water.
iii. It should have high value of molecular wt. and equivalent wt.
iv. Its composition should not be changed during storage and in air during weighing.
v. It should be non-toxic and stable in nature.

Oxalic acid crystal, sodium carbonate, Mohr's salt etc are the examples of primary standard substances.

Secondary standard solution which are obtained in impure form not stable and is affected by air is called secondary standard substances.

* Normality factor (F):

It is defined as a ratio of wt. of solute taken to the wt. of solute to be taken. OR,

It is the ratio of actual wt. taken to the theoritical weight.

Note: Normality factor helps to determine actual normality of the given solution i.e.,

actual normality = Normality x Normality factor.

* Titration:

The process of determining the strength of unknown solution with the help of standard solution in the presence of indicator is known as titration.

* Titrant:

The solution where concentration is ~~[illegible]~~ known is known as titrant an is generally kept in burette.

* Titrand or Titrate:

The solution whose concentration is to be determined is known as titrand or titrate.

* Indicator:

Indicator are weak organic acids or bases which is added during titration and indicates the completion of reaction by change of colour.

Eg Phenopthalein, methyl orange, methyl red, etc.

Difference between End point and Equivalent point:

	End point	Equivalent point
1.	The point during titration at which the rx^n completed is indicated by change in colour of the indicator.	It is the exact neutralization point where number of gram equivalent of titrant is equal to number of gram equivalent of titrand.
2.	It appears just after the equivalence point and is practical in nature.	It is a theoritical point and can not be seen/observed

* Titration error

The error during titration which is the difference between end point and equivalent point is known as titration error.

* Acid-Base titration

The titration in which the strength of acid is determined by using standard solution of base and vice versa is known as acid base titration.

$$\overset{A}{Wt} = \frac{\overset{B}{N}\,\overset{A}{E}\,\overset{B}{V}}{1000}$$

$$\left(\frac{Wt}{E}\right)_{Acid} = \left(\frac{NV}{1000}\right)_{Base}$$

$$M = \frac{\% \times sp.\ gravity \times 10}{Mol.\ wt}$$

Specific gravity : $N = \frac{\% \times specific\ gravity \times 10}{Eq.\ wt.}$

Numerical

1. Find the normality of 0.53 g/l sodium carbonate solution

Soln: Given,

$$Normality = \frac{Wt.\ of\ solute\ in\ g/l}{Equivalent\ wt.\ of\ solute}$$

$$= \frac{0.53}{53}$$

$$= 0.01$$

2. Calculate the normality and molarity of 5% of NaOH solution.

Soln: Given, 5 gm in 100 ml solution

50 gm in 1000 ml solution

$$N = \frac{\% \times 10}{Eq.wt.} = \frac{5 \times 10}{40} = 1.25$$

$$M = \frac{\% \times 10}{Mol.wt.} = \frac{5 \times 10}{40} = 1.25$$

3. What is the normality of 20 cc of 2 molar phosphoric acid

Soln: Given, 20 cc of 2M H_3PO_4

N = ?

$$H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{-3}$$

Basicity (n) = 3

M = 2

We know,

$$N = n \times M$$

$$= 3 \times 2$$

$$= 6.$$

4. Which one has high concentration and why,

a. 80 g/l NaOH solution and 3M NaOH

Soln:

$g/l = M \times Mol.wt.$

$80 = M \times 40$

$M = \frac{80}{40}$

$= 2$

3M NaOH has high concentration.

b. 5.3 gm/l Na_2CO_3 and N/10 Na_2CO_3 solution

Soln:

$gm/l = N \times Eq.wt$

$5.3 = N \times 53$

$N = \frac{5.3}{53}$

$= 0.1$

$N/10 = 0.1N$

Hence, both has same concentration.

What wt. of NaOH is required to prepare ~~standard solution~~ seminormal solution in 500 ml.

Sol: $Wt = \frac{NEV}{1000}$ $\qquad \frac{1}{2}N\ N/2 = 0.5$

$= \frac{\cancel{N}1/2\ EV}{1000}$

$= \frac{1/2 \times 4\cancel{0} \times 5\cancel{0}\cancel{0}}{1\cancel{0}\cancel{0}\cancel{0}}$

$= 10.$

Normality factor (f)

Normality factor is defined as the ratio of actual weight of substance taken to the theoretical weight of substance to be taken

$$\text{Normality factor (f)} = \frac{\text{weight of substance taken}}{\text{weight of substance to be taken}}$$

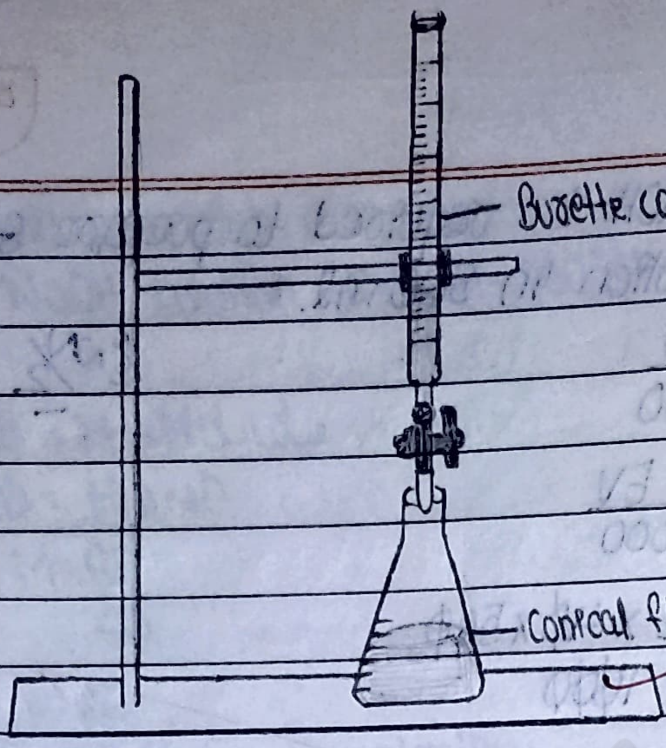
Exact strength of a solution = proposed strength × normality factor

Titration

The process of determining the strength of unknown solution with the help of standard solution (i.e., the solution whose strength is known) is called titration.

