11.) Oxidation number:

ElMOH

Rule-1. identify atoms undergoing oxidation and reduction.

2. balance atoms, undergoing oxidation and reduction.

E 3. balance charge / oxidation number by cross multiplication.

M 4. balance all atoms of metals and non-metals except oxygen and hydrogen.

O 5. balance oxygen by adding H_2O molecule.

H 6. balance hydrogen by adding H^+.

7. if reaction carried out in basic medium then add OH^- on both the sides.

Q:- 1) $\overset{+3}{FeCl_3} + \overset{+1\ -2}{H_2S} \longrightarrow \overset{+2}{FeCl_2} + \overset{0}{S} + HCl$

→ $FeCl_3 \to FeCl_2$: red.; $H_2S \to S$: oxi.

→ $\overset{+3}{FeCl_3} \xrightarrow{3-2=1} \overset{+2}{FeCl_2}$ (gap) red. 1 × 2

$\overset{-2}{H_2S} \xrightarrow{-2+0=-2} \overset{0}{S}$ (gap) ox. 2 × 1

ans:- $2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + S + 2HCl$

II) $\overset{+4}{MnO_2} + 2\overset{-1}{HCl} \longrightarrow \overset{+2}{MnCl_2} + \overset{0}{Cl_2} + H_2O$

→ $HCl \to Cl_2$: ox. 2; $MnO_2 \to MnCl_2$: red. 2

(ox = red = 2) (no ×).

(E)

- $MnO_2 + 2HCl \longrightarrow MnCl_2 + Cl_2 + H_2O$. Don't consider — bad wo koo bana raha hai

PAGE NO.:

(bal. Cl)

(M) - $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2$

(O) - ∴ $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$

III) $\overset{0}{Cu} + H\overset{+5}{N}O_3 \longrightarrow \overset{+2}{Cu}(NO_3)_2 + \overset{+4}{N}O_2 + H_2O$

→ ox. 2

red. 1

$\Rightarrow Cu + 2HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2$

(E) (M)

(O) $\Rightarrow Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Q∴(b) $\overset{+1}{K_2}\overset{+6}{Cr_2}\overset{-2}{O_7} + \overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{+1}{K}Cl + \overset{+3}{Cr}Cl_3 + \overset{0}{Cl_2} + H_2O$

⇒ red. 3

ox. 1

$\Rightarrow K_2\overset{+6}{Cr_2}O_7 + 2HCl \longrightarrow KCl + 2CrCl_3 + Cl_2$

ox. 1×3

red. 3×1

∴ red×1. ox×3

(E) (M) $K_2Cr_2O_7 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 3Cl_2 + 7H_2O$

Eq. wt of $K_2Cr_2O_7 = \frac{\text{Mol. wt}}{n\text{fact}} \longrightarrow \frac{294}{6} = 147$ ~~294~~ [49]

Normality (N):

- $$N = \frac{\text{gm. equivalent of solute}}{\text{vol. of solution (ltr)}}$$

$$N = \frac{\text{wt. of solute (gm)}}{\text{equi. of wt} \times \text{vol. of sol}^n \text{ (ltr)}}$$

⟹ Relation between N and M:

$$N = M \times n\text{-factor}.$$

⟹ Dilution of solution:

$$N_1V_1 = N_2V_2.$$

⟹ Neutralisation:

$$N_1V_1 - N_2V_2 = N_3V_3.$$

Equivalent weight of molecule:

$$\text{Eq. wt} = \frac{\text{mol. wt.}}{n \text{ factor}}$$

n factor:

(A) of acid: basis of oxo acid structure.

(B) of base:

(C) of salt: equals to total +ve or total -ve charge.

Salt	N factor.
$NaCl$	1
$CaCl_2$	2
$AlCl_3$	3
Mohr salt ↓	
$FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$	4

Eq. wt of element in a molecule:

1. eq. wt of metal hydride = $\frac{\text{wt. of metal}}{\text{wt. of hydrogen}} \times 1$

as H^{+1} ∴ $\frac{1}{+1} \rightarrow 1$

2. eq. wt of metal oxide = $\frac{\text{wt. of metal}}{\text{wt. of oxygen}} \times 8$

as O^{-2} ∴ $\frac{16}{2} \rightarrow 8$.

3. eq. wt of metal chloride = $\frac{\text{wt. of metal}}{\text{wt. of chlorine}} \times 35.5$

as Cl^{-1} ∴ $\frac{35.5}{1} \rightarrow 35.5$.

