Some Basic Concepts of chemistry
unit – I

Low of chemical Combinations –

1. Low of Conservation of mass
2. Low of definite preportions
3. Low of multiple proportions
4. Avagadro's Low
5. Gray Lussac's Low

→ **mole Concept** –

→ Concentration Terms –

(1) wt by wt %	(6) mole fraction
(2) V by V %	(7) Molarity
(3) wt by V %	(8) molality
(4) PPm	(9) Normality
(5) PPb	

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(1) **Low of Conservation of mass** → "mass neither be created nor be destroye"

$$A + B \longrightarrow AB$$

Sum of mass of Reactant = Sum of mass of product

eg →

$$C + O_2 \longrightarrow CO_2$$

12   16   12×16 = 44 g.

44 g

(2) Law of definite Preportion — "A chemical compound no matter from which source it has been obtained it will contain the same element combine together in the same fixed preportion by mass"

eg →	Sea water (H_2O)	Rain water (H_2O)	Tap water (H_2O)
	H : O	H : O	H : O
	2 : 16	2 : 16	2 : 16
	1 : 8	1 : 8	1 : 8

(3) Law of multiple preportion

"When two element combine to form more than one compound than the different masses of the one element which combines with fixed mass of other element bears a small whole no. of ratio to one another"

eg → difference mass of O (32g, 16g) which combine c̄ fixed mass of C (12g)

CO_2
12 : 32

CO
12 : 16

$\frac{32}{16} = \frac{2}{1}$ (Small ratio) eg H_2O H_2O_2

2 : 16 2 : 32

Diff. masses of O (16g, 32g) which combines with fixed mass of H (2g)

16 : 32 → (1 : 2) (small ratio)

④ Law of Reciprocal proportion (3 elements)

"When two element combine seperately c̄ a fixed mass of 3rd element than the ratio of masses in which they do so bears a small whole no. ratio to the ratio of masses in which they themselves combine".

eg →

C —CS_2 12 : 64→ S

CO_2 12 : 32 → O ← SO_2 32 : 32

C & S combine seperately with fixed mass of O in the ratio of masses

C : S
12 32
(3 : 8)

Ratio of mass in which C & S themselves combine

C : S
12 64
(3 : 16)

(small amount ratio)

$\frac{3/8}{3/16} = \frac{2}{1}$ (small ratio) eg →

SO_2

S — 32 : 32 — O

H_2S → H ← H_2O

2 : 32   2 : 16

(fixed)

Ratio of mass of S & O which combine with fixed mass of H =

S & O

32 : 16

(2 : 1)

Ratio of mass in which S & O themselves combine

S : O_2

(32 : 32)

1   1

इन दोनों का ratio small होना चाहिए

$\frac{2}{1} / \frac{1}{1} = \frac{2}{1}$ (small Ratio)

④ **Gay Lussac's Law** → (only valid for gases)

"When gases react, they do so in volume which bear a simple whole no. ratio to one another and to the volume of products formed if gaseous"

eg → $1H_2(g) + 1Cl_2(g) \longrightarrow 2HCl(g)$

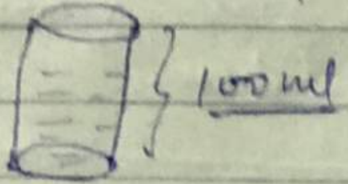
1 vol	1 vol	2 vol
20 ml	20 ml	40 ml

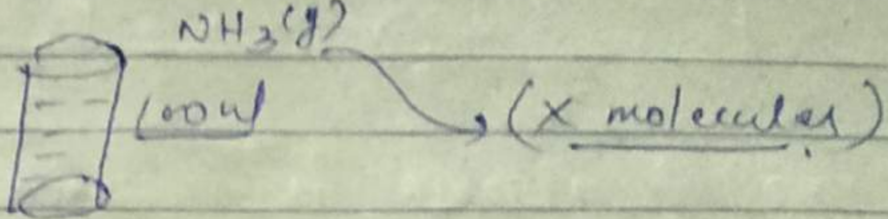
⑤ **Avagadro's Hypothesis** →

If Temp, pressure & physical conditions is remain constant (same) than equal volume of all gases contains equal no. of molecules

eg → 100 ml H_2 → x molecule

O_2 → x molecules of oxygen.