Typically, the titrant (the solution of known strength) is added from a burette to a known quantity of the titrand (the unknown solution) until the reaction is completed.

Titration is also called standardization.



Titration can be classified into following types:

- Acid-base or neutralization titration
- Oxidation-reduction or redox titration
- Precipitation titration
- Complexometric titration

Acid-base or neutralization titration:

The titration which involves the acid-base reaction (i.e., neutralization reaction) is called acid-base titration.

Acidimetry: The process of determining the strength of unknown acid by titrating it with the standard solution of alkali in presence of indicator is called acidimetry.

Alkalimetry: The process of determining the strength of unknown base by titrating it with the standard solution of acid in presence of indicator is called alkalimetry.

Oxidation Reduction or Redox titration:

The process of determining the strength of an oxidizing agent by ~~titra~~ titrating it with the standard solution of reducing agent or vice-versa is called redox titration. For eg

Titration of potassium permanganate ($KMnO_4$) (i.e., oxidizing agent) with standard oxalic acid ($C_2H_2O_4$) (i.e., reducing agent) in acidic medium is a redox titration.

$$\underset{\text{(oxidizing agent)}}{2KMnO_4} + 3H_2SO_4 + \underset{\text{(Reducing agent)}}{5C_2H_2O_4} \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$$

Precipitation titration

The titration in which a precipitate is formed as a result of reaction between the reacting solution is called precipitation titration.
For eg.

$$AgNO_3 + NaCl \longrightarrow AgCl\downarrow + NaNO_3$$

Some terms and terminology related to volumetric analysis

Titrant (Standard solution)

The solution whose strength is known during the titration is known as titrant. The titrant is taken in a burette during titration.

Titrand

The solution whose strength is not known i.e., the solution whose strength is to be determined during titration is known as titrand. The titrand is pipette out by the pipette and taken in the flask during titration

Indicators

Indicators are those chemical substances which indicate the completion of reaction (i.e., end point) during titration by changing their own colour. Indicators are of two types :

1. Internal indicators
2. External indicators

Internal indicators

The indicator which is added to the flask is known as internal indicator. Eg: acid-base indicators, self indicators, precipitation indicators, etc.

Acid-base indicators: Indicators used in acid-base titration are called acid-base or pH indicators. Eg: methyl orange, phenolphthalein, litmus paper, methyl red, etc.

Self indicators: A self indicator is a reactant which itself indicates the end point of reaction by changing the color of reaction mixture. Eg $KMnO_4$ acts as an self indicator during titration between $KMnO_4$ and oxalic acid because it gives pink colour in basic medium and colourless in acidic medium.

External indicators

External indicator is added in between the titration process by taking a drop of titrated mixture.
Example: potassium ferricyanide is used in titration of ferrous ammonium sulphate and $K_2Cr_2O_7$.

End point:

The stage (point) during the titration at which indicators indicates the completion of reaction by changing its own colour is called end point.
If the titration is carried out in between acid and base then the end point is called neutral point.

Equivalence point (Theoretical end point)

The stage (point) during the titration at which number of gram equivalent of titrant is equal to the number of gram equivalent of titrand is called equivalence point.
Indicator changes its colour after the equivalence point, hence equivalence point is also called theoretical end point.

Titration error

In theoretical concept, when equivalent amount of titrant is added to the titrand the indicator should change the colour and indicate the end point. But in actual practice, the indicator changes its colour either in acidic or alkaline medium. Therefore, in practice a small difference occurs between equivalence point and end point.
This difference between end point and equivalence point is called titration error.

Primary and secondary standard solution / substance

Primary standard solution / substance:

The substance whose standard solution can be prepared directly by dissolving the known weight of substance in fixed volume of solution is known as primary standard solution. Examples: anhydrous sodium carbonate (Na_2CO_3), oxalic acid ($C_2O_4H_2$), silver nitrate ($AgNO_3$), etc.

The solution of primary standard substance is known as primary standard solution. Concentration of primary standard solution remains constant for certain interval.

Secondary standard solution / substance

The substance whose solution can be standardize or strength can be determined by the help of primary standard solution is known as secondary standard substance. Examples: HCl, $NaOH$, $FeSO_4$, $KMnO_4$, etc.

The solution of secondary standard substance is known as secondary standard solution.

Concentration of secondary standard solution changes after certain interval.

Selection of indicators during acid-base titration

Indicators are the chemical species that indicates the end point by changing its own colour. Each pH indicator has its own pH range for its colour change. In order to determine the accurate end point of acid-base titration, the indicator should be selected in such a way that the pH range for the colour change of the indicator must coincide with the pH change (jump) at the end point of reaction.

Mainly two types of indicators i.e., methyl orange and phenolphthalein are used during acid-base titration. Methyl orange has pH range 3.1-4.4 and phenolphthalein has 8.2-10.

These are four types of acid base titrations:

1. Strong acid vs strong base titration:

The indicators pH range of both methyl orange (i.e., 3.1-4.4) and phenolphthalein (i.e, 8.2-10) coincide with the pH jump (i.e., 3-11) at end point. Hence, either methyl orange or phenolphthalein can be used as indicator during strong acid vs strong base titration.

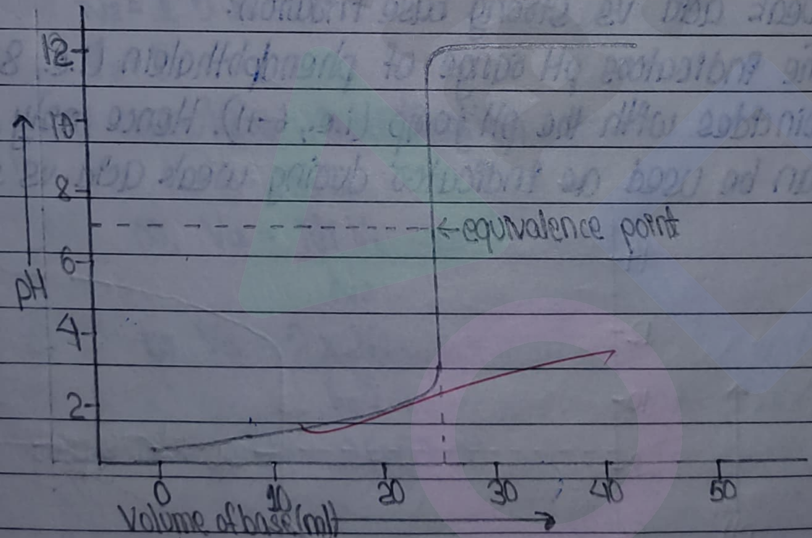


Fig: Titration curve for strong acid vs strong base

2. Strong acid vs weak base titration

The indicators pH range of only methyl orange (i.e., 3.1-4.4) coincides with the pH jump (i.e., 3-8). Hence, only methyl orange can be used as indicator during strong acid vs weak base titration