Q:11 0.71gm chlorine combined with certain weight of a metal. Given 1.11gm of metal chloride. Find eq. wt of metal.

wt of metal = 1.11 − 0.71
= 0.40

$\Rightarrow$ $eq.wt = \frac{m}{Cl} \times 35.5$.

$eq.wt = \frac{0.40 \times 100}{71 \times 10} \times 355$

$eq.wt = \boxed{20}$

n factor in redox reaction:

- total change of oxidation number of a molecule during redox reaction.

eg: 1) $\overset{+7}{KMnO_4} \xrightarrow{H^+} Mn^{+2}$ (acidic medium)

$1(7-2) = 5$; n factor = 5. eq. wt $= \frac{M}{5}$

II) $\overset{+7}{KMnO_4} \xrightarrow{H^+} \overset{+4}{MnO_2}$ (neutral condition)

$1(7-4) = 3$; n factor = 3 eq. wt $= \frac{M}{3}$.

III) $\overset{+7}{KMnO_4} \xrightarrow{OH^-} \overset{+6}{K_2MnO_4}$

$1(7-6) = 1$; n factor = 1 eq. wt $= \frac{M}{1}$

IV) $\overset{+6}{K_2Cr_2O_7} \xrightarrow{H^+} Cr^{+3}$

$2(6-3) = 6$; n factor = 6 eq. wt $= \frac{M}{6}$.

Q:12 $\overset{+4}{SO_2} + O_3 \longrightarrow \overset{+6}{SO_3} + O_2$

→ $n = +2$ ∴ eq. wt = 1/2 of mol. wt.

Q:13 $NaOH + H_3\overset{+5}{P}O_4 \longrightarrow NaH_2\overset{+5}{P}O_4 + H_2O$

→ no change in oxi.

∴ 31
3
64
|98|

N factor in disproportionate redox:

$$n\ factor = \frac{n_1 \times n_2}{n_1 + n_2}$$

oxi. (n_1)

eg: $3Br_2 + 6OH^- \longrightarrow 5Br^- + BrO_3^- + 3H_2O$

red. (n_2)

$\Rightarrow$ $n_1 = 2(1-0) \longrightarrow \underline{2}$. $n_2 = 2(5-0) \longrightarrow \underline{10}$.

$$n\ fact = \frac{2 \times 10}{2+10} \rightarrow \frac{20}{12} = \boxed{\frac{5}{3}}$$

Q.14 find N-factor:

(a) $C_2O_4^{2-} \longrightarrow CO_2$ (b) $FeSO_4 \longrightarrow Fe_2(SO_4)_3$

(c) $As_2O_3 \longrightarrow AsO_4^{-3}$ (d) $AsO_3^{-3} \longrightarrow AsO_4^{3-}$

(e) $H_2S \longrightarrow S$

$\Rightarrow$ (a) $C_2O_4^{2-} \longrightarrow CO_2$ n factor $= \underline{2}(4-3)$
(-2) (0) $= \underline{2}$.

(b) $\overset{+2}{Fe}SO_4 \longrightarrow \overset{+3}{Fe_2}(SO_4)_3$ n factor $= 1((+3)-(+2))$
$(0)(+2)$ $(+3)(0)$ $= \underline{1}$.

(c) $\overset{+3}{As_2}O_3 \longrightarrow \overset{+5}{As}O_4^{-3}$ n factor $= \underline{2}(5-3)$
(0) $(-3)-(+8)$ $= \underline{4}$.
$= (+3)$ $= \underline{+5}$

(d) $\overset{+6}{AsO_3^{-3}} \longrightarrow \overset{+8}{AsO_4^{3-}}$ n factor = (5-3) = **2**

(-3) (-3)

(-3)-(+6) (-3)-(+8)

= +3 = +5

(e) $H_2\overset{-2}{S} \longrightarrow S$ n factor = (2-0) = **2**

(0) (0)

⟹ $\overset{+2}{Fe}[\overset{+8}{C_2}\overset{-2}{O_4}] \longrightarrow Fe^{+3} + C_2O_4^{-2}$ (ferrous oxalate)

oxi

= $Fe^{+2} \longrightarrow Fe^{+3}$ n fact = 1

(3-2)

⟹ $\overset{+2}{Fe}\overset{+3}{C_2}\overset{-2}{O_4} \longrightarrow Fe^{+3} + \overset{+4}{CO_2}$

n = 1 oxi

2(4-3) = **2**

∴ eq. wt = $\frac{M}{3}$

(n = 1+2)

