☆ Redox Reaction & Equivalent concept *

Redox Reaction

Reduction ← Redox Reaction → oxidation

→ Reaction in which both oxidation as well as reduction occur simultaneously is called a redox reaction.

Oxidation	Reduction
old concept	old concept
i) Gain of Oxygen	i) loss of oxygen
$Mg + \frac{1}{2}O_2 \rightarrow MgO$	$MgO \rightarrow Mg + \frac{1}{2}O_2$
ii) loss of Hydrogen	ii) gain of Hydrogen
$CH_3OH \rightarrow HCHO$	$HCHO \rightarrow CH_3OH$
new concept	new concept
iii) Loss of e^- is oxidation	iii) Gain of e^- is Reduction
$Zn \longrightarrow Zn^{2+} + 2e^-$	$Zn^{2+} + 2e^- \rightarrow Zn$
oxidation of Zn	reduction of Zn
iv) oxidation no. is increased	iv) oxidation no. is decreased.

Oxidising Agent → (Oxidant) – Those substance / species which oxidise others & reduce itself. In a redox reaction, the oxidation no. of oxidant decreases.

Reducing Agent (Reductant) – Those substance / Species which reduces others & oxidise itself. In a redox reaction, the oxidation no. of reductant increases.

eg. $\overset{0}{Zn}_{(s)} + \overset{+2}{Cu}SO_4 \longrightarrow \overset{+2}{Zn}SO_4 + \overset{0}{Cu}_{(s)}$

Zn → oxidation no. ↑ → Reducing Agent.

Cu → oxidation no. ↓ → Oxidising agent.

eg2.

Oxidation

$$\overset{+7}{MnO_4^-} + \overset{-1}{H_2O_2} \xrightarrow{H^+} \overset{+2}{Mn^{2+}} + \overset{0}{O_2}$$

Reduction

$MnO_4^- \rightarrow$ Oxidising Agent

$H_2O_2 \rightarrow$ Reducing Agent

Oxidation Number - Hypothetical charge on a ~~com~~ compound if each bond is considered as ionic.

(1) The oxidation no. of any atom in uncombined state or combined state with itself is zero.

eg. Na, Mg, Al, Zn, Cu, H_2, F_2, Cl_2 etc.

(2) The Algebric sum of oxidation no. of all atoms in a molecule ~~&~~ must be equal to net charge on molecule.

eg. (1) SO_3

$(O.S)_S + 0 - 6 = 0$

$(O.S)_S = 6$

(2) NH_4^+

$(O.S)_N + 4 = +1$

$(O.S)_N = -3$

Atom	O.N of atom	Remarks (exception)
(1) Alkali Metals (Li, Na, K, Rb, Cs)	+1	always
(2) Alkali Earth metal (Be, Mg, Ca, Sr, Ba)	+2	always

(3) Al	+3	always
(4) F	-1	always
(5) H	+1 * If attached with non-metals	-1 * in metal Hydrides eg NaH
(6) O	-2 (Normally)	Peroxide $\overset{-1}{H_2O_2}$, $\overset{-1}{Na_2O_2}$ Superoxide $\overset{-1/2}{KO_2}$ ozonides $\overset{-1/3}{KO_3}$ $\overset{+2}{OF_2}$ O_2F_2
(7) Cl, Br, I	-1	+1, +3, +5, +7 also observed $KClO_3$, $\overset{+7}{KClO_4}$
(8) Ag	+1	always

Oxidation no. of certain groups

Group	O. N of grp
F, Cl, Br, I, $(CN)_2$ (SCN)	-1
CO, NH_3, H_2O	0
CO_3, SO_4, C_2O_4	-2

Q1. find Oxidation no.

① $K_4[Fe(CN)_6]$

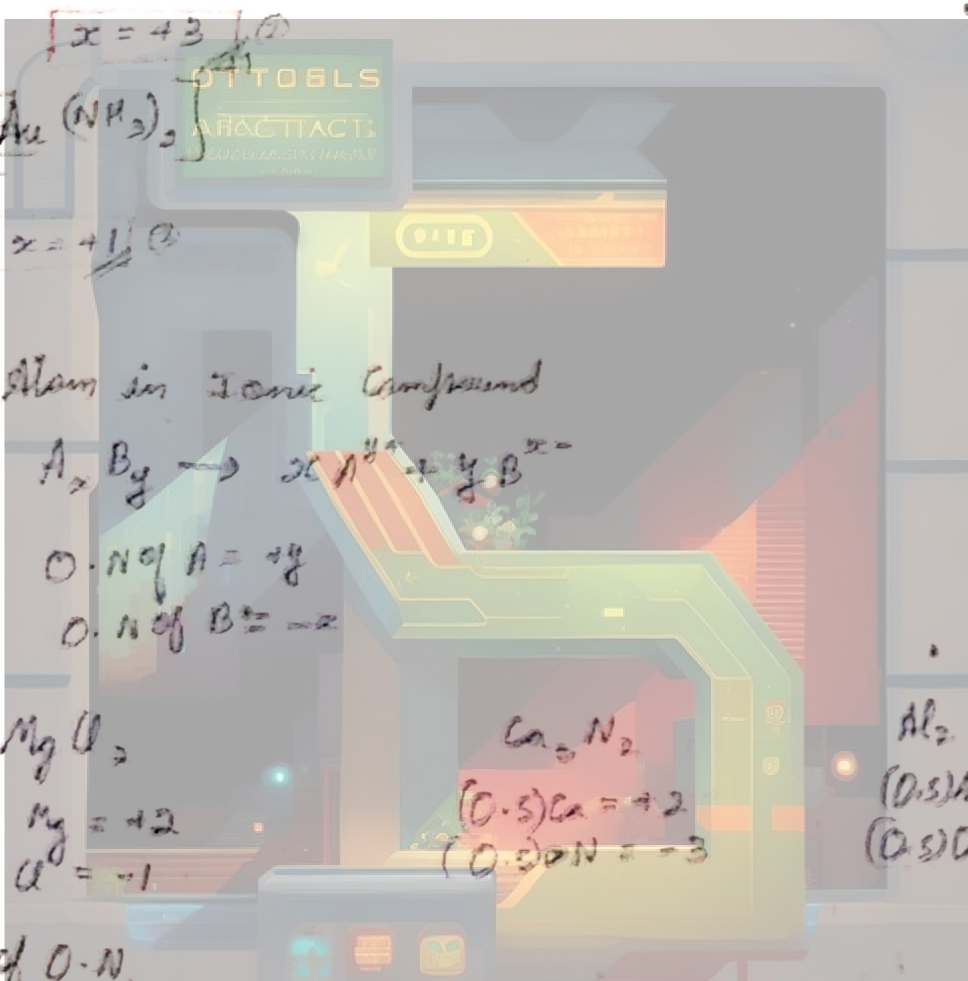
$x - 6 = -4$

$\boxed{x = +2}$ ①

② Q. $[Co(NH_3)_5 Cl]Cl_2$

$x + 0 - 1 = +2$

$\boxed{x = +3}$ ①



③ $[Ag(NH_3)_2]^{+1}$

$\boxed{x = +1}$ ①

\# O.N of Atom in Ionic Compound

A $A_x B_y \longrightarrow xA^{y+} + yB^{x-}$

O.N of A = +y

O.N of B = −x

eg.

$MgCl_2$

O.S Mg = +2

O.S Cl = −1

Ca_3N_2

(O.S)Ca = +2

(O.S)N = −3

Al_2O_3

(O.S)Al = +3

(O.S)O = −2

\# Range of O.N

for P-block non-metals

Range(O.N) = (N−8) to N

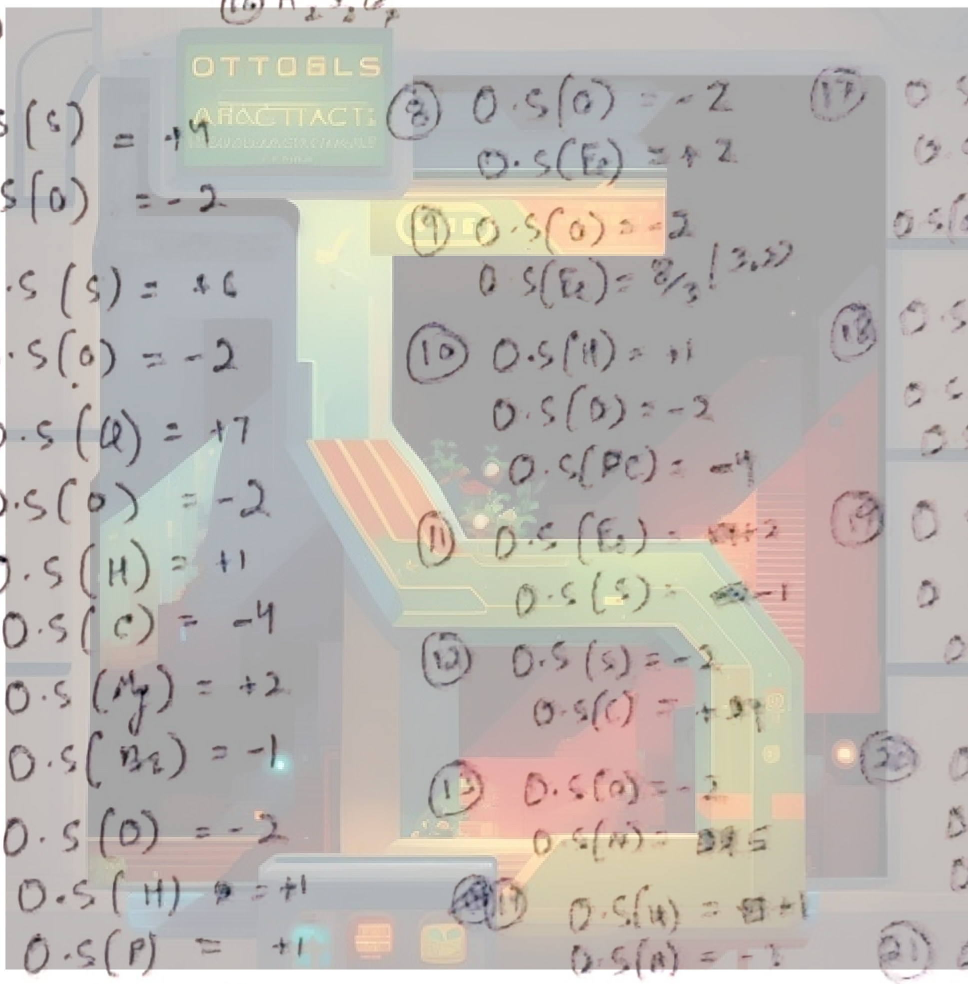
where N = no of valence e^-

B	−5 to +3
C/Si	−4 to +4
N/P	−3 to +5
S/Se/Te	−2 to +6
O	−2 to +2 (reserved)
Cl, Br, I	−1 to +7
F	0, −1

(144)

Q.2 find O.N of all atoms.

1. SO_2
2. SO_4^{2-}
3. ClO_4^-
4. CH_3MgBr
5. $H_2PO_2^-$
6. $SCN^{\ominus}$
7. $Na_2S_4O_6$
8. FeO
9. Fe_3O_4
10. C_2H_5OH
11. FeS_2
12. CS_2
13. N_2O_5
14. HCN
15. N_2O_3
16. $H_2S_2O_7$
17. $H_2S_2O_8$
18. H_2SO_5
19. $(NH_4)_2SO_4$
20. $CaOCl_2$
21. $Ba[H_2PO_2]_2$
22. ~~BaO~~ BaO_2
23. Ba_2XeO_6



(1) O.S(S) = +4
O.S(O) = −2

(2) O.S(S) = +6
O.S(O) = −2

(3) O.S(Cl) = +7
O.S(O) = −2

(4) O.S(H) = +1
O.S(C) = −4
O.S(Mg) = +2
O.S(Br) = −1

(5) O.S(O) = −2
O.S(H) = +1
O.S(P) = +1

(6) O.S(C) = +4
O.S(S) = −2
O.S(N) = −3

(7) O.S(Na) = +1
O.S(S) = +5/2
O.S(O) = −2

(8) O.S(O) = −2
O.S(Fe) = +2

(9) O.S(O) = −2
O.S(Fe) = 8/3 (3,2,2)

(10) O.S(H) = +1
O.S(O) = −2
O.S(PC) = −4

(11) O.S(Fe) = +2
O.S(S) = −1

(12) O.S(S) = −2
O.S(C) = +4

(13) O.S(O) = −2
O.S(N) = +5

(14) O.S(H) = +1
O.S(N) = −3
O.S(C) = +2

(15) O.S(O) = −2
O.S(N) = 3 (4, 2)