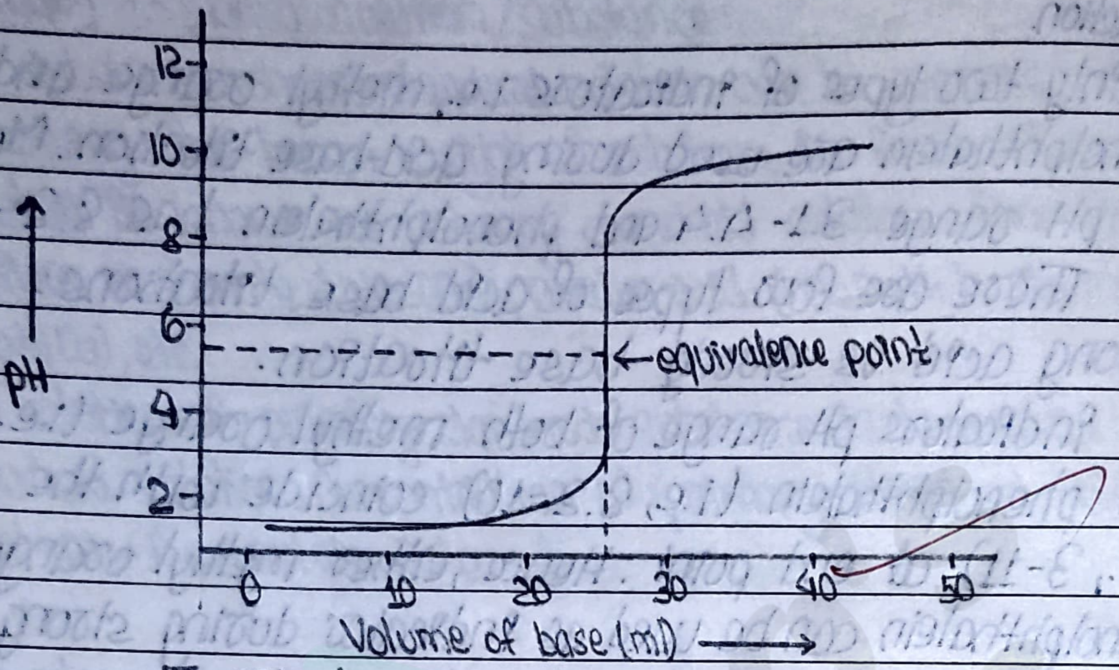


Fig: Titration curve for strong acid vs weak base

3. **Weak acid vs strong base titration:**

The indicators pH range of phenolphthalein (i.e., 8.2-10) only coincides with the pH jump (i.e., 6-11). Hence, only phenolphthalein can be used as indicator during weak acid vs strong base titration.

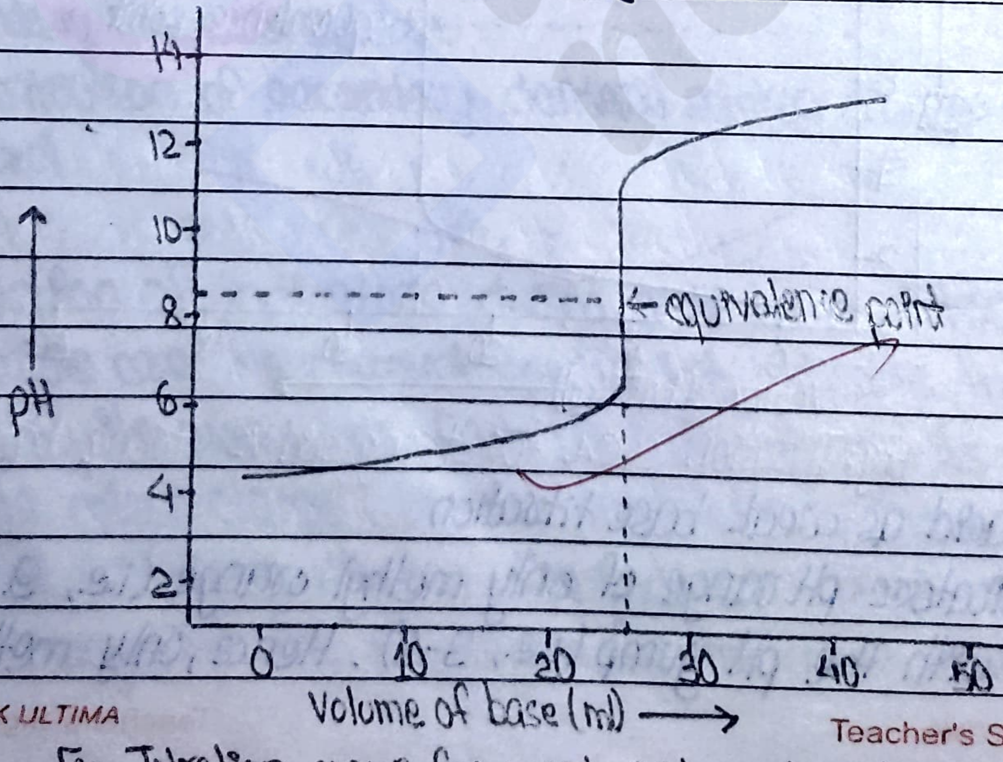


Fig: Titration curve for weak acid vs strong base

Note:

Strong acid- HCl, HNO_3, H_2SO_4, etc

Strong base- NaOH, KOH, $Ca(OH)_2$, etc.

Weak acid- formic acid, acetic acid, oxalic acid, etc.

Weak base- NH_4OH, $Cu(OH)_2$, $Fe(OH)_3$, etc.

Numericals

5. 20cc of 2N HCl is completely neutralized by 1.5N NaOH. Calculate the volume of base.