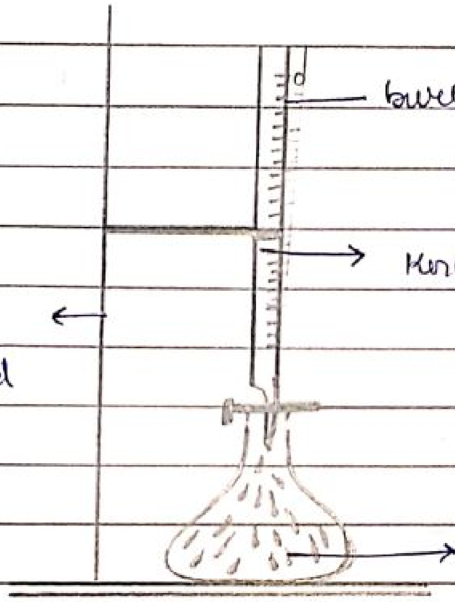
Titration:

1.)- for volumetric analysis, titration is carried out in chemical labs

2.)- by volumetric analysis, estimate the concentration of unknown solution.

PAGE NO.:

3.) - non-concentration solution (titrante) will be added by using burette till its gram equivalent will be equal to unknown concentration solution (titrate)



→ gram equivalent of Titrante = gram equivalent of Titrate

- $[\text{Mole} \times n \text{ factor}]_{\text{Titrante}} = [\text{Mole} \times n \text{ factor}]_{\text{titrate}}$

$[M = \text{mole}/\text{vol. (ltr)} \; ; \; N = \text{gm equiv}/\text{vol. (ltr)}]$

Types of titration: (redox) (iodimetric) (iodometric). (acid-base).

1.) Redox titration:

- when titration carried out between oxidising reagent or reducing reagent, are known as Redox titration.

PAGE NO.:

Q.15 find no. of moles of $KMnO_4$, required to react with one mole of sulphite ion (SO_3^{2-}) in acidic medium.

→ $KMnO_4 \rightarrow MnO_4^-$

∴ $\overset{+7}{Mn}O_4^- + \overset{+4}{S}O_3^{2-} \longrightarrow Mn^{+2} + \overset{+6}{S}O_4^{2-}$

$n = (7-2) \rightarrow \underline{5}$

$n = (6-4) \rightarrow \underline{2}$.

⟹ $(\text{Mole} \times n)_{KMnO_4} = (\text{Mole} \times n)_{SO_3^{2-}}$

→ $(x \times 5) = (1 \times 2)$.

$x = \frac{2}{5} \longrightarrow \underline{0.4\text{ mole } KMnO_4}$.

Q.16 3 mole mixture of ferrous sulphate ($FeSO_4$) and ferric sulphate ($Fe_2(SO_4)_3$) require 100 ml of 2 molar ($KMnO_4$) in acidic medium. Find mole of $FeSO_4$ in mixture.

→ $\overset{+7}{Mn}O_4^- + \overset{+2}{Fe}SO_4 + \overset{+3}{Fe_2}(SO_4)_3 \longrightarrow Mn^{+2} + Fe^{+3}$

(already last stage O.N so not...)

$\underline{n = 5}$

$\underline{n = 1}$.

⟹ molarity = $\frac{\text{mole}}{\text{vol.}}$ ∴ mole = $\frac{2 \times 100}{1000}$ = 0.2 mole.

∴ $(\text{mole} \times N)_{KMnO_4} = (\text{mole} \times N)_{FeSO_4}$

$\frac{(20 \times 5)}{100} = (\text{mole} \times 1)$.

$\underline{\text{mole} = 1\text{m}}$

PAGE NO.

Q:17 find mole fraction of $Fe_2(SO_4)_3$.

→ mole $Fe_2(SO_4)_3$ = 3-1 ($FeSO_4$)
= 2 mole

$X_{Fe_2(SO_4)_3} = \frac{2}{3}$

11.) Iodimetric titration:

- when direct estimation of reducing agent is carried out with non-concentration iodine solution is called Iodimetric titration.

- it is single-step process or the number of redox reaction is one.

- here, iodine will reduce.

$\Rightarrow \overset{0}{I_2} + Na_2S_2O_3 \longrightarrow \overset{+1\ -1}{NaI} + Na_2S_4O_6$.