(16) O.S(O) = −2
O.S(S) = +6
O.S(H) = +1

(17) O.S(H) = +1
O.S(S) = +6
O.S(O) = −2, −1 = −7/4

(18) O.S(S) = +6
O.S(H) = +1
O.S(O) = −2, −1 = −8/5

(19) O.S(N) = −2
O.S(H) = +1
O.S(O) = −2
O.S(S) = 6

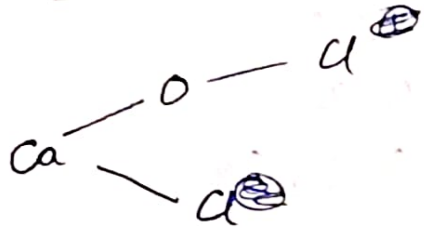
(20) O.S(O) = −2
O.S(Ca) = +2
O.S(Cl) = 0 (+1, −1)

(21) O.S(Ba) = +2
O.S(H) = +1
O.S(O) = −2
O.S(P) = +1

(22) O.S(O) = −2
O.S(Ba) = +2

(23) O.S(Ba) = +2
O.S(O) = −2
O.S(Xe) = 6

eg. $CaOCl_2$



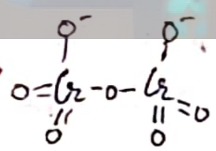
(24) $KMnO_4$
(25) MnO_2
(26) MnO_4^{2-}
(27) $K_2Cr_2O_7$
(28) Cr^{3+}
(29) $HClO_4$
(30) HCl
(31) ClO_3^-
(32) H_2SO_4
(33) H_2S
(34) SO_3
(35) SO_4^{2-}
(36) HNO_3
(37) NH_3
(38) CO_2
(39) $H_2C_2O_4$
(40) $HCHO$
(41) H_2SO_5
(42) $H_2S_4O_6$
(43) HCN
(44) HNC
(45) Cu_3P
(46) P_4S_3
(47) CrI_3
(48) PH_3
(49) $Na_2S_2O_3$
(50) $Ca_5P_3O_{12}F$
(51) $MgH_2P_2O_5$
(52) $(NH_4)_6Mo_7O_{24}$
(53) $YBa_2Cu_3O_7$
(54) $Cs_3[Re_3Cl_2]$
(55) $Ba_{1-x}K_xBiO_{3-y}$
(56) K_3CrO_8
(57) C_3O_2
(58) Br_3O_8

(24) $x-8=-1$
$\boxed{x=7}$

(25) $\boxed{x=4}$

(26) $\boxed{x=6}$

(27) $\boxed{x=6}$ →



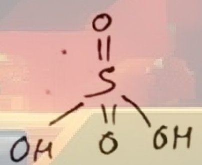
(28) $\boxed{x=3}$

(29) $Cl = 8-1$
$\boxed{x=7}$

(30) $\boxed{Cl=-1}$

(31) $\boxed{x=5}$

(32)



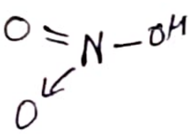
$\boxed{x=6}$

(33) H_2S
$\boxed{x=-2}$

(34) $\boxed{x=6}$

(35) $\boxed{x=6}$

(36) $\boxed{x=5}$

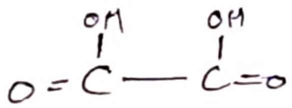


(46)

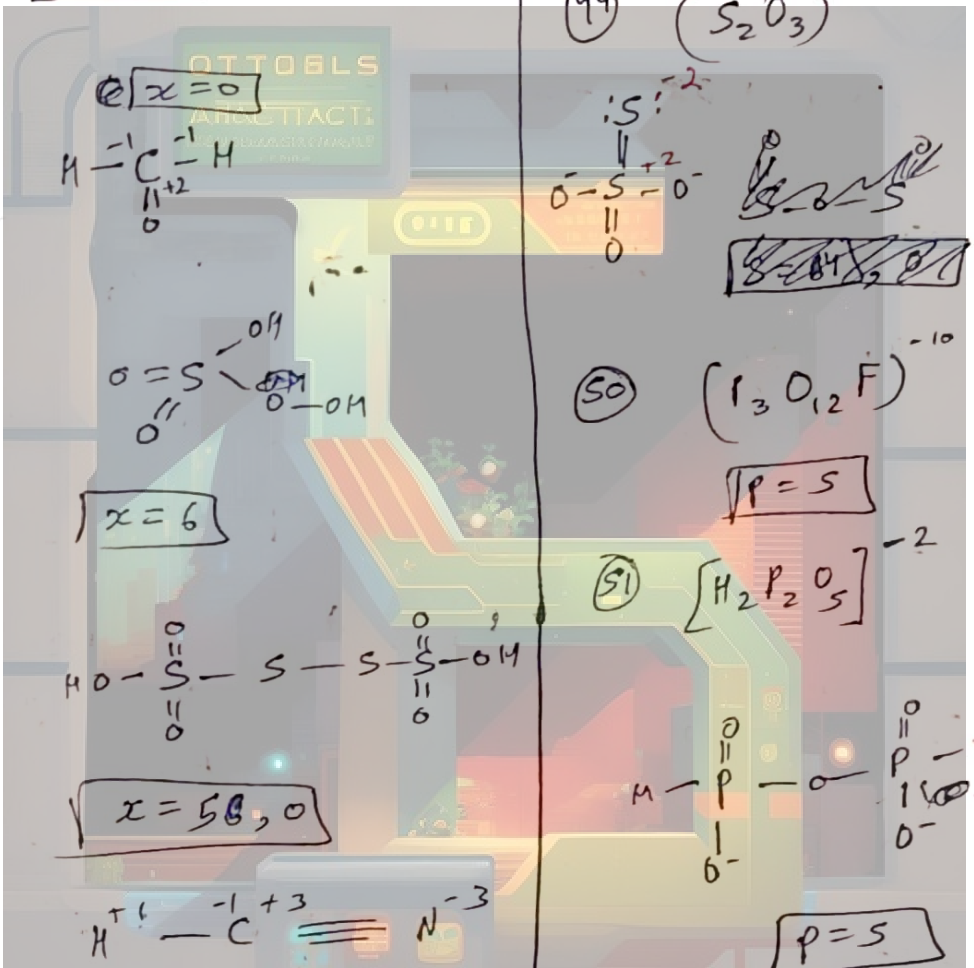
37 

$\boxed{x = -3}$

38 $\boxed{C = +4}$

39 

$\boxed{x = 3}$

40 

$\boxed{x = 0}$

41

$\boxed{x = 6}$

42

$\boxed{x = 5, 0}$

43 $H^{+1} - \overset{-1\,+3}{C} \equiv N^{-3}$

$\boxed{x = 2}$

44 $H^{+1} - \overset{-1}{N} \equiv C^{-4}$

$\boxed{x = -3}$

45 $\boxed{x = +1}$

46 $4x(-6) = 0$

$x = 3/2$

$\boxed{x = +3, +1}$

47 $\boxed{x = 3}$

48 $\boxed{P = -3}$

49 $(S_2O_3)^{-2}$

$\boxed{S = 6, -2}$

50 $(P_3O_{12}F)^{-10}$

$\boxed{P = 5}$

51 $[H_2P_2O_5]^{-2}$

$\boxed{P = 5}$

52 $[Mo_7O_{24}]^{-6}$

$7x - 48 = -6$

$7x = 42$

$\boxed{x = 6}$

(53) $3+4+3x-14=0$

$3x = 7$

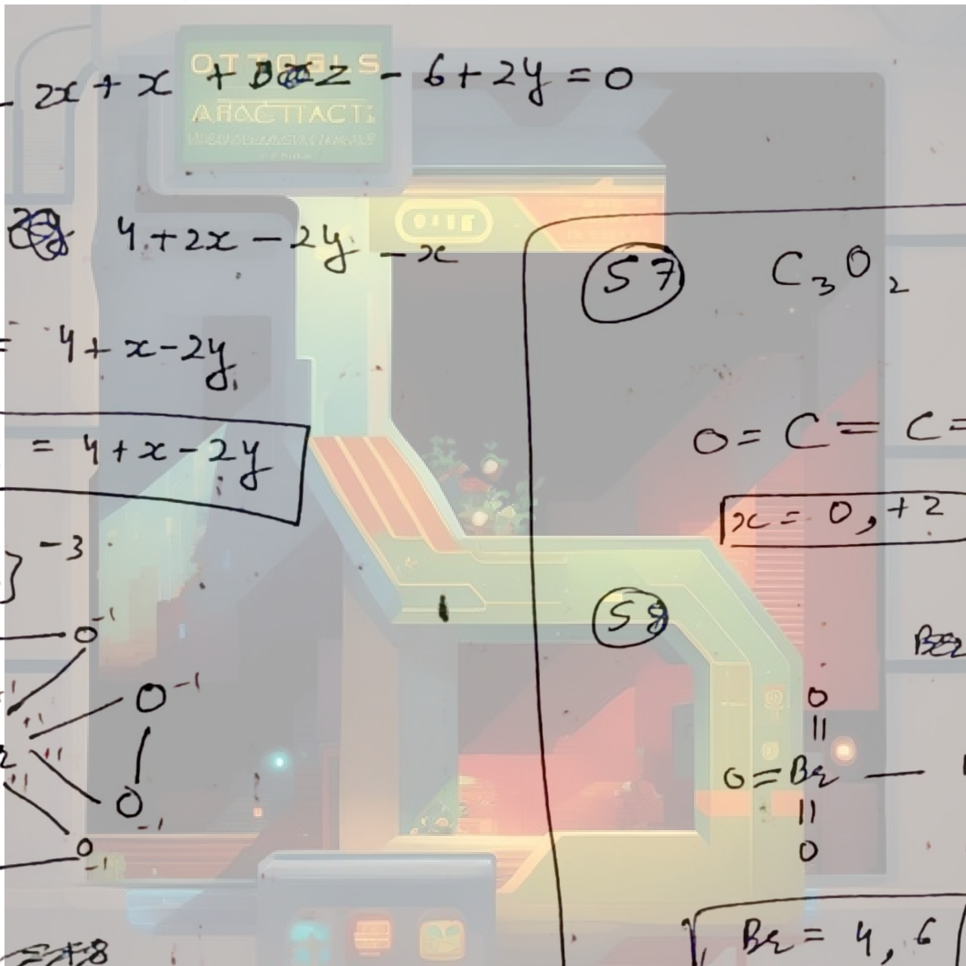
$\boxed{x = 7/3}$

(54) $[R_3 Cl_2]^{-3}$

$3x - 2 = -3$

$\boxed{x = -1/3}$

(55)



$2-2x+x+3z-6+2y=0$

$Z = \cancel{2y}\ 4+2x-2y-x$

$Z = 4+x-2y$

$\boxed{Bi = 4+x-2y}$

(56) $[CrO_8]^{-3}$

~~Cr = +8~~

$x-8=-3$

$\boxed{x=5}$

(57) C_3O_2

$O=C=C=C=O$

$\boxed{x = 0, +2}$

(58) Br_3O_8

$\boxed{Br = 4, 6}$

Types of Chemical Reaction :-

(A) Non-Redox

Oxidation no. of any element in given species do not change

Redox Reaction

Oxidation no. changes (One species is oxidised and other is reduced).

imp Types of Redox Reaction :-

(1) Disproportination Reaction (Auto Redox) :-

→ It is a kind of redox reaction in which same element (compound) undergoes oxidation as well as reduction.