Soln. Given,

$N_1 = 2N$

$V_1 = 20cc$

$N_2 = 1.5\,N$

$V_2 = ?$

Now, For complete neutralization

$$N_1V_1 = N_2V_2$$

$$\text{or, } V_2 = \frac{N_1V_1}{N_2}$$

$$\text{or, } V_2 = \frac{2 \times 20}{1.5}$$

$$\therefore V_2 = 26.67\,cc$$

\# 2 litres of decinormal acidic solution is given. What volume of water should be evaporated to make it 2N?

Soln: $\frac{N}{10} \times 2 = 2 N.V$

$V = 0.1$ litres

$\therefore$ Water should be evaporated $= 2l - 0.1l$

$= 0.9l.$

6.# X cc of 5N HCl was diluted to 1l of normal solution. Calculate the value of x.

Soln: $V_1 = X$ cc

$N_1 = 5N$

$V_2 = 1l = 1000$ cc

$N_2 = 1N$

$\therefore N_1V_1 = N_2V_2$

or, $5 \times X = 1 \times 1000$

$\therefore X = 200$ cc

7.# What volume of water must be added to 40 ml of 0.25N acidic solution in order to make it exactly decinormal solution?

Soln: $V_1 = x$ $V_2 = 40$ ml

$N_1 = 0.1N$ $N_2 = 0.25N$

$\therefore N_1V_1 = N_2V_2$

$V_1 = \frac{0.25 \times 40}{0.1}$

$= 100$ ml

$\therefore$ Water added $= 100$ ml $- 40$ ml

$= 60$ ml.

8.# 4 gm of H_2SO_4 is mixed with 50 ml 2 normal NaOH solution. Predict the solution is either acidic or basic or neutral.

Soln: $Wt = \frac{NEV}{1000}$

or, $\left(\frac{Wt}{E}\right)_A = \left(\frac{NV}{1000}\right)_B$

or, $\left(\frac{4}{40}\right)_{H_2SO_4} = \left(\frac{2\times50}{1000}\right)_{NaOH}$

or, $(0.08)_{H_2SO_4} = (0.1)_{NaOH}$

Hence, solution is basic or alkaline.

10.# 50 ml of 2 Normal H_2SO_4 is mixed with 30 ml 3 Normal NaOH. Predict the solution is either acidic or basic or neutral. Also calculate the resulting strength of the solution.

Soln:

~~$Wt = \frac{NEV}{1000}$~~

~~or, $\left(\frac{Wt}{E}\right)_A = \left(\frac{NV}{1000}\right)_B$~~

~~or, $\left(\frac{50}{49}\right)_{H_2SO_4} = \left(\frac{3\times30}{1000}\right)_{NaOH}$~~

~~or, $(1.02)_{H_2SO_4} = (0.09)_{NaOH}$~~

~~Hence, solution is acidic.~~

Acid - Base = Total

or, $N_1V_1 - N_2V_2 = N_3V_3$

or, $50\times2 - 30\times3 = N_3\times80$

or, $10 = N_3\times80$

$\therefore N_3 = 0.125$

H_2SO_4	NaOH	$V_1=(50-30)$ml
50ml of 2N	30ml of 3N	$N_2=?$
100ml of 1N	90ml of 1N	$V_2=10$ml
		$N_2=1$N

∴ Excess acid soln = 10 ml

11# 25 cc of HCl solution reacts completely with 10 gm of $CaCO_3$. What is the strength of HCl in normality.

Solⁿ: Given,

Wt. of $CaCO_3 = 10g$

Volume of $HCl = 25cc$

Now, We know

$$Wt = \frac{NEV}{1000}$$

$$\text{or, } 10 = \frac{N \times 5\cancel{0} \times 25}{100\cancel{0}}$$

$$\text{or, } 125N = 1000$$

$$\therefore N = 8N$$

Hence, the required strength of HCl is 8 N.

9. 40 ml 2N H_2SO_4 is mixed with 20 ml 2N NaOH and 20 ml 1.5N Na_2CO_3. Predict the solution is either acidic or basic or neutral.

Solⁿ: Acid − Base = Total

$$\text{or, } 40 \times 2 - 20 \times 2 = N_3 \times 60$$

$$\text{or, } 80 - 40 = N_3 \times 60$$

$$\text{or, } 40 = N_3 \times 60$$

$$\text{or, } N_3 = 0.67\ N$$

∴ Solution is acidic.

Q. 2 gm of dibasic neutralise decinormal 500ml alkaline solution. Calculate the molecular wt. of acid.

Soln: **Acid** **Base**

Wt. = 2gm N = 0.1

n = 2 V = 500ml

We know

$$\overset{A}{Wt} = \frac{\overset{B}{N}\overset{A}{E}\overset{B}{V}}{1000}$$

$$\text{or, } \left(\frac{Wt}{E}\right)_A = \left(\frac{NV}{1000}\right)_B$$

$$\text{or, } \frac{2}{E} = \frac{0.1 \times 500}{1000}$$

$$\text{or, } 0.1E = 4$$

$$E = 40$$

$$Eq. = \frac{Mol.\ wt.}{n}$$

$$\text{or, } 40 = \frac{Mol.\ wt.}{2}$$

$$\therefore Mol.\ wt. = 80$$

12.# 100 cc of 0.1N HCl is mixed with 50 cc 0.1 N NaOH. Calculate the concentration of resulting solution in normality, molarity and gram per litre.

Soln: $V_1 = 100\,cc$

$N_1 = 0.1$

$V_2 = 50\,cc$

$N_2 = 0.1$

$N_3 = ?$

Total volume = 150 cc

Now, Acid − Base = total

$V_1N_1 - V_2N_2 = V_3N_3$

$10 - 5 = 150N_3$

$5 = 150N_3$

$N_3 = 0.03$

∴ Normality = Molarity x basicity

$0.03 = M \times 1$

$\therefore M = 0.03$

$gm/l = M \times Mol.\ wt.$

$= 0.03 \times 50$

$= 1.5$

$\frac{M}{2} = 0.5M$

$N = n \times M$
$= 2 \times 0.5$
$= 1$

13.# 20ml 2N HCl is mixed with 35 ml 1N NaOH. The mixture is diluted to 1 litre. Calculate resulting normality of diluted solution.