Volume of gas $\propto$ No. of molecules

eg → 100 ml of methane gas → y molecules

100 ml of $CO_2(g)$ → y molecules

50 ml of $CO_2(g)$ → $\frac{y}{2}$ molecules

200 ml of $N_2(g)$ → 2y molecules

$1 \text{ mole} = 6.022 \times 10^{23}$

1 mole of oxygen atom = 6.022×10^{23} oxygen atom

1 mole of N_2 molecule = 6.022×10^{23} N_2 molecules

1 mole of CO_2 = 6.022×10^{23} CO_2 molecules

$$\text{no. of moles} = \frac{\text{mass given}}{\text{Atomic mass / M.M}}$$

CH_4: 12 + 4 = 16

$$\text{no. of moles} = \frac{\text{Volume given (STP)}}{22.4 L \ (22.4 dm^3)}$$

$$\text{no. of moles} = \frac{\text{molecules given / atoms}}{6.022 \times 10^{23}}$$

Q = find no. of moles present in –

(i) 11.2 L of N_2 gas STP → $\frac{11.2}{22.4} = \frac{1}{2} = 0.$

(ii) 16g of CH_4 gas → $\frac{16}{16} = 1$

(iii) 12×10^{24} molecules of O_2 (g) → $\frac{12 \times 10^{24}}{6.022 \times 10^{23}}$ = 2

(iv) 49 g of H_2SO_4 → $\frac{49}{...} = \frac{1}{...} = 0.5$

$$\% \text{ Composition} = \frac{\text{mass of that quantity in comp}}{\text{mass of compound}} \times 100$$

eg H_2O O% = $\frac{16}{18} = \frac{16}{18} \times 100 =$

% of Cl in NaCl = $\frac{35.5}{23+35.5} \times 100$

% of O in H_2SO_4 = $\frac{64}{2+32+64} \times 100$

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molecular formula | emperical formula (simplest ratio of atom)

eg → ethane C_2H_6 — C_1H_3

glucose $C_6H_{12}O_6$ — $C_1H_2O_1$

Butane C_4H_{10} — C_2H_5

molecular formula = n × Eperical formula

molecular weight = n × emperical wt

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Solution →

A solution is a homogeneous mixture of two or more chemically non-reacting substances whose composition can be varied within certain limits.

Solution
- (Solute) ⇓ Solute is that component of solution which is present in small amount by mass
- (Solvent) ⇓ Solvent is that component of the solution which present in larger amount by mass

eg → 20% NaOH solution
20% NaOH (Solute) 80% water (solvent)

→ 80% ethanol solution
means 80% ethanol (solvent) & 20% water (solute)

Concentration Terms —

- (Temperature dependent) (Volume related)
  - → V/V %
  - → W/V %
  - → Molarity
  - → Normality
- (Temp. Independent) mass (Related)
  - → w/w %
  - → mole fraction
  - → Molality
  - → PPM / PPB

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1) **w/w %** → A solution of NaCl in water is 5% (w/w)

it means 5g NaCl is present in 100g of solⁿ.

$$w/w\,\% = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$$

Q-① 10g of glucose is dissolved in 100g of water find w/w % ?

Ans →
$$w/w\,\% = \frac{\text{mass of solute}}{\text{mass of sol}^n} \times 100$$

$$w/w\,\% = \frac{10}{110} \times 100 = \frac{100}{11} = 9.09\,\%$$

Q-② 10g of NaCl is present in 100ml of solution find w/w %. If density of solution is 1.2g/ml

Ans →
$$w/w\,\% = \frac{\text{mass of solute}}{\text{mass of sol}^n} \times 100$$

$$w/w\,\% = \frac{10}{120} \times 100 = \frac{100}{12} = \frac{25}{3} = 8.33\%$$

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$1.2 = \frac{\text{mass}}{100\,\text{ml}}$$

mass = 1.2 × 100
mass = 120g

② **v/v %** → A HCl solution is 7% (v/v)

it means 7ml HCl present in 100 ml of solution

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$$V/V\ \% = \frac{\text{Volume of Solute}}{\text{Vol. of Solution}} \times 100$$