→ The Oxidant and Reductant are same species.

eg. $H_2\overset{-1}{O}_2 \longrightarrow H_2\overset{-2}{O} + \frac{1}{2}\overset{0}{O}_2$

Reduction: $\overset{-1}{O} \rightarrow \overset{-2}{O}$; oxidation: $\overset{-1}{O} \rightarrow \overset{0}{O}$

Reducing Agent → H_2O_2

Oxidising Agent → H_2O_2

eg2. $\overset{0}{Cl}_2 + KOH \longrightarrow K\overset{-1}{Cl} + K\overset{+5}{Cl}O_3 + H_2O$

reduction: $\overset{0}{Cl} \rightarrow \overset{-1}{Cl}$; Oxidation: $\overset{0}{Cl} \rightarrow \overset{+5}{Cl}$

eg3. $\overset{0}{P}_4 + NaOH + H_2O \longrightarrow \overset{-3}{P}H_3 + NaH_2\overset{+1}{P}O_2$

reduction: $\overset{0}{P} \rightarrow \overset{-3}{P}$; oxidation: $\overset{0}{P} \rightarrow \overset{+1}{P}$

eg4. $\overset{0}{S_8} + NaOH \longrightarrow Na_2\overset{-2}{S} + Na_2\overset{+2}{S_2}O_3$

reduction

oxidation

eg5. $H_3\overset{+3}{P}O_3 \longrightarrow \overset{-3}{P}H_3 + H_3\overset{+5}{P}O_4$

reduction

oxidation

eg6. $\overset{+7}{Mn}O_4^- \longrightarrow \overset{+4}{Mn}O_2 + \overset{+2}{Mn}O$ (not disproportionation) ✗

reduction

reduction

② Comproportionation Reaction

→ Reverse of Disproportionation ~~reacti~~ reaction is called comproportio- comproportionation reaction.

eg. $\overset{0}{O_2} + H_2\overset{-2}{O} \longrightarrow H_2\overset{-1}{O_2}$

reduce

oxidise.

eg2. $\overset{+5}{I}O_3^- + \overset{-1}{I^-} \longrightarrow \overset{0}{I} + H_2O$

③ Intramolecular Redox Reaction

→ In such reaction, one atom of a molecule is Oxidised while another ~~atom~~ atom of same molecule is reduced.

eg. $\overset{+1}{K}\overset{+5}{Cl}\overset{-2}{O_3} \longrightarrow \overset{+1}{K}\overset{-1}{Cl} + \overset{0}{O_2}$

oxidation

reduction

~~Cl Oxidised~~ Cl - reduced

~~O →~~ O - oxidised

eg 2. $\overset{+5}{P}\overset{-1}{Cl_5} \longrightarrow \overset{+3}{P}\overset{-1}{Cl_3} + \overset{0}{Cl_2}$ P – reduced
reduced   oxidised   Cl – oxidised

→ Oxidising Agent & Reducing agent are same

Some other types of reactions

① Combination Reaction

eg. $\overset{0}{H_2} + \overset{0}{O_2} \longrightarrow \overset{+1}{H_2}\overset{-2}{O}$

eg 2. $\overset{0}{H_2} + \overset{0}{Cl_2} \longrightarrow \overset{+1}{H}\overset{-1}{Cl}$ Redox

eg 3. $\overset{+1}{H_2}\overset{-2}{O} + \overset{+6}{S}\overset{-2}{O_3} \longrightarrow \overset{+1}{H_2}\overset{+6}{S}\overset{-2}{O_4}$ ✗ not Redox.

Note :- It is not necessary that all combination reaction are redox reaction.

② Decomposition Reaction
→ Those reaction in which, compound ~~does~~ breaks into 2 or more components by the help of any kind of energy.

eg. $K\overset{+5}{Cl}\overset{-1}{O_3} \xrightarrow{\Delta} \overset{+1}{K}\overset{-1}{Cl} + \overset{0}{O_2}$

eg 2. $\overset{-2}{Ca}\overset{+1}{H_2} \xrightarrow{\Delta} \overset{0}{Ca}_{(s)} + \overset{0}{H}_{2(g)}$ Redox

eg 3. $\overset{+2}{Ca}\overset{+4}{C}\overset{-2}{O_3} \xrightarrow{\Delta} \overset{+2}{Ca}\overset{-2}{O} + \overset{+4}{C}\overset{-2}{O_2}$ / not Redox.

Note :- It is not necessary that all decomposition reaction are redox reaction.

③ Displacement Reaction

i) Metal Displacement :

eg. $\overset{0}{Zn}_{(s)} + \overset{+2}{Cu}SO_{4(aq)} \longrightarrow \overset{+2}{Zn}SO_{4(aq)} + \overset{0}{Cu}_{(s)}$ (Redox)

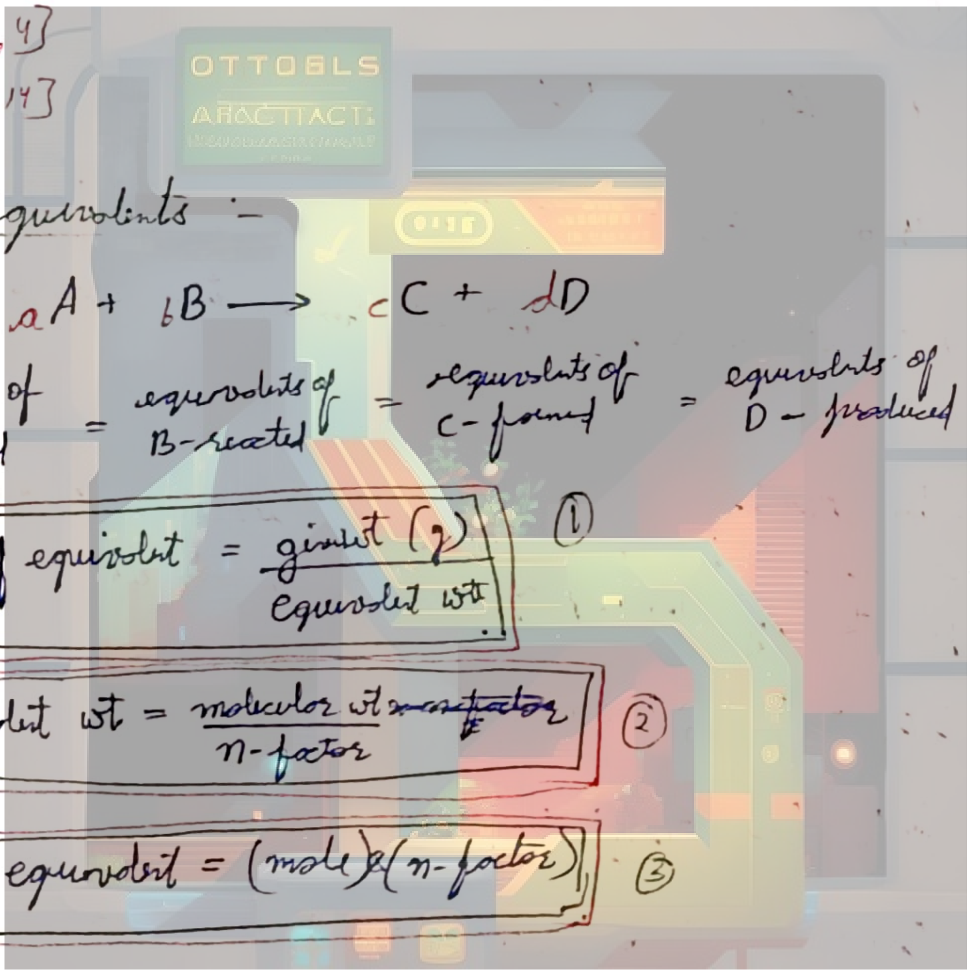
ii) Non - metal Displacement :

eg. $\overset{0}{Cl_2} + \overset{+1}{K}\overset{-1}{I} \longrightarrow \overset{+1}{K}\overset{-1}{Cl} + \overset{0}{I_2}$ (Redox)

H.W. 12-9-24

S-1 [1, 4]

O-1 [1, 14]



Law of Equivalents :-

$$aA + bB \longrightarrow cC + dD$$

equivalents of A-reacted = equivalents of B-reacted = equivalents of C-formed = equivalents of D-produced

$$\boxed{\text{no. of equivalent} = \frac{\text{given wt (g)}}{\text{equivalent wt}}} \quad ①$$

$$\boxed{\text{equivalent wt} = \frac{\text{molecular wt}\ \cancel{\text{n-factor}}}{\text{n-factor}}} \quad ②$$

$$\boxed{\text{no. of equivalent} = (\text{mole}) \times (\text{n-factor})} \quad ③$$

Normality (N):-

→ no. of equivalents of solute present in 1L solⁿ.

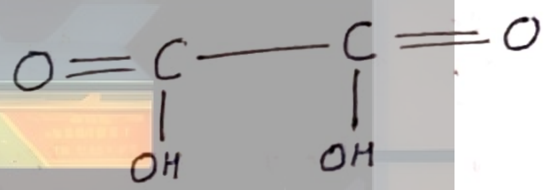
$$\boxed{N = \frac{\text{no. of equivalents}}{\text{Vol}^n \text{ of sol}^n \text{ (L)}}} \quad ④$$

$$\boxed{\text{no. of equivalents} = N \times V_{(Lit)}}$$ (5)

Normality = (Molarity)(n-factor)

$$\boxed{\text{no. of equivalents} = (M)(\text{n-factor})(V_{Lit})}$$ (6)

Q3. find the wt in g of Oxylic Acid ($H_2C_2O_4$) if Sol^n is 500 ml and 0.5 N. (Assume n-factor = Basicity)



equivalents = (0.5)(0.5)

= 0.25

n-factor = 2

moles = $\frac{0.25}{2}$

mass = $\frac{1}{8} \times 90$

$$\boxed{\text{mass} = 11.25\ g}$$

n-factor

for non-Redox:-

① Acids – n-factor is equal to the no. of replaceable H^+ ions OR Basicity.

eg. $H_2SO_4 \longrightarrow 2$

$H_3PO_4 \longrightarrow 3$

$H_3PO_3 \longrightarrow 2$

$HCl \longrightarrow 1$

$HNO_3 \longrightarrow 1$

$H_3PO_2 \longrightarrow 1$

$H_2S_2O_7 \longrightarrow 2$

$H_4P_2O_7 \longrightarrow 4$

$H_3BO_3 \longrightarrow 1$

(3) Acidic Oxide

eg. $CO_2 + H_2O \longrightarrow \cancel{Q}\, H_2CO_3$

$\downarrow$ $\qquad\qquad\qquad\qquad \downarrow$

$n\text{-}f = 2 \longleftrightarrow n\text{-}f = 2$

Same.

eg. 2. $SO_3 + H_2O \longrightarrow H_2SO_4$

$\downarrow$ $\qquad\qquad\qquad\qquad \downarrow$

$n\text{-}f = 2$ $\qquad\qquad$ $n\text{-}f = 2$

eg 3. $SO_2 + H_2O \longrightarrow H_2SO_3$

$\downarrow$ $\qquad\qquad\qquad\qquad \downarrow$

$n\text{-}f = 2$ $\qquad\qquad$ $n\text{-}f = 2$

eg 4. $N_2O_5 + H_2O \longrightarrow \cancel{2NH_3}\ 2HNO_3$

$\downarrow$ $\qquad\qquad\qquad\qquad \downarrow$

$n\text{-}f = 1(2)$ $\qquad\qquad$ $n\text{-}f = 1$

$n\text{-}f = 2$

Note:- If the reaction is given then n-factor is equal to no. of H^+ ions lost by acid molecule in a reaction.

eg. $H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$

$\downarrow$ $\quad$ 1 H^+ replaced $\quad$ equivalent wt $= \frac{98}{1} = 98$

$n\text{-}f = 1$

eg 2. $H_3PO_4 + 2NaOH \longrightarrow Na_2HPO_4 + 2H_2O$

$\downarrow$ $\quad$ 2 H^+ replaced. $\quad$ equivalent wt $= \frac{98}{2} = 49$

$n\text{-}f = 2$

eg 3. $H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O$

equivalent wt $= \frac{98}{3} = 32.66$

$\downarrow$

$n\text{-}f = 3$ $\quad$ 3 H^+ replaced.

→ Equivalent wt. of a compound is not fixed, it changes as the value of n-factor changes.

② <u>Bases</u>:- n-factor of A base is equal to the no. of OH^- ion lost by 1 molecule of a base In a reaction.

→ If base is lewis base then check for no. of L.P donated.

eg. $NaOH$ n-f = 1

$Ca(OH)_2$ n-f = 2

$Al(OH)_3$ n-f = 3

$B(OH)_3$ n-f = 1 (Basic acid)

$\ddot{N}H_3$ n-f = 1

$$\left.\begin{array}{l} CH_2 - \ddot{N}H_2 \\ \quad | \\ CH - \ddot{N}H_2 \\ \quad | \\ CH_2 - \ddot{N}H_2 \end{array}\right] \quad n\text{-}f = 3$$

N_2H_4 n-f = 2

<u>Basic Oxides</u>. -

eg. $Na_2O + H_2O \longrightarrow 2NaOH$

Na_2O: n-f = 1(2) = 2; $NaOH$: n-f = 1

eg 2. $MgO + H_2O \rightarrow Mg(OH)_2$

MgO: n-f = 2; $Mg(OH)_2$: n-f = 2

eg 3. $Al_2O_3 + 3H_2O \longrightarrow 2Al(OH)_3$

Al_2O_3: n-f = (3)(2) = 6; $Al(OH)_3$: n-f = 3

In Reactions

eg 1. $Al(OH)_3 + HCl \rightarrow AlCl(OH)_2 + H_2O$

$\hookrightarrow$ n-f = 1

eg 2. $Al(OH)_3 + 2HCl \rightarrow AlCl_2(OH) + 2H_2O$

$\hookrightarrow$ n-f = 2

eg 3. $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$

$\hookrightarrow$ n-f = 3

eg 4. $\begin{matrix} CH_2-\ddot{N}H_2 \\ | \\ CH_2-\ddot{N}H_2 \end{matrix} + HCl \longrightarrow \begin{matrix} CH_2-\overset{\oplus}{N}H_3\overset{\ominus}{Cl} \\ | \\ CH_2-\ddot{N}H_2 \end{matrix}$

$\hookrightarrow$ n-f = 1

③ **Ions:-**

n-factor on ion = |charge of ion|.

eg. Mg^{2+} n-f = 2

Cl^-, I^-, Br^- n-f = 1

PO_4^{3-} n-f = 3

SO_4^{2-} n-f = 2

eg. Equivalent wt of Al^{3+} = $\frac{M.M}{n-f}$ = $\frac{27}{3}$ = 9.