[sod. thio sulphate]

[hypo. solution]

or

$\Rightarrow \overset{0}{I_2} + \overset{+2}{S_2}O_3^{-2} \longrightarrow I^- + S_4O_6^{-2}$

(mild oxiding agent) (reducing agent).

→ gram equivalent of I_2 solution = gram equivalent of Hypo solution.

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PAGE NO.:

Q.18 find weight of (I_2) molecule present in a 100 ml of 0.2 N hypo solution. $I = 127$ (126.90)

→ formula: $M \times n = M \times n$.

∴ of I_2 soln = of hypo soln.

$$\overset{0}{I_2} + Na_2\overset{2}{S_2}O_3 \longrightarrow NaI + Na_2\overset{2.5}{S_4}O_6$$

$n = 1 \times 2 = 2$.

→ $N = \frac{gm\ eq.}{V(ml)} \times 10^3$ $\qquad \frac{100 \times 0.2}{10^3} = gm$

gm eq = 0.02

∴ mole $I_2 \times n = 0.02$

mole × ~~2~~ = ~~0.02~~

mole = 0.01.

∴ mole = $\frac{gm}{mol.m}$ $\qquad 0.01 = \frac{x}{254}$

∴ **2.54**

III.) Iodometric titration:

- this method is used for measuring the concentration of oxidising reagent.
- it is a two-step process.
- here, initially Iodine is oxidised then reduced by reducing agent.

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- unlike iodimetric titration it is indirect titration method.

⟹ $\overset{+5}{KMnO_4} + \overset{-1}{KI} \longrightarrow \overset{0}{I_2} + Mn^{+2}$ (step-1)

(O.A)

$KI \rightarrow I_2$: oxidised

$KMnO_4 \rightarrow Mn^{+2}$: reduced.

⟹ $\overset{0}{I_2} + Na_2S_2O_3 \longrightarrow \overset{-1}{NaI} + Na_2S_4O_6$. (step-II)

(R.A)

$I_2 \rightarrow NaI$: reduce

$Na_2S_2O_3 \rightarrow Na_2S_4O_6$: oxidise

⟹ step-1 iodine is totally consumed in step-II.

⟹ mole of iodine in step-1 is equal to mole of iodine in step-II.

[Mole I_2 (step-1) = Mole I_2 (step-II)]

⟹ n-factor of iodine in step-1 and in step-II may be equal or unequal.

case 1 :- n-factor of iodine equal.

⟶ $[\text{gm.eq of O.A}]_{S-1} = [\text{gm.eq of R.A}]_{S-2}$

PAGE NO.

Q:19 • 50ml $KMnO_4$ solution mixed with excess of NaI solution in acidic medium.

• Liberated I_2 require 200ml of 0.25M hypo solution for titration completion.

→ find molarity of $KMnO_4$.

$\Rightarrow$ $\overset{+7}{KMnO_4}$ (O.A) + $\overset{-1}{NaI}$ ⟶ $\overset{0}{I_2}$ + Mn^{2+}

n = 1×2 = 2.

$\Rightarrow$ $\overset{0}{I_2}$ + $Na_2\overset{2}{S_2}O_3$ (R.A) ⟶ $\overset{-1}{NaI}$ + $Na_2\overset{2.5}{S_4}O_6$.

n = 1×2 = 2.

0.5×2.

→ n = same:

$\Rightarrow$ gm. eq of OA = gm. eq of RA.

mole × 5 = 0.05 × 1

$\Rightarrow$ RA ⇒ molarity = $\frac{NA}{vol.}$ $0.25 = \frac{x}{200} \times 1000$

$mole = \frac{50}{1000} = \underline{0.05\ mole}.$

also, mole $KMnO_4$ = $\frac{0.05}{5}$ $\underline{0.01}$

So, $M = \frac{0.01}{\frac{50}{1000}}$ ⟶ $\frac{1}{100} \times \frac{100}{5}$

$\boxed{= 0.2\ M}$ $KMnO_4$

PAGE NO.

Iodometric	Iodimetric
- indirect titration method.	- direct titration method
- total no. of redox rxn is 2	- total no. of redox rxn is 1.
- here, initially I_2 will oxidise and then reduce	- here, I_2 will reduce.
- method used for estimation of O.A	- method used for estimation of R.A.