Soln: Given,

$V_1 = 20ml$

$N_1 = 2N$

$V_2 = 35ml$

$N_2 = 1N$

Total volume = 1 l

$\therefore N_1V_1 - N_2V_2 = N_3V_3$

or, $20 \times 2 - 35 \times 1 = N_3 \times 1000$

or, $5 = N_3 \times 1000$

$\therefore N_3 = 0.05$

4 l of N/5 H_2SO_4 solution is prepared by adding X litre of M/2 H_2SO_4 and Y litre of N/10 H_2SO_4 in 2 l of water. Find X and Y.

Soln:

4 l of N/5 $H_2SO_4 \longrightarrow$ X l of M/2 H_2SO_4 + Y l of N/10 H_2SO_4 + 2 l water

$V_m = 4\,l$ $\quad V_1 = X\,l$ $\quad V_2 = Y\,l$ $\quad$ + 2 l water

$N_m = 0.2N$ $\quad N_1 = 1N$ $\quad N_2 = 0.1N$

$(X + Y + 2) = 4$

or, $X + Y = 2$

or, $X = (2 - Y)$

By the question,

$V_1N_1 + V_2N_2 = V_mN_m$

or, $X \times 1 + Y \times 0.1 = 4 \times 0.2$

or, $2 - Y + 0.1Y = 0.8$

or, $2 - 0.8 = 0.9Y$

$\therefore Y = 1.33$

$\therefore X = 2 - 1.33$
$= 0.67$

24.# What volume of 12M NaOH and 2M NaOH should be mixed to get 2 l of 9M NaOH solution.

Soln: Let the value of 12M be x l and 2M NaOH be $(2-x)$ l.

$M_1V_1 + M_2V_2 = M_mV_m$

or, $12 \times x + 2(2-x) = 9 \times 2$

or, $12x + 4 - 2x = 18$

or, $10x = 14$

$\therefore x = 1.4$ litre

$\therefore (2-x)$ l $= 0.6$ l

Hence, 1.4 l of 12M NaOH and 0.6 l of 2M NaOH should be mixed.

23. What volume of 12 N HCl and 3N HCl must be mixed to form one litre 6N HCl?

Soln: Let the value of 12 N HCl be x l and 3N HCl be $(\overset{1000-x}{1-x})$ l

$N_1V_1 + N_2V_2 = N_tV_t$

or, $12 \times x + 3 \times (1-x) = 6 \times 1$

or, $12x + 3 - 3x = 6$

or, $9x = 3$

$\therefore x = 1/3$ litre

$1 - x = 1 - 1/3$

$= 2/3$ litre

1 Xg of $CaCO_3$ reacts completely with 20mL of 1M HCl. Calculate the value of x.

Soln. Wt. of Ca_2CO_3 (W) = X

Volume of HCl (V) = 20mL

Molarity of HCl (M) = 1

Now, Normality = M.x [∵ x = acidity / basicity / valency]

= 1×1 [∵ For HCl, x = 1]

= 1

∴ No. of gram equivalent of $CaCO_3$ = No. of gram equivalent of HCl

$$\Rightarrow \frac{W}{Eq.wt} = \frac{N \times V}{1000}$$

$$or,\ \frac{X}{50} = \frac{1 \times 20}{1000}$$

$$\therefore X = 1\,gm$$

2. If 20mL of 0.5N NaOH is mixed with 30mL of 0.3N HCl, is the resulting solution acidic or basic? Calculate the normality with respect to the acidic or basic final solution.

Given,

(V_1) Volume of NaOH = 20mL

N_1 = 0.5N

Volume of HCl (V_2) = 30mL

N_2 = 0.3N

then, Volume of final soln (N_3) = 20mL + 30mL = 50mL

N_3 (Normality of final solution) = ?

$N_2V_2 - N_1V_1 = N_3V_3$

or, $30\times0.3 - 20\times0.5 = N_3\times50$

or, $9 - 10 = 50N_3$

or, $-1 = 50N_3$

Hence, the final solution is basic.

$\therefore N_3 = 1/50$

$= 0.02N$.

3. 5 g of diacidic base is completely neutralized by 50 mL 2N HCl. Find the molecular weight of the base.

Soln: <u>Acid</u> <u>Base</u>

Acid	Base
V = 50 mL	Wt = 5 g
N = 2N	n = 2

Now, we know

$$Wt = \frac{NEV}{1000}$$

or, $\left(\frac{Wt}{E}\right)_B = \left(\frac{N.V}{1000}\right)_A$

or, $\frac{5}{E} = \frac{2\times50}{1000}$

or, $E = \frac{100\cancel{0}\times\cancel{5}}{2\times\cancel{50}}$

$\therefore E = 50$

$$Eq.wt. = \frac{Mol.\ wt.}{n}$$

$\Rightarrow 50 = \frac{Mol.\ wt}{2}$

$\therefore$ Molecular weight = 100 amu

21. 4. 0.8g of a divalent metal was dissolved in 100cc of 1.28 N HCl and the solution was diluted to 200cc. Then 50cc of this solution required 54.6cc of 0.22N NaOH for neutralization. Find the atomic weight of the metal.

Soln: Given

Metal	HCl	Diluted to 200ml	NaOH
W = 0.8g	V_1=100ml	V = 200ml	V = 54.6mL
V = 2	N_1= 1.28N		N = 0.22N

ⓞ 50 mL

50ml of the final solution is neutralized by 54.6ml of NaOH having N = 0.22N

∴ 200ml of the final solution is neutralized by $\left(\frac{54.6 \times 200}{50}\right)$ mL

i.e., 218.4 mL of NaOH, N = 0.22N

HCl↔metal, HCl↔NaOH } No. of gram equivalent of HCl = No. of gram eq. of metal and NaOH

$$\frac{N_1 \times V_1}{1000} = \frac{Wt}{Eq.wt} + \frac{N_2 \times V_2}{1000}$$

$$\Rightarrow \frac{1.28 \times 1\cancel{0}\cancel{0}}{10\cancel{0}\cancel{0}} = \frac{0.8}{E} + \frac{0.22 \times 218.4}{1000}$$

$$\Rightarrow 0.128 = \frac{0.8 \times 1000 + 0.22 \times 218.4 \times E}{1000E}$$

or, 128 E = 800 + 48.048E

or, 79.952E = 800

or, $E = \frac{80\cancel{0}}{8\cancel{0}}$

∴ E = 10

Now, Atomic wt. = Eq.wt. × V
= 10 × 2
= 20 amu

22. 5. xg of a metal (equivalent weight = 12) was completely dissolved in 100cc of N/2 HCl. The volume was then made up to 500cc. 25cc of this diluted acid required 17.5 cc N/10 NaOH for complete neutralization. Find the value of x.