④ ionic salts :-

n-factor of ionic salt = either Total ⊕ve or |⊖ve| charge

eg. $\overset{+1\ -1}{NaCl}$ n-f = 1

$\overset{+2\ \ -2}{MgCl_2}$ n-f = 2

$\underset{+3(2)\ \ -2(3)}{Al_2O_3}$ n-f = 6

n-factor = no. of cationic ion × O.N. of cation

⑤ Element :-

n-factor = valency of element

eg. Na n-f = 1

Mg n-f = 2

Al n-f = 3

Note :- Equivalent weight of a substance = The weight of substance that combines with 8 g Oxygen.

Old Definition

eg. MgO 12 g Mg combines with 8 g O

24 : 16 Equivalent weight of Mg = 12 g

12 : 8

eg. Al_2O_3 Equivalent wt = 9

54 : 48

$54/3$: 16

$\frac{54}{6}$: 8

Q4. If x g of metal combines with oxygen to form y g metal oxide then find equivalent wt of metal

$$aM + bO \longrightarrow M_aO_b$$

x g $\qquad$ y g

$\dfrac{x}{m_a}$ mol $\qquad$ $\dfrac{y}{16b + m_a}$ mol

$$\frac{x}{a\,m_a} = \frac{y}{16b + m_a}$$

$$16bx + x\,m_a = y\,m_a$$

$$16bx = (y - x)\,m_a$$

$b \rightarrow 1/2$

$$8x = (y - x)\,m_a$$

$$2M + \frac{1}{2}O \longrightarrow M_2O_{1/2}$$

x g $\qquad$ 8 g $\qquad$ y g

$$x + 8 = y$$

Metal + Oxygen $\longrightarrow$ metal oxide

x $\qquad$ $y - x$ $\qquad$ y

$(y - x)$ g O combine with x g Metal

8 g combine with $\boxed{\dfrac{8x}{(y-x)}}$

(6) ion exchange reaction :-

n-factor = magnitude of charge displaced.

eg

$H_3PO_4 + 2NaOH \longrightarrow Na_2HPO_4 + 2H_2O$

$\downarrow$

n-f = 2

eg. $K_4[Fe(CN)_6] + Zn\,SO_4 \longrightarrow K_2Zn[Fe(CN)_6] + K_2SO_4$

n-f = 2.

(2 K ki gahah Zn ne le li , +2 charge move hua)

for Redox Reactions

→ n-factor of a substance in a redox reaction is equal to the moles of e^- lost or gained per mole of that substance.

(1) n-factor of substance undergo reduction or oxidation. (Only one atom of that substance must be undergoing change in O.N).

eg. 1. $Sn^{2+} \longrightarrow Sn^{4+}$

n-factor = 2

2. $\underset{+7}{MnO_4^-} + 3e^- \longrightarrow \underset{+4}{MnO_2}$

n-factor = 3 n-f = 3

3. $\underset{+6}{Cr_2O_7^{2-}} \longrightarrow \underset{+3}{Cr^{3+}}$ — n-f = 3

n-f = 6

e^- involvement = 6 - 3 = 3

n-f = (3×2) = 6

4. $MnO_4^- \xrightarrow{H^+} Mn^{2+}$

$+7 \qquad\qquad +2$

n-factor $= 7-2 = 5$

5. $P_4 \longrightarrow PH_3$

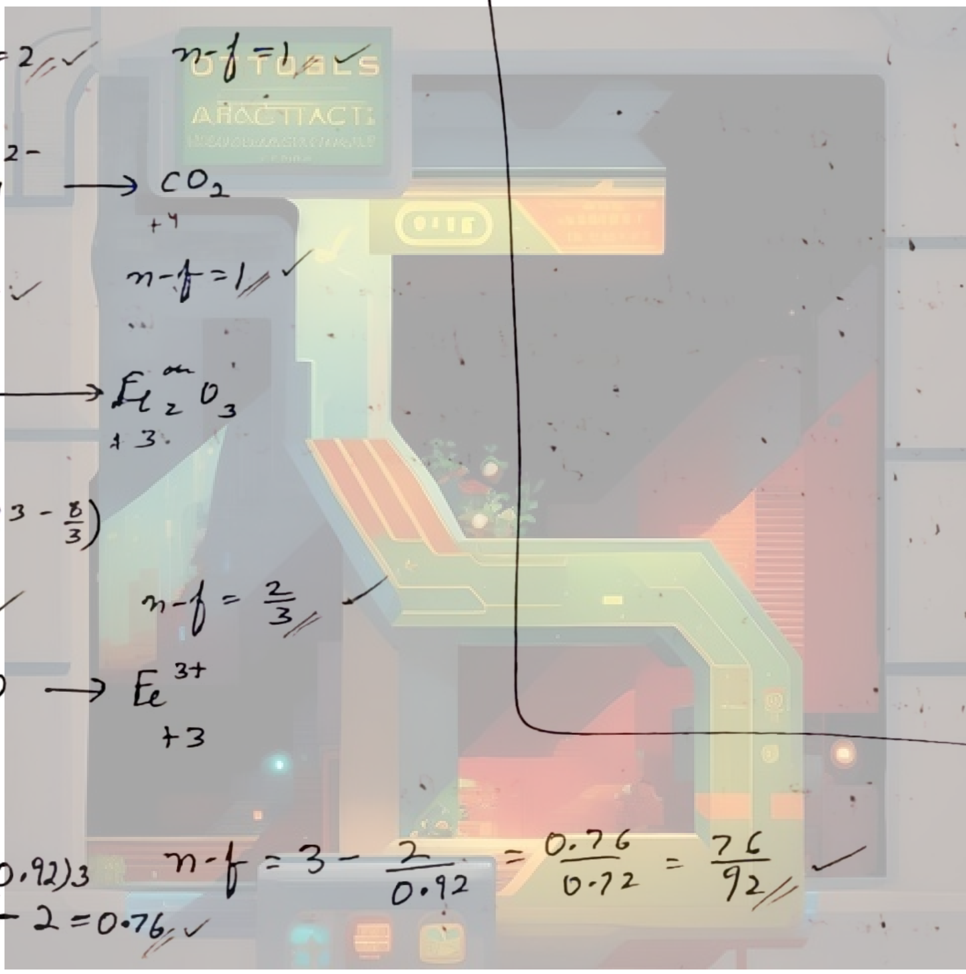
$0 \qquad\qquad -3$

n-f $= 12$ $\qquad$ n-f $= 3$

6. $I_2 \longrightarrow I^-$

$0 \qquad\qquad -1$

n-f $= 2$ $\qquad$ n-f $= 1$



7. $C_2O_4^{2-} \longrightarrow CO_2$

$+3 \qquad\qquad +4$

n-f $= 2$ $\qquad$ n-f $= 1$

8. $Fe_3O_4 \longrightarrow Fe_2O_3$

$+\frac{8}{3} \qquad\qquad +3$

n-f $= 3\left(3 - \frac{8}{3}\right)$

n-f $= 1$ $\qquad$ n-f $= \frac{2}{3}$

9. $Fe_{0.92}O \longrightarrow Fe^{3+}$

$\frac{2}{0.92} \qquad\qquad +3$

n-f $= (0.92)3 - 2 = 0.76$ $\qquad$ n-f $= 3 - \frac{2}{0.92} = \frac{0.76}{0.92} = \frac{76}{92}$

10. $Na_2S_2O_3 \longrightarrow Na_2S_4O_6$

$+2 \quad +2 \qquad\qquad +2 \quad \frac{10}{4}$

n-f $= 2.5 - 2 = 0.5$

n-f $= 1$ $\qquad$ n-f $= 2$

11. $(K_2C_2O_4 \cdot 3H_2C_2O_4 \cdot 4H_2O) \rightarrow CO_2$

$+3 \qquad\qquad +4$

n-f $= 8$ $\qquad$ n-f $= 1$

② n-factor of a substance undergoing intramolecular redox reaction

→ n-factor of such cases can be determined either by oxidation or reduction.

eg. 1. $K\overset{+5}{Cl}\overset{-2}{O_3} \rightarrow K\overset{-1}{Cl} + \overset{0}{O_2}$

n-factor $= 6$ (by Cl) $n\text{-}f(KCl) = 6$

n-factor ~~(by O)~~ $n\text{-}f(O_2) = 4$

$= (2)(3)$

$= 6$ (by O)

2. $\overset{+7}{Cl_2}\overset{-2}{O_7} \rightarrow \overset{0}{Cl_2} + \overset{0}{O_2}$

$n\text{-}f = 14$

$n\text{-}f(Cl_2) = 14$

$n\text{-}f(O_2) = 4$

3. $2\overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{0}{H_2} + \overset{0}{Cl_2}$

~~$n\text{-}f$~~ ~~$n\text{-}f(H) = 1$~~ $n\text{-}f(HCl) = 1$

~~$n\text{-}f(Cl) = 1$~~ $n\text{-}f(H_2) = 2$

~~$n\text{-}f$~~ $n\text{-}f(Cl_2) = 2$

③ n-factor of ionic compound in which both cation & anion are oxidised or reduced.

$(n\text{-factor})_{(\text{Ionic compound})} = n_1 + n_2$

$n_1 \rightarrow$ n-factor for cation

$n_2 \rightarrow$ n-factor for anion.

eg. $\overset{+1}{Cu_2}\overset{-2}{S} \rightarrow \overset{+2}{Cu} + \overset{+6}{SO_4^{2-}}$ $n_1(Cu) = 1 \times 2 = 2$

Oxidised Oxidised. $n_2(S) = 8$

n-factor $= 8 + 2 = 10$

eg2. $\overset{+1}{Cu_3}\overset{-3}{P} \longrightarrow \overset{+2}{Cu^{2+}} + \overset{+5}{PO_4^{3-}}$

$n_1 = 1 \times 3 = 3$

$n_2 = 8$

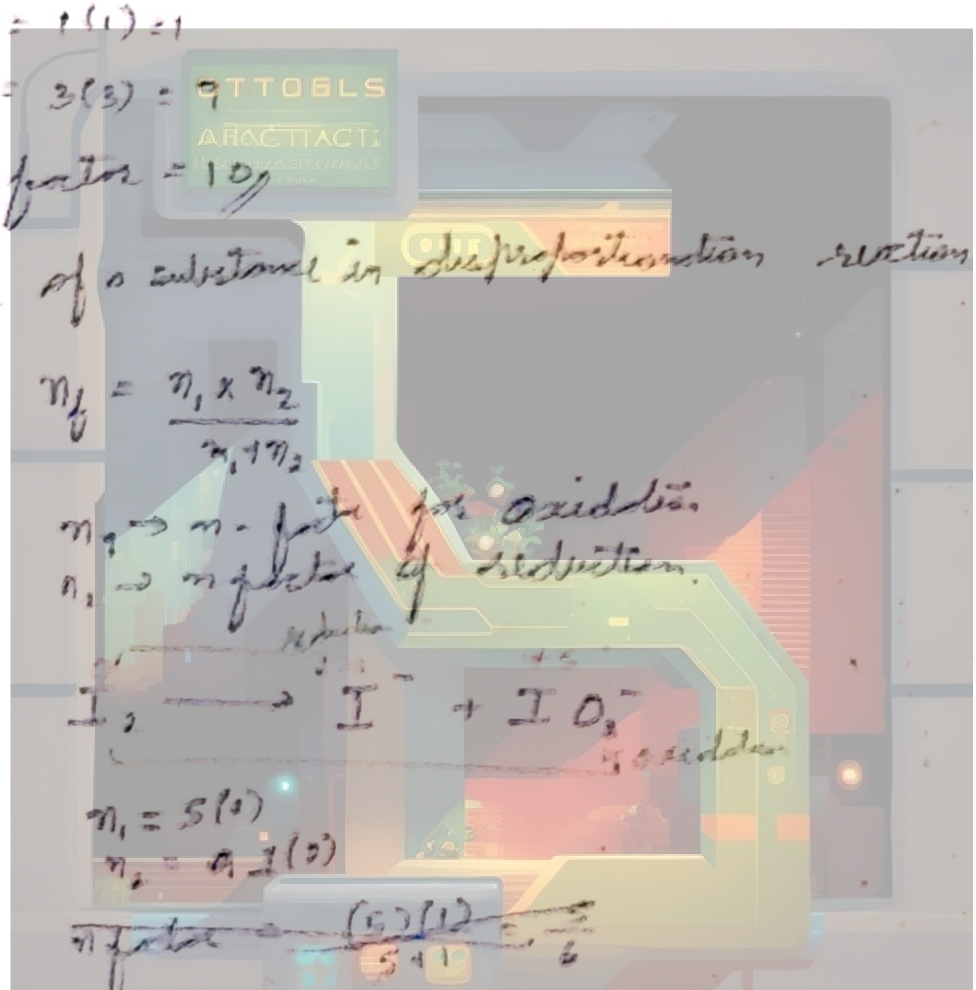
n-factor = 11

eg3. $\overset{+3}{Fe}(\overset{+5}{NO_3})_3 \longrightarrow \overset{+2}{Fe^{2+}} + \overset{+2}{NO}$