3) W/V % → A Sugar solution is 3% (W/V)

it means 3g sugar is present in 100 ml of solution.

$$W/V\ \% = \frac{\text{mass of Solute}}{\text{Vol. of solution}} \times 100$$

Q= A Sugar solution is 10% (W/V) find W/W % if the density of solution is 1.25g/ml

Ans → 10g Sugar present in 100 ml of Solution.

$$W/V\ \% = \frac{\text{mass of solute}}{\text{vol. of solution}} \times 100$$

$$W/V\ \% = \frac{10}{125} \times 100 = \frac{40}{5} = 8\%$$

$d = \frac{M}{V}$

$1.25 = \frac{M}{100}$

$m = 1.25 \times 100$

$M = 125g$

Q= A Solution of HNO_3 is 5% (W/W) find the mass of HNO_3 present in 100 ml of Solution (density of solⁿ = 1.4 g/ml)

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Ans → $w/w\,\% = \dfrac{\text{mass of solute}}{\text{mass of sol}^n} \times 100$

$d = \dfrac{m}{V}$

$1.4 = \dfrac{m}{100}$

$m = 140$

$5\% = \dfrac{x}{140} \times 100 =$

$x = \dfrac{5 \times 140}{100} = \dfrac{70}{10} = 7g$

$\boxed{x = 7g}$

④ Mole fraction ⇒

Mole fraction of a constituent (solute as well solvent) is the fraction obtained by dividing number of moles of that constituent by the total no. of moles of all the constituents present in the solution

→ it is denoted by 'χ'

no. of moles	Ⓐ	Ⓑ
	1	3

mole fraction of A = $\dfrac{\text{no. of moles of A}}{\text{no. of moles of A + no. of moles of B}}$

$\chi_A = \dfrac{n_A}{n_A + n_B}$

Mole fraction = $\dfrac{\text{no. of moles of solute}}{\text{Total moles}}$

$\boxed{\chi_A + \chi_B = 1}$

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eg → 40 g NaOH + 54 g H_2O find X_{NaOH} & X_{H_2O}

Ans → $X_{NaOH} = \frac{1}{1+3} = \frac{1}{4} = 0.25$

$X_{H_2O} = \frac{3}{1+3} = \frac{3}{4} = 0.75$

no. of moles = $\frac{mass}{M.M}$

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

$n_{H_2O} = \frac{54}{18} = 3$

$X_{NaOH} + X_{H_2O} = 1$

Q= A solution has 46% (w/w) ethyl alcohal in water find mole fraction of ethyl alcohal.

Ans → 46 g of C_2H_5OH is present in 100g of Solⁿ.

Solution = Solute + Solvent
" = C_2H_5OH + H_2O
100 g = 46 + 54 g.

$n_{C_2H_5OH} = \frac{46}{46} = 1$

$n_{H_2O} = \frac{54}{18} = 3$

mole fraction of C_2H_5OH = $\frac{\text{no. of moles of } C_2H_5OH}{\text{Total moles}}$

$X_{C_2H_5OH} = \frac{1}{3+1} = \frac{1}{4} = 0.25$

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⑤ **PPM** → Parts per million it means mass of solute present in 10^6 parts of solution.

eg → Sugar 2ppm in solution.

it means 2g sugar is present in 10^6 g of solution.

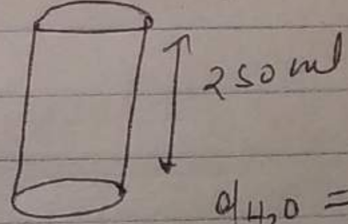
$$\text{no. of ppm} = \frac{\text{mass of Solute}}{\text{mass of sol}^n} \times 10^6$$

Q=① O_2 is dissolved in water as 8×10^{-4} g O_2 in 100 g of water find conc^n of O_2 in ppm.

Ans - $$\text{no. of ppm} = \frac{\text{mass of Solute}}{\text{mass of sol}^n} \times 10^6$$

$$\text{no. of ppm} = \frac{8 \times 10^{-4}\,g}{100\,g} \times 10^6 = 8\,\text{ppm}$$

Q=② Sea water contain 53 ppm of Na_2CO_3. find mass of Na_2CO_3 present in a glass of water.