Case 3 II :- n-factor of iodine is different

eg: ⟶ $\overset{+3}{C_2O_4^{-2}} + \overset{+5}{IO_3^-} \longrightarrow \overset{0}{I_2} + \overset{+4}{CO_2}$ n fact = 2(5) = 10.

R.A O.A

$\overset{0}{I_2} + \overset{+2}{Na_2S_2O_3} \longrightarrow \overset{-1}{I^-} + \overset{2.5}{S_4O_6^{-2}}$ n fact = 1(2) = 2

O.A R.A (0.5)×2 = 1

$\therefore$, $[\text{gm eq. of } I_2]_{S-2} = [\text{gm eq. of hypo sol}^n]_{S-2}$

mole of I_2 = $\dfrac{\text{mole of hypo sol}^n \times \text{n factor of hypo}}{\text{n factor of } I_2 \text{ sol}^n}$

(Step 2) (Step 2)

for eg: Solve

⟹ mole I_2 = $\dfrac{\text{mole hypo} \times 1}{2}$ —— eq(1)

mole × n fact. mole × n fact

$\therefore$, $[\text{gm eq. of } C_2O_4^{-2}]_{S-1} = [\text{gm eq. of } IO_3^-]_{S-1}$

$[\text{mole} \times \text{n factor}]_{C_2O_4^{2-}} = [\text{mole} \times \text{n factor}]_{IO_3^- / I_2}$

$$(mole \times 2)_{C_2O_4^{-2}} = (mole \times 5)_{IO_3^-}$$

Q:20 Potassium iodate reacts to excess of KI in acidic medium. The liberated I treated with $Na_2S_2O_3$ (1ml and 1M). Find gm. eq. of KIO_3 in solution

→

$$\overset{+5}{KIO_3} + \overset{-1}{KI} \longrightarrow \overset{0}{I_2}$$

O.A R.A

$$\overset{0}{I_2} + Na_2\overset{2}{S_2}O_3 \longrightarrow Na_2\overset{2.5}{S_4}O_6 + Na\overset{-1}{I}$$

n-fact = 2(1) = 2

→ $n_1 = 5(2)$ $n_2 = -1(2)$ $Na_2S_2O_3 = n = 0.5(2) = 1$

$$\frac{n_1 \times n_2}{n_1 + n_2} \Longrightarrow \frac{10 \times 2}{10+2} = \frac{20}{12} = \frac{5}{3}$$

⟹ (gm eq. of I_2) = (gm eq. $Na_2S_2O_3$)

S-1. mole × 2 = mole × 1

$$mole\ I_2 = \frac{mole\ Na_2S_2O_3}{2}$$

⟹ $M = \frac{n}{V}$ ∴ $n = \frac{1 \times 1}{1000} = 0.001$ mole $(Na_2S_2O_3)$.

$$\therefore mole\ I_2 = \frac{0.001}{2}.$$

now,

S-2 ⟹ (gm. eq of KIO_3) = (gm. eq. of I_2)

$$mole \times 5 = \frac{0.001}{2} \times \frac{5}{3}$$

mole of KIO_3 = $\frac{0.001}{2} \times \frac{8}{3} \times \frac{1}{8}$

$= \frac{10^{-3}}{6}$

$\therefore$ gm. eq. of KIO_3 = $(5) \times \frac{10^{-3}}{6}$

$\longrightarrow$ $\boxed{\frac{15}{6} \times 10^{-3}}$

Volume strength (V):

- volume strength concentration term used only for H_2O_2 solution. $H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$

- at STP, volume of oxygen gas produce by unit volume of H_2O_2 solution is VOLUME STRENGTH of H_2O_2 solution.

- it is calculated by:

$N = M \times n$

$(n=2)$

$M = \frac{N}{n}$

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

$\frac{N}{2} \times 11.2$

$= N \times 5.6$

$$\boxed{\text{Volume strength} = M \times 11.2}$$

$$\boxed{\text{Volume strength} = N \times 5.6}$$

$H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$

1mole, 1lit } 1M.

$\frac{22.4}{2} \times M \rightarrow 11.2 \times M$

mole at STP = 22.4 litre.

* 20V strength of H_2O_2 means 20 ltr of O_2 produce at STP by 1 ltr of H_2O_2 solution.