$n_1 = 1(1) = 1$

$n_2 = 3(3) = 9$

n-factor = 10



(4) n-factor of a substance in disproportionation reaction.

$$n_f = \frac{n_1 \times n_2}{n_1 + n_2}$$

$n_1 \rightarrow$ n-factor for oxidation

$n_2 \rightarrow$ n factor of reduction.

eg1. $\overset{0}{I_2} \xrightarrow{\text{reduction}} \overset{-1}{I^-} + \overset{+5}{IO_3^-}$ (oxidation)

$n_1 = 5(2)$

$n_2 = 1(2)$

~~n factor = $\frac{(5)(1)}{5+1} = \frac{5}{6}$~~

n-factor $= \frac{2(10)(2)}{12} = \frac{20}{12} = \frac{10}{6} = \frac{5}{3}$

eg2. $\overset{+1}{H_2}\overset{-1}{O_2} \longrightarrow \overset{+1}{H_2}\overset{-2}{O} + \overset{0}{O_2}$

$n_1 = 2$

$n_2 = 2$

$n = \frac{2 \times 2}{2+2} = \frac{4}{4} = 1$

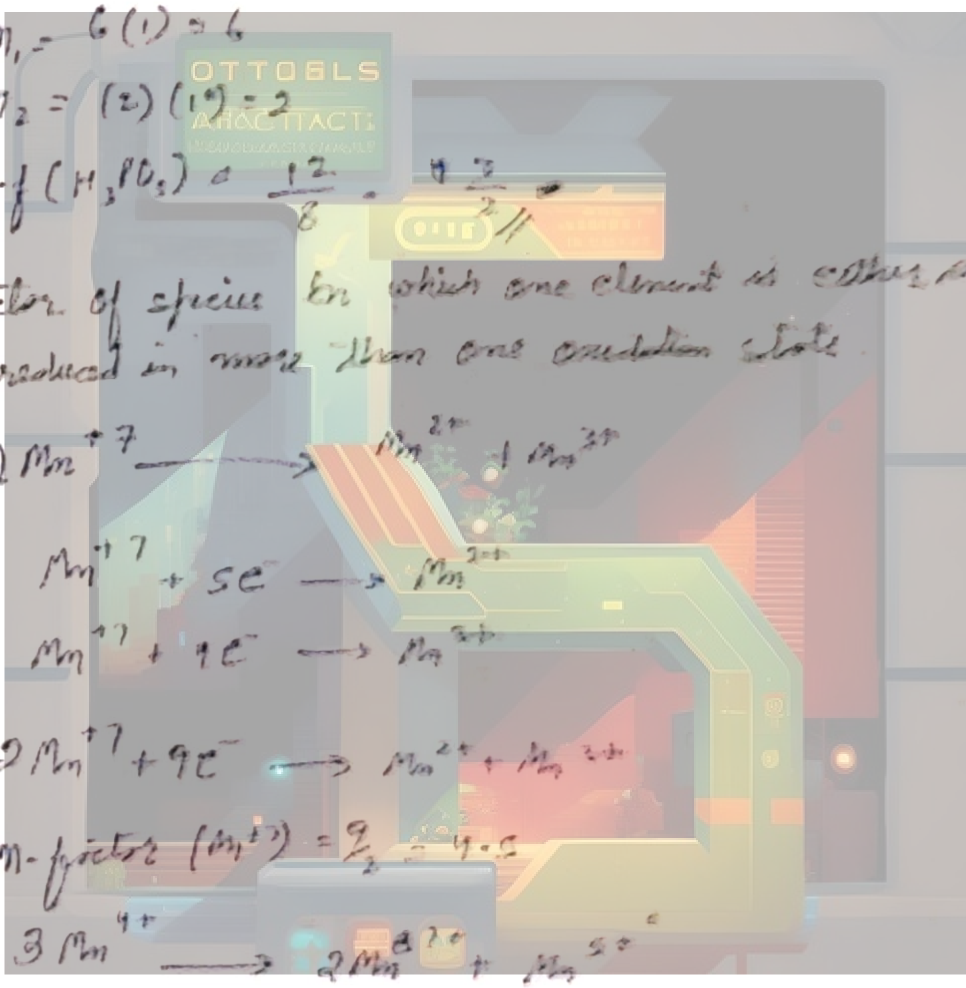
eg: $P_4 + NaOH \longrightarrow PH_3 + H_3PO_4$ (n-f of P_4)

$n_1 = 3(4) = 12$

$n_2 = 5(4) = 20$

$n\text{-}f(P_4) = \frac{20 \times 12}{20+12} = \frac{240}{32} = \frac{15}{2}$

eg 4. $H_3PO_3 \longrightarrow PH_3 + H_3PO_4$



$n_1 = 6(1) = 6$

$n_2 = (2)(1) = 2$

$n\text{-}f(H_3PO_3) = \frac{12}{8} = \frac{3}{2}$

(5) n-factor of species in which one element is either oxidised or reduced in more than one oxidation state.

eg. $2Mn^{+7} \longrightarrow Mn^{2+} + Mn^{3+}$

$Mn^{+7} + 5e^- \longrightarrow Mn^{2+}$

$Mn^{+7} + 4e^- \longrightarrow Mn^{3+}$

$2Mn^{+7} + 9e^- \longrightarrow Mn^{2+} + Mn^{3+}$

n-factor $(Mn^{+7}) = \frac{9}{2} = 4.5$

eg2. $3Mn^{4+} \longrightarrow 2Mn^{+7} + Mn^{5+}$

e^- involved $= 19 - 12 = 7$

$n\text{-}f(Mn^{4+}) = 7/3$

$n\text{-}f(Mn^{7+}) = 7/2$

$n\text{-}f(Mn^{+5}) = 7$

Q4. find equivalent wt of underlined species.

① $\underline{H_2SO_4} + NaOH \longrightarrow NaHSO_4 + H_2O$

$\downarrow$

$n\text{-}f = 1$

$eq\ wt = \frac{98}{1} = 98$

② $\underline{Na_2CO_3} + 2HCl \longrightarrow H_2CO_3 + 2NaCl$

$\downarrow$

$n\text{-}f = 2$

$eq\ wt = \frac{46+12+48}{2} = \frac{106}{2} = 53$

③ $\underline{Cu_3P} \longrightarrow Cu^{2+} + PO_4^{3-}$

$\downarrow$

~~n-f = 3~~

~~$eq\ wt = \frac{127+31}{3}$~~ ~~158~~

$n\text{-}f\,(Cu) = 3$

$n\text{-}f\,(P) = 8$

$n\text{-}f = 11$

$eq\ wt = \frac{221.5}{11}$

④ $Cl_2 \longrightarrow Cl^- + \underline{\overset{+5}{Cl}O_3^-}$

$n\text{-}f = 5$

~~$eq\ wt = \frac{35.5+48}{5} = \frac{93.5}{85} =$~~

~~$n_1 = 1$~~

~~$n_2 = 5$~~

~~$n\text{-}f = \frac{5 \times 1}{5+1} = \frac{5}{6}$~~

~~n-f~~

$eq\ wt = \frac{93.5}{5} = 16.7$

Q5. Calculate n-factor for each reactant & Product in ~~data~~ a balanced chemical reaction.

① $\overset{+1}{K_2}\overset{+6}{Cr_2}\overset{-2}{O_7} + 14\,\overset{+1}{H}\overset{-1}{Cl} \longrightarrow 2KCl + 2\overset{+3}{Cr}\overset{-1}{Cl_3} + 3\overset{0}{Cl_2} + 7H_2O$

n-f = 6, n-f = $\frac{3}{7}$, n-f = 3, n-f = 3, n-f = 2, n-f = $\frac{6}{7}$

no. of e^- involved = (3)(2) = 6

② $4\overset{0}{Zn} + 10\,\overset{+1}{H}\overset{+5}{N}\overset{-2}{O_3} \longrightarrow 4\overset{+2}{Zn}(NO_3)_2 + \overset{-3}{N}H_4NO_3 + 3\overset{+1}{H_2}\overset{-2}{O}$

2, $\frac{4}{5}$, 2, 8, $\frac{8}{3}$

no. of e^- involved = (2)(4) = 8

③ $2K\overset{+7}{Mn}O_4 + 5K_2C_2O_4 + 16HCl \longrightarrow 2\overset{+2}{Mn}Cl_2 + 10CO_2 + 12KCl + 8H_2O$

5, 2, $\frac{5}{8}$, 5, 1, $\frac{5}{6}$, $\frac{5}{4}$

no. of e^- → (5)(2) = 10

Balancing Of Redox Reaction

1. In Acidic Medium.

(A) Ion-Electron / Half Reaction method

Q6. Balance the reaction in Acidic medium.

$$Fe^{2+} + Cr_2O_7^{2-} \longrightarrow Fe^{3+} + Cr^{3+} + H_2O$$

Step 1 → Break the reaction into two half reaction.

Oxidation half — Reduction Half

$$Fe^{2+} \longrightarrow Fe^{3+} \quad [\text{Oxidation Half}]$$

$$Cr_2O_7^{2-} \longrightarrow Cr^{3+} \quad [\text{Reduction Half}]$$

Step 2- Balance other atoms except H & O.

$$Fe^{2+} \longrightarrow Fe^{3+} \quad [\text{Oxidation Half}]$$

$$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} \quad [\text{Reduction Half}]$$

Step 3- Balance O atoms by adding H_2O.

$$Fe^{2+} \longrightarrow Fe^{3+} \quad [\text{Oxidation half}]$$

$$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O \quad [\text{Reduction Half}]$$

Step-4 - Balance H atoms by adding H^+

$$Fe^{2+} \longrightarrow Fe^{3+} \quad [\text{oxidation half}]$$

$$Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 7H_2O \quad [\text{Reduction Half}]$$

Step-5 Balance Charge on both eq

$$Fe^{2+} \longrightarrow Fe^{3+} + e^- \quad (1) \quad [\text{Oxidation Half}]$$

$$\underset{(-2)}{Cr_2O_7^{2-}} + \underset{(+14)}{14H^+} + \underset{(-6)}{6e^-} \longrightarrow \underset{(+6)}{2Cr^{3+}} + 7H_2O \quad (2) \quad [\text{Reduction Half}]$$

Step-6 Multiply both half Reaction by suitable factor to remove e^-.

$$6 \times (Fe^{2+} \longrightarrow Fe^{3+} + e^-) \quad (1) \quad [\text{oxidation Half}]$$

$$1 \times (Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O) \quad (2) \quad [\text{Reduction Half}]$$

$6 \times ① + 1 \times ②$

$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ + e^- \rightarrow 6Fe^{3+} + 6e^- + 2Cr^{3+} + 7H_2O$

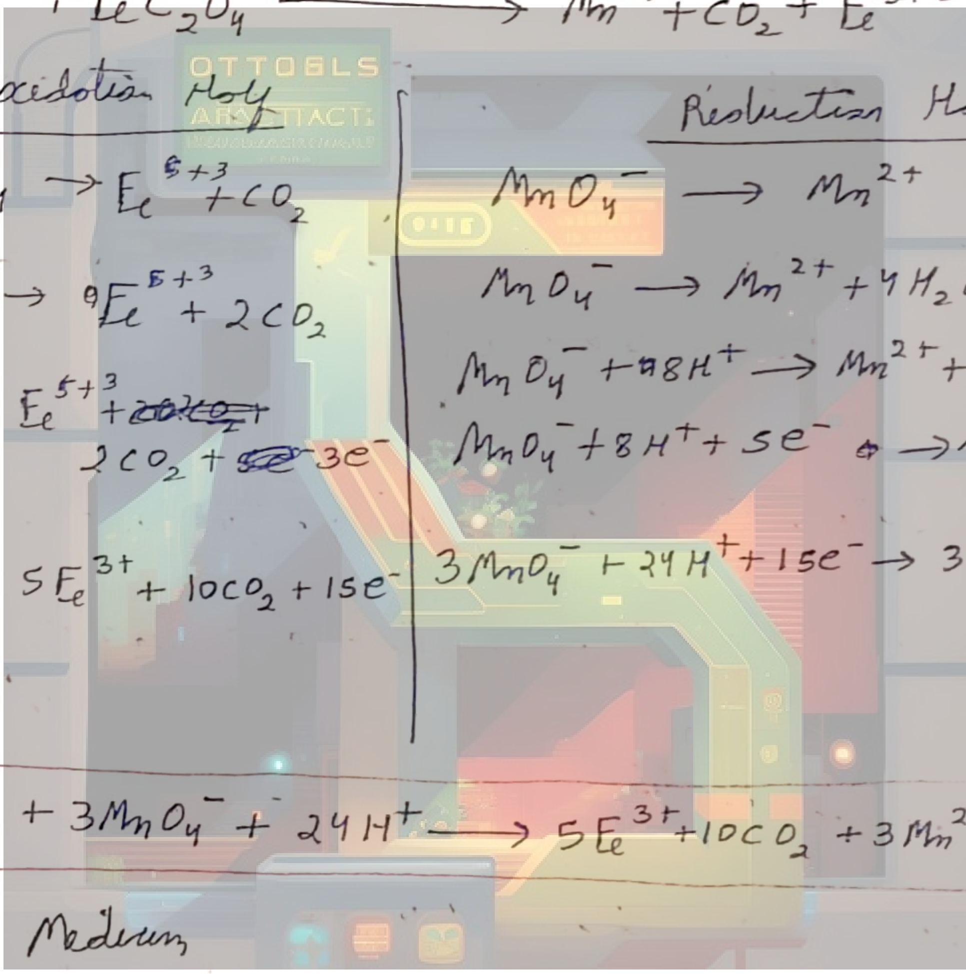
Acidic Medium

$$\boxed{6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O}$$

Q 7: Balance by Half Reaction method

In acidic medium

$\overset{+7}{Mn}O_4^- + FeC_2O_4 \xrightarrow{H^+} \overset{+2}{Mn^{2+}} + CO_2 + Fe^{\cancel{5}\,+3}$