Sol^n: Given

Metal	HCl	diluted	Final		NaOH
Wt = xg	V = 100ml		V = 500ml	→ (25cc)	V = 17.5 ml
Et wt = 12	N = 1/2 N				N = 1/10

25ml of final sol^n can be neutralized by 17.5ml of NaOH, N = 1/10

∴ 500ml of final sol^n can be neutralized by $\left(\frac{17.5}{25}\times 500\right)$ ml of NaOH, N = $\frac{1}{10}$

i.e., 350ml

No. of gram equivalent of HCl = No. of gram eq. of metal and NaOH

$$\frac{V_1\times N_1}{1000} = \frac{W}{Eq.wt} + \frac{V_2\times N_2}{1000}$$

$$\Rightarrow \frac{1\cancel{00}\times 1/2}{10\cancel{00}} = \frac{x}{12} + \frac{35\cancel{0}\times 1/1\cancel{0}}{1000}$$

$$\Rightarrow 0.05 = \frac{x}{12} + 0.035$$

$$\Rightarrow x + 0.42 = 0.6$$

$$\therefore x = 0.18g$$

6. 4g of NaOH was added to 20 cc of 2N H_2SO_4 solution an the volume was diluted to one litre. Predict whether the dilute solution is acidic, basic or neutral and also calculate the resulting normality of the diluted solution in term of g/l.

Soln:

$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$$

$(2\times40)g \quad 98g$

⇒ 98g of H_2SO_4 requires 80 g of NaOH for complete reaction.

1g of H_2SO_4 requires $\left(\frac{80}{98}\right)$g of NaOH for complete reaction.

NaOH
Wt=4g

H_2SO_4
V=20ml
N=2N
Wt.=?

$$Wt = \frac{NEV}{1000} \qquad \left(\frac{Wt}{E}\right)_B = \left(\frac{NV}{100}\right)_A$$

$$= \frac{2\times49\times20}{1000}$$

$$= 1.96\ g$$

1.96g of H_2SO_4 requires $\left(\frac{80}{98}\times1.96\right)$ g of NaOH

$$= 1.6\ g$$

Total NaOH = 4g
NaOH used = 1.6g
left = 4g − 1.6g = 2.4g NaOH ∴ Soln is basic.

In 1 l of total volume, 2.4g NaOH is present = 2.4g/l

$$Normality = \frac{g/l}{Eq.\ Wt.} = \frac{2.4}{40}$$

$$= 0.06N$$

7. What volume of 95% sulphuric acid (density = 1.85g/cc) ~~of N/10~~ and what mass of water must be taken to prepare 100cc of 15% solution of sulphuric acid (density = 1.1g/cc)

Soln: Given,

Initial
% purity = 95%
density = 1.85g/cc

Final soln
V = 100 cc
d = 1.1g/cc

$$N = \frac{\%\ \text{purity} \times \text{density} \times 10}{\text{Eq.wt.}}$$

$$= \frac{95 \times 1.85 \times 10}{49}$$

$$= 35.86$$

$$\text{Normality of final soln} = \frac{15 \times 1.1 \times 10}{49}$$

$$= 3.36$$

Now, $N_1V_1 = N_2V_2$

$$\text{or, } V_1 = \frac{N_2V_2}{N}$$

$$= \frac{3.36 \times 100}{35.86}$$

$$= 9.36\ \text{cc}$$

Volume of water $= (100 - 9.36)$cc
$= 90.64$cc

$$\text{Density} = \frac{m}{V}$$

Water = 1g/cc

$$\text{or, } 1 = \frac{m}{90.64}$$

$\therefore m = 90.64$g

8. 12g of commercial zinc is made to react with excess dilute H_2SO_4. The total volume of H_2 gas liberated was found to be 4.2 litres at 570 mmHg pressure and 279K. Determine the percentage purity of the zinc. (Atomic mass of Zn = 65).

Soln: Given,

<u>Zinc</u>	<u>H_2</u>	
Wt = 12g	$V = 4.2\,l$	% purity = ?
	$P = 570\text{ mmHg} = \frac{570}{760} = 0.75\text{ atm}$	
	$T = 279K$	

$$\therefore PV = nRT$$

$$n = \frac{PV}{RT}$$

$$= \frac{0.75 \times 4.2}{0.0821 \times 279} \quad [\because R = 0.0821]$$

$$= 0.1375$$

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$$

1 mole H_2 is produced from 65g (1 mole) of zinc

0.1375 mole of H_2 is produced from (65×0.1375)g of zinc

i.e., 8.9375g of zinc

$$\% \text{ purity} = \frac{8.9375}{12} \times 100\%$$

$$= 74.48\%$$

19. ~~9.~~ 0.715g of $Na_2CO_3 \cdot nH_2O$ required 20 mL of seminormal hydrochloric acid solution for complete reaction. Find the value of n.

Soln. Given,

$Wt = 0.715g$

HCl

$V = 20ml$

$N = 0.5N$

$\therefore Wt = \frac{NEV}{1000}$

or, $0.715 = \frac{0.5 \times (106+18n) \times 2\cancel{0}}{2 \times 100\cancel{0}}$

or, $143 = 106 + 18n$

or, $18n = 37$

$\therefore n = 2.056 \approx 2$

$\boxed{Eq.\,wt. = \frac{mol.\,wt}{valency \times No.of\,m} = \frac{106+18n}{2}}$

$Na_2CO_3 = 106$

$H_2O = 18$

$Na_2CO_3 \cdot nH_2O$

$= 106 + 18n$

10. What volume of 5% NaOH are required to neutralize 2 litres of decinormal H_2SO_4?

Soln: Given

In 100 ml soln of NaOH → 5g NaOH is present

1000 ml → 50g

NaOH gm/l = 50g

$N = \frac{gm/l}{Eq.wt} = \frac{50}{40}$

$= 1.25$

H_2SO_4

$V = 2l$

$N = 0.1$

$N_1V_1 = N_2V_2$

or, $1.25 \times V = 2 \times 0.1$

$\therefore V = 0.16 l$

11 7.5g of a dibasic acid dissolved in water and the solution made up to 250cc. 25cc of this acid requires 16.3cc (1N) NaOH for complete neutralization. Calculate the molecular weight of the acid.