Ans - $$53\,\text{ppm} = \frac{\text{mass of solute}}{\text{mass of sol}^n} \times 10^6$$

$d_{H_2O} = 1 g/ml$

$$53 = \frac{x}{250\,g} \times 10^6 = x = \frac{250 \times 53}{10^6} = 13250 \times 10^{-6}$$

$$\boxed{x = 1.32 \times 10^{-5}}$$

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PPB → Parts Per billion it means mass of solute present in 10^9 part of solution.

eg → 5 ppB NaCl.
it means 5g NaCl present in 10^9 g solution.

$$\text{no. of PPB} = \frac{\text{Mass of Solute}}{\text{Mass of Sol}^n} \times 10^9$$

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Molarity →

Molarity of solution is defined as the no. of moles of Solute dissolved per litre (or dm^3) of solution.

→ it is denoted by "M"

$$\text{Molarity (M)} = \frac{\text{no. of moles of Solute}}{\text{Vol. of Solution in litre}}$$

$$M = \frac{m \times 1000}{m\omega \times V(l)}$$

Q = ① find Molarity of 40 g NaOH in 250 ml of solⁿ ?

Ans -

$$M = \frac{m \times 1000}{m\omega \times V(l)}$$

$$M = \frac{40 \times 1000}{40 \times 250} = 4M$$

Q = ② find Molarity of 4.9 g. of H_2SO_4 in 500 cm^3 of solution ?

Ans -

$$M = \frac{m \times 1000}{m\omega \times V(l)}$$

$$M = \frac{4.9 \times 1000}{98 \times 500} = \frac{2}{20} = \frac{1}{10} = 0.1M$$

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Q=③ find the mass of Na_2CO_3 present in 100ml of 3M solⁿ.

Na_2CO_3 M.M = 106

Ans -
$$M = \frac{m \times 1000}{mw \times V(l)}$$

$$3 = \frac{x \times 1000}{106 \times 100} = x = \frac{3 \times 106}{10} = 31.8g$$

$$\boxed{x = 31.8g}$$

Q=④ find molarity
If 120 g urea (NH_2CONH_2) is dissolved in 1000 g of water find molarity if density of solⁿ is 1.12 g/ml.

Ans -
$$M = \frac{m \times 1000}{mw \times V(l)}$$

$$M = \frac{120 \times 1000}{60 \times 100}$$

$$\boxed{M = 20M}$$

solvent = 1000 g
Solute = 120 g
$d = \frac{m}{V}$ = 1120g

$1.12 = \frac{1000g}{V}$

$V = \frac{1000g}{1.12}$

$V = \frac{112000}{1.12}$

V = 100 ml

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Molarity represent as -

Molar — M=1 , 1M

Bimolar — M=2 , 2M

Semimolar — $\frac{M}{2}$, $\frac{M}{2}$

Decimolar — $\frac{1}{10}$, $\frac{M}{10}$.

centimolar — $\frac{1}{100}$ = $\frac{M}{100}$

Q=① find the mass of KOH present in 150 cm³ of semimolar aqous solⁿ ?.

Molarity of ions →

Q=① If 53 g Na_2CO_3 is dissolved in 500 ml of solⁿ find molarity of (i) Na_2CO_3 (ii) Na^+ ,(iii) CO_3^{2-}

Ans - Molarity = $\frac{m \times 1000}{M_0 \times V(l)}$

$M = \frac{53 \times 1000}{106 \times 500} = 1$

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

1M 2M 1M

molarity of Na_2CO_3 = 1M
" " Na^+ = 2M
" " CO_3^{2-} = 1M

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Q=② find molarity of $H^{\oplus}$ ions if 49 g H_2SO_4 is dissolved in 250 ml of Sol^n.