Oxidation Half

$FeC_2O_4 \rightarrow Fe^{\cancel{5}+3} + CO_2$

$FeC_2O_4 \rightarrow Fe^{\cancel{5}+3} + 2CO_2$

$FeC_2O_4 \rightarrow Fe^{5+3} + \cancel{2CO_2} + 2CO_2 + \cancel{5e^-}\ 3e^-$

$5FeC_2O_4 \rightarrow 5Fe^{3+} + 10CO_2 + 15e^-$

Reduction Half

$MnO_4^- \rightarrow Mn^{2+}$

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

$3MnO_4^- + 24H^+ + 15e^- \rightarrow 3Mn^{2+} + 12H_2O$

$$\boxed{5FeC_2O_4 + 3MnO_4^- + 24H^+ \rightarrow 5Fe^{3+} + 10CO_2 + 3Mn^{2+} + 12H_2O}$$

2. Basic Medium

Step 1 :- Balance the reaction in Acidic Medium

Step 2 :- Add (OH^-) on both sides equal to no. of H^+ present on any side.

Step 3 :- Addition of H^+ & OH^- will give H_2O

Step 4:- OH^- will appear in final expression (with represent reaction is in basic medium).

H.W- 17-9-24

S-1

Q 6, 7, 8, 9, 10 – 15

O-1

~~15–27~~

21–27

Q8. $C_2O_4^{2-} + MnO_4^- \longrightarrow Mn^{2+} + CO_2$ (Basic Medium)

$MnO_4^- \longrightarrow Mn^{2+}$ | $C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$

$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$

$2MnO_4^- + 16H^+ + 16OH^- + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2 + 16OH^-$

$$\boxed{2MnO_4^- + 8H_2O + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2 + 16OH^-}$$

(B) Disproportionation Reaction

Q9. $Cl_2 + OH^- \longrightarrow Cl^- + ClO_3^- + H_2O$

Oxidation | Reduction

$Cl_2 + 6H_2O \longrightarrow 2ClO_3^- + 12H^+ + 10e^-$ | $Cl_2 + 2e^- \longrightarrow 2Cl^-$

$6Cl_2 + 6H_2O \xrightarrow{+12OH^-} 2ClO_3^- + 10Cl^- + 12H^+ + 12OH^-$

$6Cl_2 + 12OH^- \longrightarrow 2ClO_3^- + 10Cl^- + 6H_2O$

$$\boxed{3Cl_2 + 6OH^- \longrightarrow ClO_3^- + 5Cl^- + 3H_2O}$$

Q10. $KMnO_4 + \underbrace{H_2SO_4}_{\text{Acidic Medium}} + HCl \longrightarrow K_2SO_4 + MnSO_4 + Cl_2 + H_2O$

~~Oxidation~~ ~~Reduction~~

~~$KMnO_4$~~

Note :- convert into ionic form & eliminate species which donot undergo redox

$\cancel{K^+} + MnO_4^- + 2H^+ + \cancel{SO_4^{2-}} + H^+ + Cl^- \rightarrow \cancel{2K^+} + SO_4^{2-} + Mn^{2+} + SO_4^{2-} + Cl_2 + H_2O$

$MnO_4^- + Cl^- \rightarrow Mn^{2+} + Cl_2$

$2MnO_4^- + 16H^+ + \cancel{5Cl}\ 10Cl^- \longrightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$

$2MnO_4^- + \underbrace{16H^+ + 10Cl^-}_{6H^+ + 10HCl} \longrightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$

$+2K^+ \downarrow 2KMnO_4$

$6H^+ + 10HCl$; $+3SO_4 \rightarrow 3H_2SO_4 \downarrow 3H_2SO_4$; $10HCl$

$+2K^+ + SO_4 \rightarrow K_2SO_4$; $+2SO_4 \rightarrow 2MnSO_4$; $5Cl_2$; $8H_2O$

$$\boxed{2KMnO_4 + 3H_2SO_4 + 10HCl \longrightarrow K_2SO_4 + 2MnSO_4 + 5Cl_2 + 8H_2O}$$

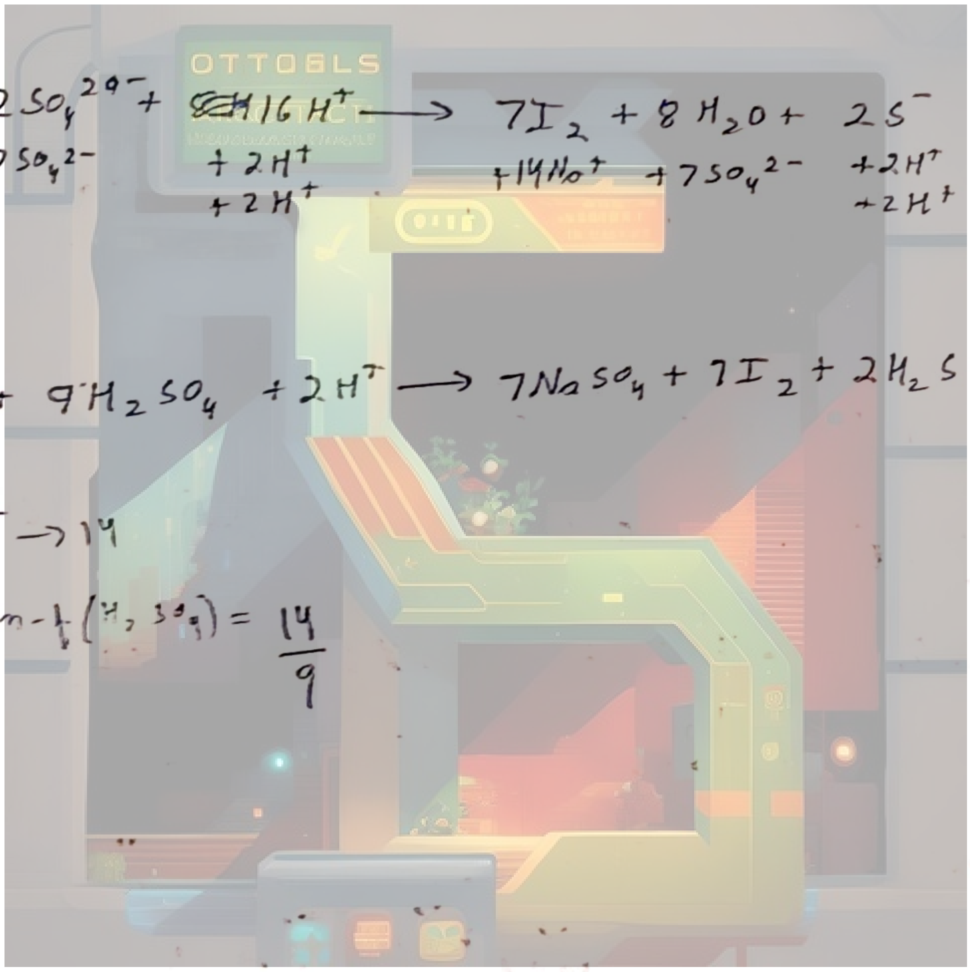
Q11. $H_2SO_4 + NaI \rightarrow Na_2SO_4 + I_2 + H_2S + H_2O$

$2H^+ + SO_4^{2-} + Na^+ + I^- \rightarrow 2Na^+ + SO_4^- + I_2 + 2H^+ + S^{2-} + H_2O$

$SO_4^{2-} + I^- \rightarrow I_2 + S^-$

$2I^- \rightarrow I_2 + 2e^-$

$SO_4^{2-} + 8H^+ \xrightarrow{+7e^-} S^- + 4H_2O$



$14I^- + 2SO_4^{2-} + \cancel{8H}\,16H^+ \rightarrow 7I_2 + 8H_2O + 2S^-$

$+14Na^+ \quad + 7SO_4^{2-} \quad + 2H^+ \quad + 2H^+ \qquad +14Na^+ \quad + 7SO_4^{2-} \quad + 2H^+ \quad + 2H^+$

$14NaI + 9H_2SO_4 + 2H^+ \rightarrow 7NaSO_4 + 7I_2 + 2H_2S + 8H_2O$

$e^- \rightarrow 14$

$n\text{-}f(H_2SO_4) = \frac{14}{9}$

② Oxidation No. Method.

Step-1 → Identify the atom undergoing change in oxidation no.

Step-2 → Find the n-factor of oxidation half & reduction half & cross multiply

e.g. $\overset{+7}{Mn}O_4^- + Fe^{2+} \longrightarrow \overset{+2}{Mn^{2+}} + Fe^{3+}$

reduction

n-f = 5   n-f = 1   oxidation

$MnO_4^- + 5Fe^{2+} \longrightarrow Mn^{2+} + Fe^{3+}$

Step-3 → Balance all other atoms except hydrogen & oxygens.

Step 4 :- → Balance Oxygen by adding H_2O

Step 5 → Balance Hydrogen by adding H^+

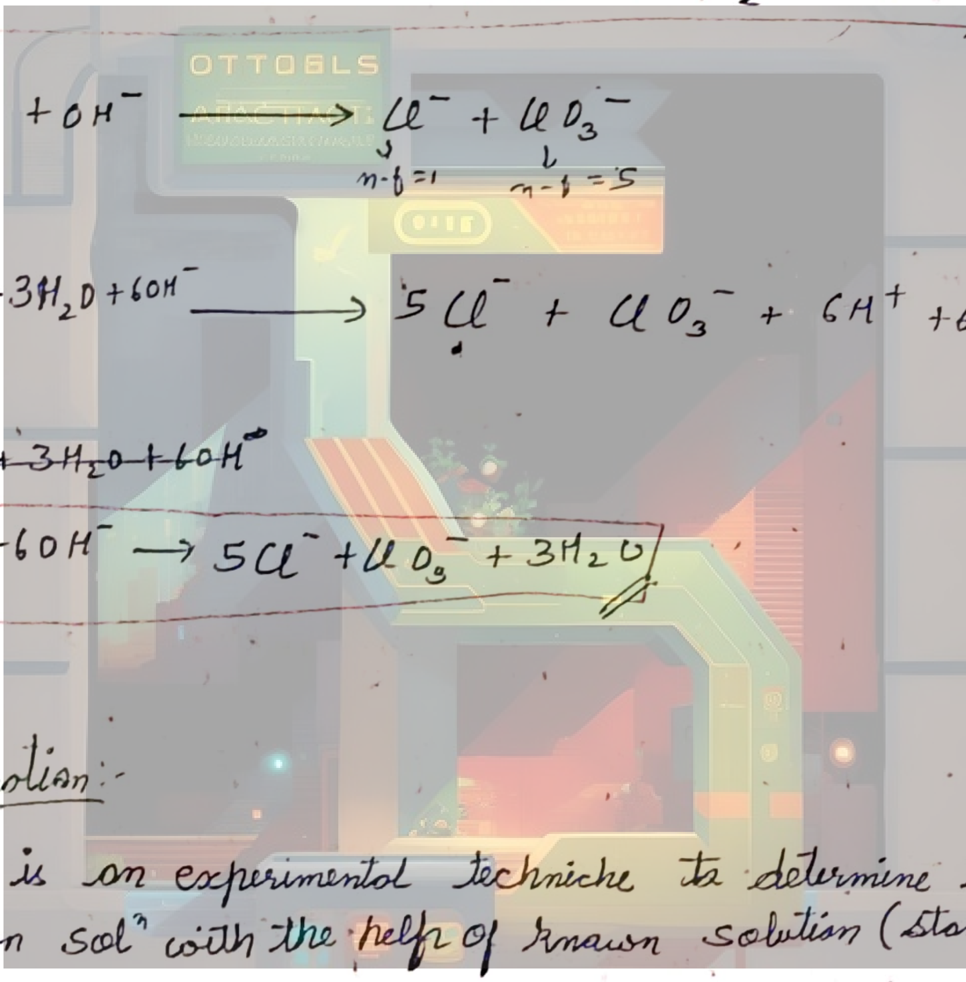
Step 6 → If the medium is basic then add OH^- on Both sides equal to H^+ present in any side.