Q:21 Find volume strength of 2M and 2N H_2O_2 solution.
→ $V = 2 \times 11.2$ $V = 2 \times 5.6$
$= \underline{22.4V}$ $= \underline{11.2V}$

Q:22 Find % w/v of 11.2V H_2O_2.
→ $V = M \times 11.2$
$11.2 = M \times 11.2$ ∴ $\underline{M = 1M}$

now,
$M = \frac{mole}{volume}$ $1 = \frac{mole}{1 ltr.}$ ∴ $\underline{mole = 1}$,

∴ $mole = \frac{given\ mass}{molecular\ mass}$ $1 = \frac{m}{34}$. $\underline{m = 34}$.

∴ $\%\frac{w}{v}$ (vol) → $\frac{34}{1000} \times 100$ $= \underline{3.4}$

Hardness of water:

- hardness of water is due to salts of calcium and magnesium.

Temporary
- it is due to bicarbonate salts of Ca and Mg.
eg: $Ca(HCO_3)_2$; $Mg(HCO_3)_2$

Permanent
- they are except bicarbonate salts of Ca and Mg.
eg: $CaCl_2$; $CaCO_3$; $MgCl_2$; MgF_2; etc.

PAGE NO.:

→ Temporary hardness: can be removed by boiling water

→ Permanent hardness: can be removed by chemical treatments:

(a). by boiling = $2HCO_3^- \longrightarrow H_2O + CO_2 + CO_3^{2-}$

(b) by slaked lime = $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3 + 2H_2O$.

$Ca^{+2} + CO_3^{2-} \longrightarrow CaCO_3$

(c.) by washing soda = $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$.

(d) by ion exchange resin = $Na_2R + Ca^{2+} \longrightarrow CaR + 2Na^+$

(e.) by adding chelating agents like $(PO_3^-)_3$ etc.

- hardness of water is generally calculated in terms of ppm → parts per million.

hardness of water (ppm) = wt of $CaCO_3$ or (gm) wt of equivalence of $CaCO_3$ / T.wt of H_2O × 10^6

Q:23 1 ltr of water contain 1mg $CaCl_2$ and 1mg $MgCl_2$ then the total hardness of water in terms of $CaCO_3$ is ? (find in ppm). $MgCl_2 = (24)+(71) = 95$.

→ $CaCO_3 = (40)+(12)+(48) = 100$ $CaCl_2 = (40)+(71) = 111$.

$$\therefore \left[\frac{wt}{m.wt}\right]_{CaCO_3} = \left[\frac{wt}{m.wt}\right]_{CaCl_2} + \left[\frac{wt}{m.wt}\right]_{MgCl_2}.$$

$$\frac{wt}{100} = \left[\frac{1\times10^{-3}}{111}\right] + \left[\frac{1\times10^{-3}}{95}\right]$$

$$wt = 10^{-3}\left[\frac{1}{111} + \frac{1}{95}\right] \times 100$$

$$= \left[\frac{1}{111} + \frac{1}{95}\right] 10^{-1}$$

$$\therefore ppm = \frac{\left[\frac{95+111}{95 \times 111}\right] 10^{-1}}{1000} \times 10^{6}$$

$$= \frac{\left[\frac{95+111}{95 \times 111}\right] \times 10^{\not{6}\,2}}{\not{10000}} = \frac{206}{10545} \times 10^{2}$$

$$= \underline{\underline{1.9}}.$$

Q:24 1ltr of water contain: (I) $Mg(HCO_3)_2$ = 73 mg/ltr.
(II) $CaCl_2$ = 111 mg/ltr.
find (a) total water × (III) NaCl = 58.5 mg/ltr.
hardness and permanent hardness also.

wt. ⟶ $Mg(HCO_3)_2 = 146$ $CaCl_2 = 111$ $NaCl = 58.5$

$CaCO_3 = 100$

$$\left(\frac{wt}{100}\right)_{CaCO_3} = \left(\frac{\not{111} \times 10^{-3}}{\not{111}\,1}\right)_{CaCl_2} + \left(\frac{\not{73} \times 10^{-3}}{\not{146}\,2}\right)_{MgCl_2}$$

$$wt = \left[\frac{1}{1000} + \frac{\overset{0.5}{1}}{2000}\right] \times 100$$

$$T.hard. = \frac{\left[\frac{0.5+1}{2000}\right] \times 10^{-3} \times 10^{6} \times 100}{10^{3}}$$

$$= \frac{(100) \times (1.5) \times 10^{6}}{100} = \underline{150\,ppm}.$$

permanent hardness = $\frac{100 \times 10^{-3} \times 10^{6}}{10^{3}}$

= 100 ppm.

01/1/2