Soln. Given,

25cc of the acid requires 16.3cc of NaOH

Then, 250cc of the acid requires 163cc of NaOH.

$\therefore N_1V_1 = N_2V_2$

or, $N_1 \times 250 = 1 \times 163$

$\therefore N_1 = 0.652$

Now, $Wt. = \frac{NEV}{1000}$

or, $7.5 = \frac{0.652 \times E \times 25\cancel{0}}{100\cancel{0}}$

or, $750 = 16.3 \times E$

or, $E = 46.012$

or, $\frac{Mol.\ wt}{n} = 46.012$

or, $\frac{Mol.\ wt}{2} = 46.012$

$\therefore$ Mol. wt. = 92.024 amu

12. 20 mL of a sulphuric acid solution neutralizes 0.265g of Na_2CO_3. Calculate the normality of the acid solution.

Sol^n: Given, Wt. of Na_2CO_3 = 0.265g

Volume of acid = 20mL

Now, $Wt = \frac{NEV}{1000}$

or, $0.265 = \frac{N \times 53 \times 2\cancel{0}}{100\cancel{0}}$

or, 26.5 = 106 N

∴ N = 0.25N

⑭ ~~13~~ 25cc of an alkali solution is mixed with 8cc of 0.75N acid solution for complete neutralization, it further requires 15cc of 0.8N acid solution. Find the strength of the given alkali solution.

Sol^n: Given,

$25 \times N = 8 \times 0.75 + 15 \times 0.8$

or, $25N = 6 + 12$

or, $25N = 18$

∴ N = 0.72 N

Hence, the required strength of the given alkali solution is 0.72 N.

15. 20 ml of a decinormal solution of NaOH neutralizes 25 ml of solution of dibasic acid containing 6 gm of acid per litre. Find the equivalent weight and molecular weight of acid.

Soln:

$N_1 = 0.1N$

$V_1 = 20ml$

$V_2 = 25ml$

Eq. wt. of acid = ?

Mol. wt. of acid = ?

Now,

$$N_1V_1 = N_2V_2$$

or, $0.1 \times 20 = \frac{(gm/l)\ \text{weight of solute}}{\text{Eq. wt. of solute}} \times 25$

or, $2 = \frac{6}{E} \times 25$

or, $E = \frac{150}{2}$

$\therefore E = 75$

$E = \frac{\text{Mol. wt}}{n}$

or, $75 = \frac{\text{Mol. wt}}{2}$

$\therefore$ Mol. wt. = 150 amu

16 0.012 gm of a divalent metal is completely dissolved in 40cc of N/10 [redacted] for complete neutralization. Find the equivalent weight and atomic weight of metal.

Soln:

Wt of metal = 0.012 gm

$n = 2$

Volume of [redacted] = 40 cc

$N = N/10$

Now,

$$Wt = \frac{NEV}{1000}$$

$$\text{or, } 0.012 = \frac{0.1 \times E \times 40}{1000}$$

$$\text{or, } 12 = 4E$$

$$\therefore E = 3$$

$$E = \frac{\text{Molecular wt.}}{n}$$

$$3 = \frac{\text{Mol. wt.}}{2}$$

$$\therefore \text{Mol. wt.} = 6 \text{ amu.}$$

$$\text{Atomic mass} = \text{Eq. wt.} \times n$$

$$= 3 \times 2$$

$$= 6 \text{ amu}$$

17. 3 gm trivalent metal was completely dissolved with 750 ml of 1 N HCl. The residual solution further required 1000 ml of N/2 NaOH solution for complete neutralization. Find the atomic mass of the metal.

M = A − B

Soln:

Metal	HCl	NaOH
Wt = 3 gm	$V_1 = 750$ ml	$V_2 = 1000$ ml
n = 3	$N_1 = 1$ N	$N_2 = N/2$

No. of gram eq. of HCl = No. of gram eq. of metal and NaOH

$$\frac{N_1 \times V_1}{1000} = \frac{Wt.}{Eq. wt.} + \frac{N_2 V_2}{1000}$$

$$\text{or, } \frac{1 \times 750}{1000} = \frac{3}{E} + \frac{1/2 \times 1000}{1000}$$

$$\text{or, } \frac{3}{E} = 0.75 + 1/2$$

$$\text{or, } \frac{3}{E} = 1.25$$

$$\therefore E = 2.4$$

And Atomic mass = Eq. wt. × n

= 2.4 × 3

= 7.2 amu.

18. How many moles of H_2SO_4 are required to neutralize 4 litre of 2N NaOH solution?

$l = mole \times 22.4$

Soln: 98g $2 \times 40g = 80g$

$mole = \frac{l}{22.4}$

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

One mole of H_2SO_4 reacts with 2 moles of NaOH.

4 litre $\left(\frac{4}{22.4} = 0.1786 \text{ mole}\right)$ is neutralized by $\frac{1}{2} \times 0.1786$ mole
$= 0.0893$ mole

Q. 20 ml 2N HCl is mixed with 35 ml 1N NaOH. The mixture is then diluted to 1 litre. Calculate the result in Normality of diluted solution.

Soln: **HCl**   **NaOH** $V_3 = 1$ litre
$V_1 = 20ml$ $V_2 = 35ml$ $\longrightarrow$ $= 1000ml$
$N_1 = 2N$ $N_2 = 1N$ $N_3 = ?$

Now, $N_1V_1 - N_2V_2 = N_3V_3$

or, $2 \times 20 - 1 \times 35 = N_3 \times 1000$

or, $N_3 = \frac{5}{1000}$

$N_3 = 0.005$

~~Q. 25cc of alkali solution is mixed with 8cc of 0.75Nacc~~

Q18 ~~0.012~~ How many moles of H_2SO_4 are required to neutralize 4 litre of 2N NaOH solution?