Q12. $Cr_2O_7^{2-} + 6I^- \xrightarrow{H^+} Cr^{3+} + I_2$

$\downarrow$ n-f = 6 $\qquad \downarrow$ n-f = 1

$Cr_2O_7^{2-} + 6I^- + 14H^+ \xrightarrow{H^+} 2Cr^{3+} + 3I_2 + 7H_2O$

$$\boxed{Cr_2O_7^{2-} + 6I^- + 14H^+ \xrightarrow{H^+} 2Cr^{3+} + 3I_2 + 7H_2O}$$



Q13. $Cl_2 + OH^- \longrightarrow Cl^- + ClO_3^-$

$\downarrow$ n-f = 1 $\qquad \downarrow$ n-f = 5

$6Cl_2 + 3H_2O + 6OH^- \longrightarrow 5Cl^- + ClO_3^- + 6H^+ + 6OH^-$

~~$Cl_2 + 3H_2O + 6OH^-$~~

$$\boxed{3Cl_2 + 6OH^- \longrightarrow 5Cl^- + ClO_3^- + 3H_2O}$$

Titration:-

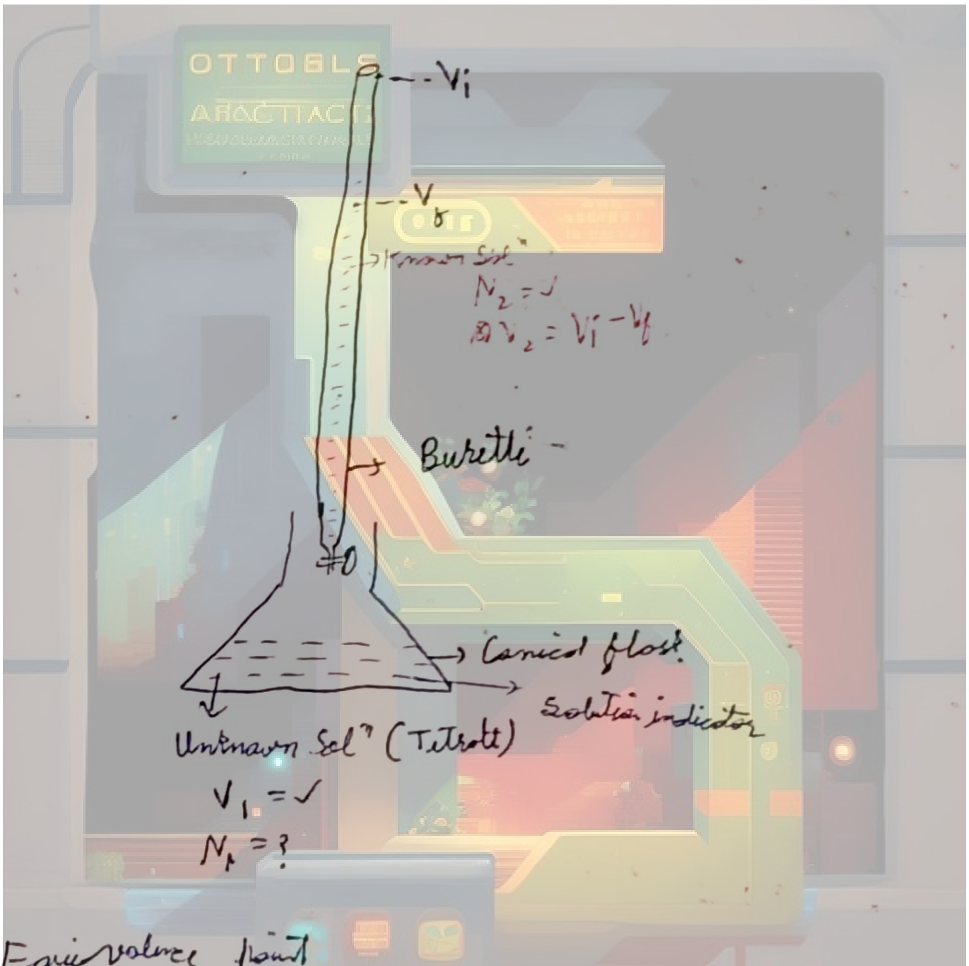
- Titration is an experimental techniche to determine the concentration of unknown sol^n with the help of known solution (standard sol^n).
- These reactions are based on law of equivalent

$aA + bB \rightarrow cC + dD$

no. of equivalent of A reacted = equivalents of B reacted = equivalents of C formed = equivalents of D formed

Procedure :-

- A given amount of unknown solⁿ (Titrate) is taken in a conical flask & standard solⁿ (Titrant) is added drop by drop from Burette, reaction takes place between these two solⁿs.
- At the Equivalence point (when reaction is completed, the indicator changes its color & volume of ~~sto~~ standard solⁿ used in the reaction is measured.



At Equivalence point

eq. of Titrant = equivalents of Titrate

$$N_1 V_1 = N_2 V_2$$

$$\boxed{N_1 = \frac{N_2 V_2}{V_1}}$$

Titration

Acid - Base Titration

Acid + Base $\rightarrow$

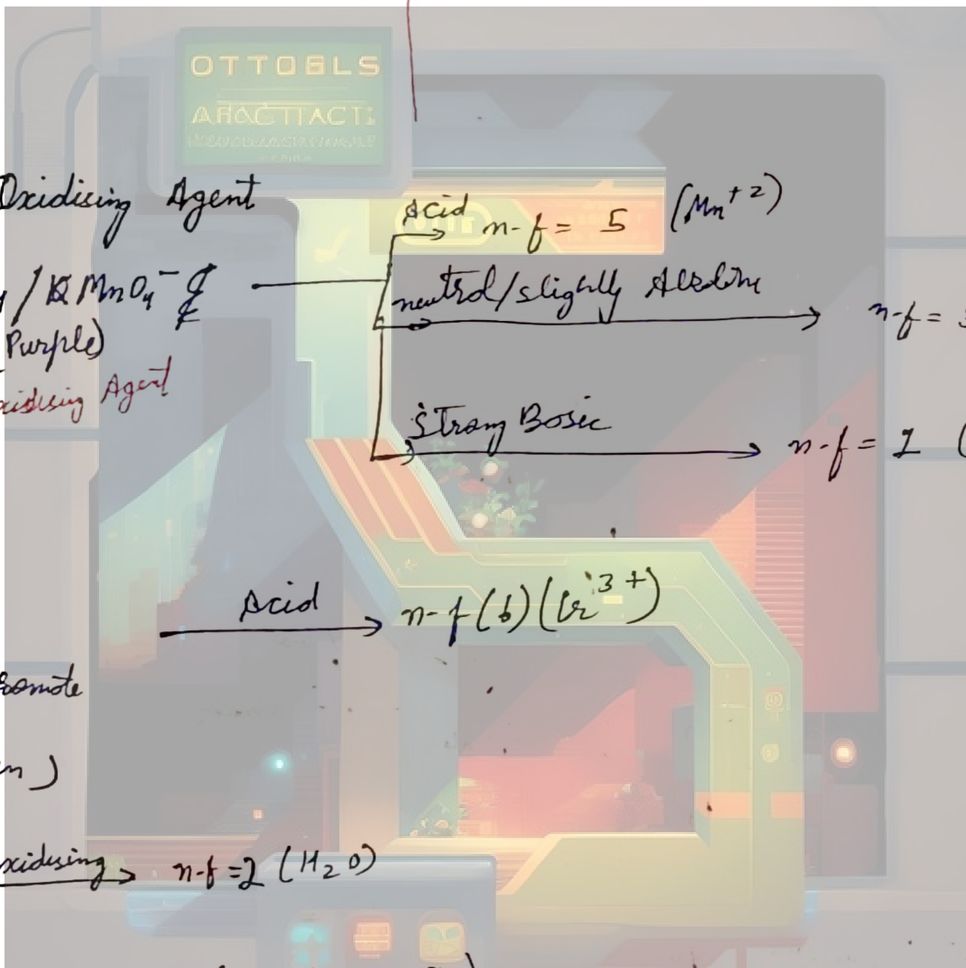
no. of equivalents of Base = no. of equivalents of Acid

Redox ~~Bo~~ Titration

$O \cdot A + R \cdot A \rightarrow$

at equivalence Point

$(eq)_{O \cdot A} = (eq)_{R \cdot A}$



Common Oxidising Agent

① ~~KM~~ $KMnO_4 / \cancel{K} MnO_4^-$ ~~Colourless~~ (Purple)

Strongest oxidising Agent

$\xrightarrow{\text{Acid}}$ $n\text{-}f = 5$ (Mn^{+2})

$\xrightarrow{\text{neutral/slightly Alkaline}}$ $n\text{-}f = 3$ (MnO_2)

$\xrightarrow{\text{Strong Basic}}$ $n\text{-}f = 1$ (MnO_4^{2-})

② $K_2Cr_2O_7$ (Potassium Dichromate or Dichromate ion) $\xrightarrow{\text{Acid}}$ $n\text{-}f(6)$ (Cr^{3+})

③ H_2O_2 $\xrightarrow{\text{Oxidising}}$ $n\text{-}f = 2$ (H_2O)

④ XO_3^- $\longrightarrow$ X^- $(x \Rightarrow Cl, Br, I)$

$n\text{-}f = 6$

⑤ PbO_2 $\longrightarrow$ Pb^{2+}

$n\text{-}f = 2$

⑥ $Cr_2O_4^{2-} \xrightarrow{\text{Acidic}} Cr^{3+}$
(Chromate ion)
$n\text{-}f = 3$

⑦ $O_3 \xrightarrow{H^+} O_2 + H_2$
$n\text{-}f = 2$

Common Reducing Agents

① $C_2O_4^{2-} \xrightarrow{\text{Acidic}} CO_2$
(Oxalate ion)
$n\text{-}f = 2$

② $Na_2S_2O_3 / S_2O_3 \longrightarrow Na_2S_4O_6$
(Hypo sol^n) (Sodium Tetra Thionate)
$n\text{-}f = 1$

③ $H_2O_2 \longrightarrow O_2$
$n\text{-}f = 2$

④ H_2S (Acidic)
$\longrightarrow S$ $(n\text{-}f = 2)$
$\longrightarrow SO_2$ $(n\text{-}f = 6)$
$\longrightarrow SO_4^{2-}$ $(n\text{-}f = 8)$

⑤ $KI \longrightarrow I_2$
$n\text{-}f = 1$

Q14. Calculate moles of $KMnO_4$ required to react completely with 90 g $H_2C_2O_4$ in Acidic medium. Also find the volume (lit) of CO_2 produced at STP.

$MnO_4^- + \overset{+3}{H_2C_2O_4} \xrightarrow{H^+} Mn^{2+} + \overset{+4}{CO_2}$

equivalents of $H_2C_2O_4$ = 2

equivalents of $KMnO_4$ = 2

moles = 2/5

$\boxed{\text{moles} = 0.4}$

equivalents of CO_2 = 2

moles = 2

Vol = $\boxed{44.8\ l}$

Q15. Calculate vol^n (in ml) of 0.1 M $KMnO_4$ sol^n to completely react with 50 ml, 0.1 M H_2S in acidic medium, H_2S is oxidised to SO_2.

$$\underset{\substack{\downarrow \\ n\text{-}f = 5}}{MnO_4^-} + \underset{\substack{\downarrow \\ n\text{-}f = 6}}{H_2\overset{-2}{S}} \xrightarrow{H^+} \underset{\substack{\downarrow \\ n\text{-}f = 5}}{Mn^{2+}} + \underset{\substack{\downarrow \\ n\text{-}f = 6}}{\overset{+4}{S}O_2}$$

$$(0.1)(5)(V) = (50)(0.1M)(6)$$

$$V = \frac{50 \times 6}{5}$$

$$\boxed{V = 60\,ml}$$

Q16. Find the mass (g) of Fe_3O_4 that will react completely with 25 ml, 0.3 M $K_2Cr_2O_7$. (max Possible oxidation state of iron is +3) (At wt Fe = 56)

$$\underset{\substack{\downarrow \\ n\text{-}f = 6}}{K_2\overset{+6}{Cr_2}\overset{-2}{O_7}} + \underset{\substack{\downarrow \\ n\text{-}f = (3 - \frac{8}{3}) \times 3 = 1}}{\overset{+8/3}{Fe_3}O_4} \longrightarrow \overset{+3}{Cr^{3+}} + \overset{+3}{Fe^{3+}}$$

equivalents $(Cr_2O_7^{-2}) = (0.025)(0.3)(6)$

eq Fe_3O_4 = 0.045

~~mass = 0.045 × 56 (120)~~

~~mass = 2.520~~

~~mass =~~

mass = (0.045) (232)

$$\boxed{= 10.44\,g}$$

Q17. Calculates of NaOH required to react completely with 1 mol HCl and 3 mole H_3PO_4.