Ans -

$$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$$

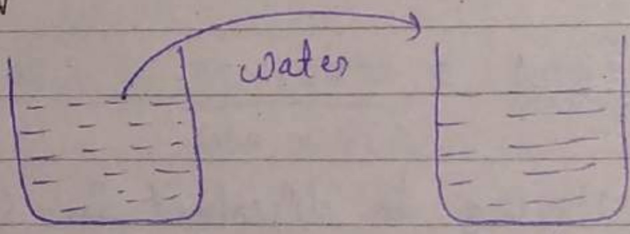
$$2M \qquad 2\times 2M \qquad 2M$$

$$M = \frac{m \times 1000}{Mw \times V(l)}$$

$$M = \frac{49 \times 1000}{98 \times 250} = 2M$$

The molarity of $H^{\oplus}$ = 4 M

Molarity of dilute solution -



$M_1 V_1$ $\qquad$ $M_2 V_2$

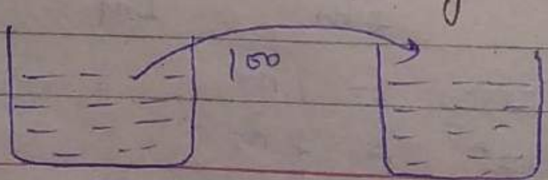
no. of moles equal than $M_1V_1 = M_2V_2$

$$M_1 V_1 = M_2 V_2$$

$M_1 = \frac{n}{V_1}$ $\qquad$ $M_2 = \frac{n}{V_2}$ $\Rightarrow$ $M_1V_1 = M_2V_2$

Q=① 0.2 M, 100 ml HNO_3 solution is dissolved $\bar{c}$ 100 ml water find new molarity.

Ans →



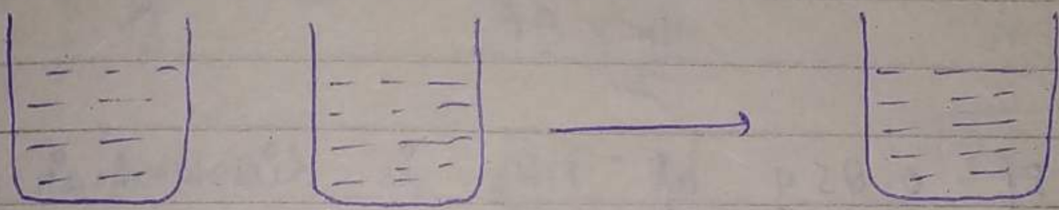
$M_1 = 0.2$
$V_1 = 100$ ml

$M_2 = ?$
$V_2 = 200$

$$M_1V_1 = M_2V_2$$

$$\frac{M_1V_1}{V_2} = M_2 \Rightarrow \frac{0.2 \times 1000}{2000} \Rightarrow \frac{1}{10} = 0.1$$

Molarity of Mixture →



M_1V_1 M_2V_2 $M_3(V_1+V_2)$

$$M_3 = \frac{M_1V_1 + M_2V_2}{(V_1 + V_2)}$$

Molality → Molality of a solution is defined as the no. of moles of the solute dissolved in 1000 g (1kg) of the solvent.

→ it is denoted by "m"

$$\text{molality}(m) = \frac{\text{no. of moles of solute}}{\text{mass of solvent in kg}}$$

$$m = \frac{M \times 1000}{mw \times (\text{mass of solvent in kg})}$$

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Q=① find molality of 20g of NaOH dissolve in 100g of Sol^n.

Ans -
$$m = \frac{M \times 1000}{m\omega \times (\text{mass of solvent in kg})}$$

$$m = \frac{20 \times 1000}{40 \times 80} = \frac{100}{} \; \frac{50}{8} = 6.2\,m$$

Q=② If 0.85g of NH_3 is dissolved in 100 ml of solution find molality. If density of Sol^n is 1.2 g/ml

Ans -
$$m = \frac{M \times 1000}{m\omega \times \text{mass of solvent in kg}} \qquad d = \frac{M}{V}$$

$$1.2 = \frac{M}{100}$$

$$m = \frac{0.85 \times 1000}{17 \times 119.15} = \frac{850}{2025.55} = 0.4 \qquad M = 120g$$

$$\boxed{m = 0.4}$$

(*)