Soln: $$Wt = \frac{NEV}{1000}$$

$$= \frac{2 \times 49 \times 4000}{1000}$$

$$= 392\ gm$$

$$\text{No. of mole} = \frac{Wt.}{M}$$

$$= \frac{392}{98}$$

$$= 4\ mole$$

Q Calculate the volume of 1M NaOH required to neutralise 200cc of 2M HCl. What mass of NaCl are produced from neutralize reaction?

Soln: $$(M_A V_A)_{Acid} = (M_B V_B)_{Base}$$

$$200 \times 2 = 1 \times V$$

$$V = 400\ ml$$

40g NaOH produces 58.5g NaCl

16g NaOH produces $\frac{58.5 \times 16g}{40}$

$= 23.4g$ NaCl

$$\text{Molarity} = \frac{W}{M_0} \times \frac{1}{V(l)} \times 100$$

$$(W)_{NaOH} = \frac{M \times M_0 \times V}{1000} = \frac{1 \times 40 \times 400}{1000} = 16gm$$

$$(W)_{HCl} = \frac{M \times M_0 \times V}{1000} = \frac{2 \times 36.5 \times 200}{1000} = 14.6g$$

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

$40g \quad 36.5g \longrightarrow 58.5g$

Given, $16g \quad 14.6g \quad ?$

1. 30 ml of 2N HNO_3, 50 ml of 3M H_2SO_4 and 20 ml of 36.5% of HCl (specific gravity = 1.18) are mixed. Calculate the strength of resulting solution.

Soln: Normality of H_2SO_4 = Molarity x basicity

$$= 3 \times 2$$

$$= 6$$

$$\text{Normality of HCl} = \frac{\% \times \text{specific gravity} \times 10}{\text{Eq. wt.}}$$

$$= \frac{36.5 \times 1.18 \times 10}{36.5}$$

$$= 11.8$$

Now, $N_1V_1 + N_2V_2 + N_3V_3 = NV$

or, $2 \times 30 + 6 \times 50 + 11.8 \times 20 = N \times 100$

or, $60 + 300 + 236 = N \times 100$

or, $N = 5.96\,N$

The required strength of resulting solution is 5.96 N.

2. 1 gm of an ordinary sample of limestone is dissolved in 16.6 cc of 0.92 N HCl leaving some sandy residue. Calculate the percentage of pure $CaCO_3$ in the sample.

Soln: $CaCO_3$ | HCl

$W = ?$ | $V = 16.6\,ml$

$E = 50$ | $N = 0.92\,N$

At equivalence point

$$\left(\frac{W}{E}\right)_{CaCO_3} = \left(\frac{NV}{100}\right)_{HCl}$$

or, $\frac{W}{50} = \frac{0.92 \times 16.6}{1000}$

$\therefore W = 0.7636gm$

Now, % of pure $CaCO_3 = \frac{0.7636}{1} \times 100\%$

$= 76.36\%$

3. 0.2273gm of metal was dissolved into 350ml HCl of 0.1N (f=0.115N) and the solution was diluted to 500ml. 50 ml of this solution required 15cc of 0.1 N NaOH for neutralisation. Calculate the equivalent weight of metal.

Soln Here, 50 ml of HCl neutralise 15 ml of 0.1 N NaOH

500ml of HCl neutralise 150 ml of 0.1 N NaOH

At equivalence point,

$$\left(\frac{W}{E}\right)_M = \left(\frac{NV}{1000}\right)_{HCl} - \left(\frac{NV}{1000}\right)_{NaOH}$$

or, $\frac{0.2273}{E} = \frac{0.115 \times 500}{1000} - \frac{0.1 \times 150}{1000}$

or, $\frac{0.2273}{E} = \frac{42.5}{1000}$

or, $E = \frac{227.3}{42.5}$

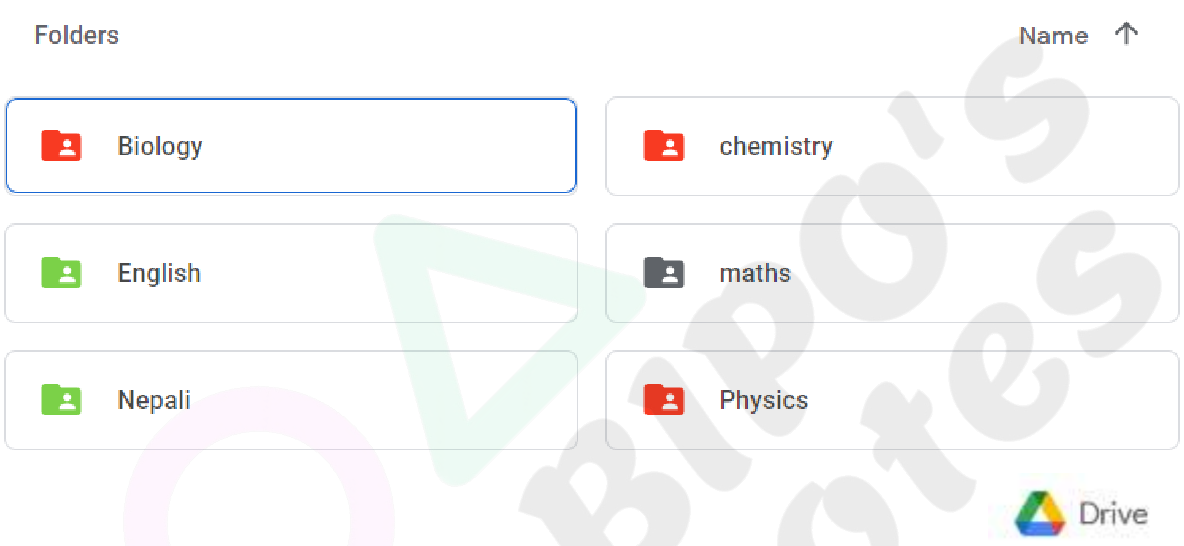
$\therefore E = 5.348gm$

Hence, the equivalent weight of metal is 5.348 gm.

Bipin Khatri

(Bipo)

Class 12 complete notes and paper collection.



Feedbacks:

admin@bipinkhatri.com.np | bipinkhatri.ram@gmail.com

Contact:

@im.bipo www.bipinkhatri.com.np @im.bipo