$$\text{Equivalent Mass} = \frac{\text{Molar mass}}{\text{Valency factor}}$$

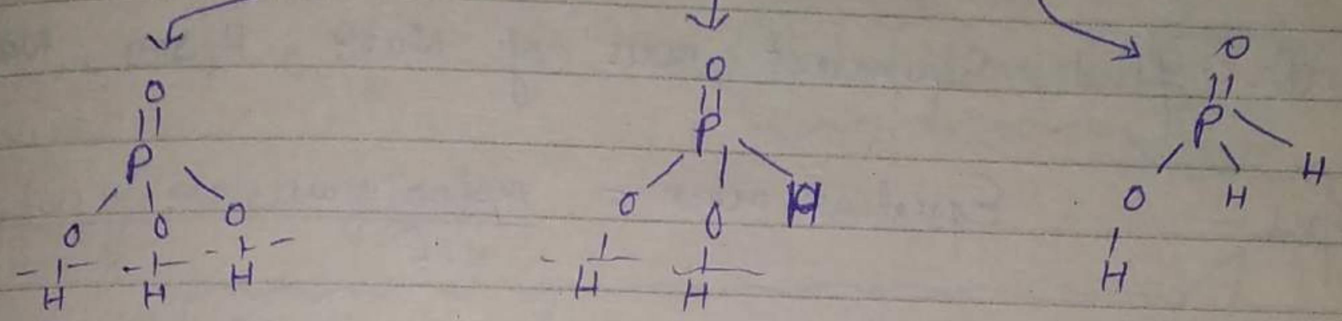
Valancy factor →

Acid →. V.F = Basicity

eg→ H_2SO_4 V.F = 2

$HCl \Rightarrow V.f = 1$

eg → V.f of H_3PO_3 , H_3PO_3 , H_3PO_2.



Valency factor = 3 $\quad$ $\boxed{V.f = 2}$ $\quad$ $\boxed{V.f = 1}$

it means valency factor in case of acid is how much H^+ ions are replacable.

~~Basicity~~ <u>Base</u> → in case of base V.f = Acidity

eg → $Ca(OH)_2 = V.f = 2$.

$Al(OH)_3 = V.f = 3$

$NaOH = V.f = 1$

<u>Salt</u> → in case of salt valency factor is total positive charge on cation / total negative charge on anion.

eg → $Na_2CO_3 \longrightarrow 2Na^+ + CO_3^{2-}$

$\boxed{V.f = 2}$

eg → $Al_2(SO_4)_3 \longrightarrow 2Al^{3+} + 3SO_4^{2-}$

$\boxed{V.f = 6}$

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eg → $MgSO_4 \longrightarrow Mg^{2+} + SO_4^{2-}$

$\boxed{V.f = 2}$

Q=① find Equvalent mass of NaOH, H_2SO_4, Na_2CO_3

Ans - Equalent mass = $\frac{\text{molar mass}}{V.f}$

(i) Eq^n mass of NaOH = $\frac{40}{1} = 40g$

(ii) Equ^n mass of H_2SO_4 = $\frac{98}{2} = 49g$

(iii) Equvalent mass of Na_2CO_3 = $\frac{106}{2} = 53g$

Equalent mass of ion = $\frac{\text{formula mass of ion}}{\text{charge on ion}}$

Equvalent mass of oxidizing/reducing agent = $\frac{M.M}{\text{No. of } e^- \text{ lost or gained by one molecule of the substance}}$

eg → $H_2SO_4 + NaOH \xrightarrow[<200°C]{} NaHSO_4 + H_2O$

$\boxed{V.f \text{ of } H_2SO_4 = 1}$

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no. of moles = $\frac{\text{mass}}{\text{Molar mass}}$

no. of gram equⁿ = $\frac{\text{mass}}{\text{Equivalent mass}}$

Equivelent mass = $\frac{M.M}{V.F}$

If no. of moles given

gram equivalent = no. of moles × V.F

Q=① find no. of gram equivalent present in 0.4g of NaOH

Ans - Equivalent mass = $\frac{40}{1}$ = 40g

gram equⁿ = $\frac{\text{mass}}{\text{Equⁿ mass}}$ = $\frac{0.4}{40}$ = $\frac{1}{100}$ = 0.01

Q=② find gram equivelent present in 53g of Na_2CO_3.

Ans - gram equivalent = $\frac{\text{mass}}{\text{Equⁿ mass}}$ = $\frac{53}{106/2}$ = $\frac{53}{53}$ = 1

Q=③ find no. of gram equivalent present in 3 moles of H_2SO_4.

Ans - when no. of moles given than use this formula

gram equⁿ = no. of moles × V.F

gram equⁿ = 3 × 2 = 6

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Q=(4) find no. of gram equivalent present in 3 mole of $AlCl_3$.

Ans → gram equivalent = no. of moles × v.f

gram equ^n = $3 \times 3 = 9$

Normality →

Normality of solution is defined as the no. of gram equivalents of the solute dissolved per litre (dm^3) of given solution.

→ it is denoted by "N"

$$\text{Normality} = \frac{\text{No. of gram equivalent of solute}}{\text{Volume of the solution in litres}}$$

→ $$\text{Normality} = \frac{\text{strength in gram per litre}}{\text{Equivalent mass of solute}}$$

$$N = \frac{m \times 1000}{\text{Equ mass} \times V(l)}$$

Q=(1) If 0.98 g of H_2SO_4 are present in 500 ml of sol^n find Normality.

Ans -
$$N = \frac{M \times 1000}{Eq^n \times V(l)}$$

$$Eq^n = \frac{m.m}{v.f}$$

$$N = \frac{0.98 \times 1000}{49 \times 500} \quad \frac{4}{100} = 0.04$$

$$Eq^n = \frac{98}{2} \; 49$$

$$\boxed{N = 0.04}$$

(*) Normality also represents as -

Normal $\rightarrow 1 \rightarrow 1N$

Binormal $\rightarrow 2 \rightarrow 2N$

Semimolar $\rightarrow \frac{1}{2} \rightarrow \frac{N}{2}$

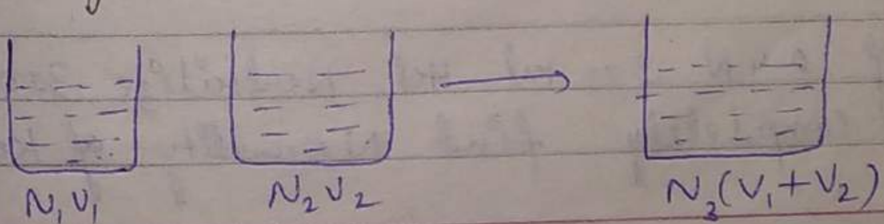
Decimolar $\rightarrow \frac{1}{10} \rightarrow \frac{N}{10}$

Centimolar $\rightarrow \frac{1}{100} \rightarrow \frac{N}{100}$

* Relation b/w Normality & molarity -

Normality = molarity × V.F

Normality of mixture -



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Acid + Acid → mixture
Base + Base → mixture

$$N_3 = \frac{N_1V_1 + N_2V_2}{V_1 + V_2}$$

Imp

(*) Acid + Base → mixture

→ If $N_aV_a > N_bV_b$

$$N = \frac{N_aV_a - N_bV_b}{(V_a + V_b)}$$

→ If $N_bV_b > N_aV_a$ then –

$$N = \frac{N_bV_b - N_aV_a}{V_a + V_b}$$

Q = ① find normality of 0.4 M H_3PO_4 solution ?

Ans → Normality = Molarity × v.f

⇒ N = 0.4 × 3 = 1.2

N = 1.2

Q = ② If 0.4 N 500 ml HCl Neutralize 300 ml of KOH completely find Normality of KOH solⁿ.

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Ans -
$$N_aV_a = N_bV_b$$
$$N_1V_1 = N_2V_2 \rightarrow N_2 = \frac{N_1V_1}{V_2}$$
$$N_2 = \frac{0.4 \times 5\cancel{00}}{3\cancel{00}} = \frac{4.5}{30} = \frac{3}{2}$$

* **Strength** → The strength of solution is defined as the amount of the solute in grams present in one litre (or dm^3) of the solution.
→ it is expressed in g/litre (or g/dm^3)

$$\text{Strength} = \frac{\text{mass of solute in (gm)}}{\text{Vol. of Solution } (dm^3)}$$

* **Formality** - The formality of a solution is defined as the no. of gram formula masses of the solute dissolved per litre of the solution.
→ it is denoted by "F".

$$\text{Formality} = \frac{\text{gram formula mass of solute}}{\text{Vol. of solution}}$$