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

equivalents of $(HCl) = 1$

equivalents of $(H_3PO_4) = (3)(3) = 9$

equivalents of $(NaOH)$ = moles of NaOH
= equivalents of HCl + equivalents of H_3PO_4

$\boxed{= 10 \text{ mol}}$

Q18. An Equimolar mixture of FeO & $Fe_{0.95}O$ reacts completely with 0.5 l, 1 M $KMnO_4$ in acidic medium find total moles of FeO & Fe^{3+} ion produced.

$\overset{+7}{Mn}O_4^- + \overset{+2}{Fe}O + Fe_{0.95}O \longrightarrow Fe^{3+} + Mn^{+2}$

n-f = 5 ; n-f = 1 ; n-f = $\frac{17}{19}$; n-f = $\frac{\frac{17}{19}}{\frac{36}{19}} = \frac{17}{36}$

no. of equivalents = 2.5

no. of equivalents of FeO = 2.5 − equivalents of $Fe_{0.95}O$

$\boxed{\cancel{\text{moles FeO} = 2.5}}$

$x = 2.5 - \frac{17x}{36}$

~~no. of equivalents~~

$36x = 90 - 17x$

$x = \frac{90}{53}$

moles Fe^{3+} = $\frac{2.5}{17} \times 36$

$= \frac{18 \times 5}{17}$

$= \frac{90}{17}$

$$MnO_4^- + FeO + Fe_{0.75}O \longrightarrow Fe^{3+} + Mn^{+2}$$

MnO_4^-: $n\text{-}f = 5$ FeO: $n\text{-}f = 1$ $Fe_{0.75}O$: $n\text{-}f = \left(3 - \frac{2}{0.75}\right) 0.75$

$$\frac{0.85 \times 1}{1.85} = \frac{85}{185} = \frac{17}{37}$$

$n\text{-}f = 2.85 - 2$

$n\text{-}f = 0.85$

equivalents $(MnO_4^-) = 2.5$

$eq(MnO_4^-) = eq(FeO) + eq(Fe_{0.75}O)$

$x = 2.5 - 0.85x$

$1.85x = 2.5$

$x = \frac{2.5}{18.5}$

$x = \frac{5}{3.7}$

$\boxed{x = 1.35}$

~~$n_{Fe^{2+}}\left(\frac{17}{37}\right) = 2.5$~~

~~$n_{Fe^{3+}} = \frac{2.5 \times 37}{17}$~~

~~$n_{Fe^{3+}} = \frac{185}{34}$~~

~~$n_{Fe^{3+}} = 5.44$~~

POAC

$x + 0.75x = n_{Fe^{3+}}$

$$\boxed{n_{Fe^{3+}} = \frac{1.75 \times 2.5}{1.85}}$$

Q19. find Molarity of H_2O_2 sol^n if 20ml react complete with 20ml 2M $KMnO_4$ in Acidic Medium.

$$MnO_4^- + H_2O_2 \longrightarrow Mn^{2+} + H_2O$$

MnO_4^-: $n\text{-}f = 5$ H_2O_2: $n\text{-}f = 2$

$eq = \frac{20 \times \cancel{2} \times 5}{1000} = \cancel{2} \times \text{mole}(H_2O_2)$

$0.1 = \text{mole}(H_2O_2)$

$M = \frac{0.1}{0.02}$

$M = \frac{10}{2}$

$\boxed{M = 5 \text{ molar}}$

Q20. 696 g of mixture Fe_2O_3 & FeO reacts with completely with 158 g $KMnO_4$ in Acidic Medium find the weight of (g) of FeO present in sample. (wt Atomic Fe = 56, K = 39, Mn = 55)

$$MnO_4^- + Fe_2O_3 + FeO \longrightarrow Mn^{2+} + Fe^{3+}$$

$n\text{-}f = 5 \qquad n\text{-}f = 0 \qquad n\text{-}f = 1$

equivalents of $MnO_4^- = \frac{158}{158} \times 5 = 5$

~~moles of FeO = $\frac{158 \times 5}{119}$~~

~~mass FeO = $\frac{158 \times 5}{119} \times$~~

~~moles~~ = 5

mass $FeO = 5 \times 72$

$\boxed{= 360\ g}$

Q21. 40 ml of 0.5 M Ce^{4+} is required to completely react 10 ml of 1 M Sn^{2+} to Sn^{4+} what is O.S. of Cerium in reduction product

Q22. 6 mole of sol^n A^{n+} requires 2 mole $Cr_2O_7^{2-}$ ions for Oxidation of A^{n+} to AO_3^- in Acidic Medium. The value n is?

Q23. 50 ml of Acidic Sol^n 0.25 M $K_2Cr_2O_7$, 30 ml of 0.4 M $K_2C_2O_4$ and 120 ml of 0.2 M Fe^{3+} are added together. Compute the Molarities of Fe^{3+} ions & $Cr_2O_7^{2-}$ ions in the final sol^n?

Q24. 5.1 g sample of H_2O_2 solⁿ containing x% H_2O_2 by wt. requires x ml of $K_2Cr_2O_7$ solⁿ for complete oxidation under acidic medium. What is the molarity of $K_2Cr_2O_7$ solⁿ.

H.W. 21-9-24

Race, 12-13

S-1 16 to 39

S-2 1 to 4

5 to 10

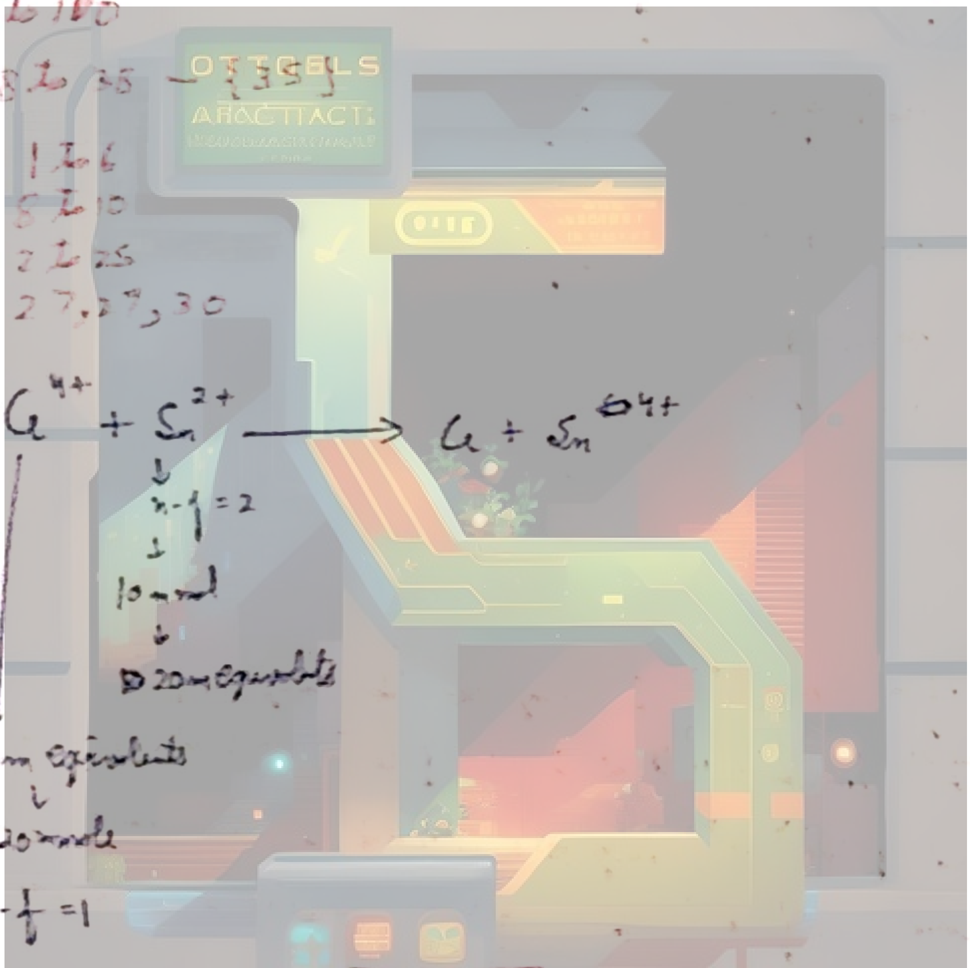
O-1 28 to 35 — {35}

JM- 1 to 6

8 to 10

12 to 25

27, 29, 30



Ans 21

$Cr^{4+} + Sn^{2+} \longrightarrow Cr + Sn^{4+}$

Sn^{2+}: n-f = 2 → 10 m mol → 20 m equivalents

Cr^{4+}: 20 m equivalents → 20 m mole

n-f = 1

O.S in product = $\boxed{+3}$

Ans 22. $A^{n+} + Cr_2O_7^{2-} \longrightarrow \overset{+5}{A}O_3^- + Cr^{3+}$

$Cr_2O_7^{2-}$: n-f = 6 → equivalents = 12

A^{n+} = (6)(n-f) = 12

n-f = 2

+5 - n = 2

5 - 2 = n

$\boxed{n = 3}$

(150)

Ans 23

$$K_2Cr_2O_7 + K_2\overset{+3}{C_2}O_4 + Fe^{2+} \longrightarrow Cr^{3+} + Fe^{3+} + \overset{+4}{CO_2}$$

$K_2C_2O_4$: n-f = 2

Fe: n-f = 1

(12.5)(6) m equivalents = 24 m equivalents + 24 m mol

V_f = 200 ml

Find $K_2Cr_2O_7$ = ~~51 m equivalents = $\frac{51}{6}$ m mol~~ = $\frac{27}{6}$ m mol

Fe^{3+} = 24 m mol

$$[Fe^{3+}] = \frac{24}{200} = \boxed{0.12\,M}$$

$$[K_2Cr_2O_7] = \frac{27}{6 \times 200} = \cancel{0.0225} \quad \boxed{0.0225\,M}$$

Ans 24. wt H_2O_2 = $\frac{5.1x}{100}$ g

$$K_2Cr_2O_7 + H_2O_2 \longrightarrow O_2$$

$K_2Cr_2O_7$: n-f = 6

H_2O_2: n-f = 2

~~1 mol $K_2Cr_2O_7$ = 1 mol H_2O_2~~

$$\text{mol } H_2O_2 = \frac{5.1x}{100} \times \frac{1}{34} \times 2$$

$$\text{mol } K_2Cr_2O_7 = \frac{5.1x}{3400 \times 6} \times 2$$

$$[K_2Cr_2O_7] = \frac{5.1x}{3400 \times 6} \times \frac{1000}{x} \times 2$$

$$= \frac{51}{204} = \frac{2}{4} = \boxed{0.5\,M}$$

Back Titration

→ This titration method is used to determine the excess reagent. It is also used to determine the % Purity of substance.

eq (Acid) = eq (Base)

eq(H_2SO_4) + eq(HCl) → eq(NaOH)

Q 25. 10 g $CaCO_3$ was dissolved in 250 ml of 1M HCl, what volume of 2M KOH would be required to neutralize excess HCl.

equivalents HCl = 250 milli eq. = 0.25

equivalents $CaCO_3$ = 0.1 (2) = 0.2

equivalents KOH = 0.05

moles = 0.05

$$\text{volume} = \frac{0.05}{2} = 0.025\ l$$

$$\boxed{= 25\text{ml}}$$

MII

$CaCO_3$ + HCl

$(eq)_{CaCO_3} = (eq)_{HCl\ used}$

mol × n f = $n_{HCl\ used}$ × nf

$\left(\frac{10}{100}\right) \times 2 = n_{HCl\ used} \times 1$

$n_{HCl\ used}$ = 0.2 mole

Total mole of HCl = 1 × 0.25 = 0.25 mol

eq (Remaining of HCl) = (eq) KOH

$(0.05)(1) = 2 \times V_{(l)} \times 1$

$V_{ml} = \frac{0.05}{2} = \frac{50}{2} = \boxed{25\text{ml}}$

Q26. 20g sample of ~~BaCO~~ $Ba(OH)_2$ is dissolved in 10ml of 0.5 N HCl solⁿ. The excess of HCl was titrated with 0.1 N NaOH. Volume of NaOH used is 20 cm^3. Calculate % $BaSO_4$ in sample. (Ba = 137u)

$\cancel{\left(\frac{20}{171}\times 2\right) + [}$

$HCl = 5\ meq$

$NaOH = 2\ meq$

$Ba(OH)_2 = 3\ meq$

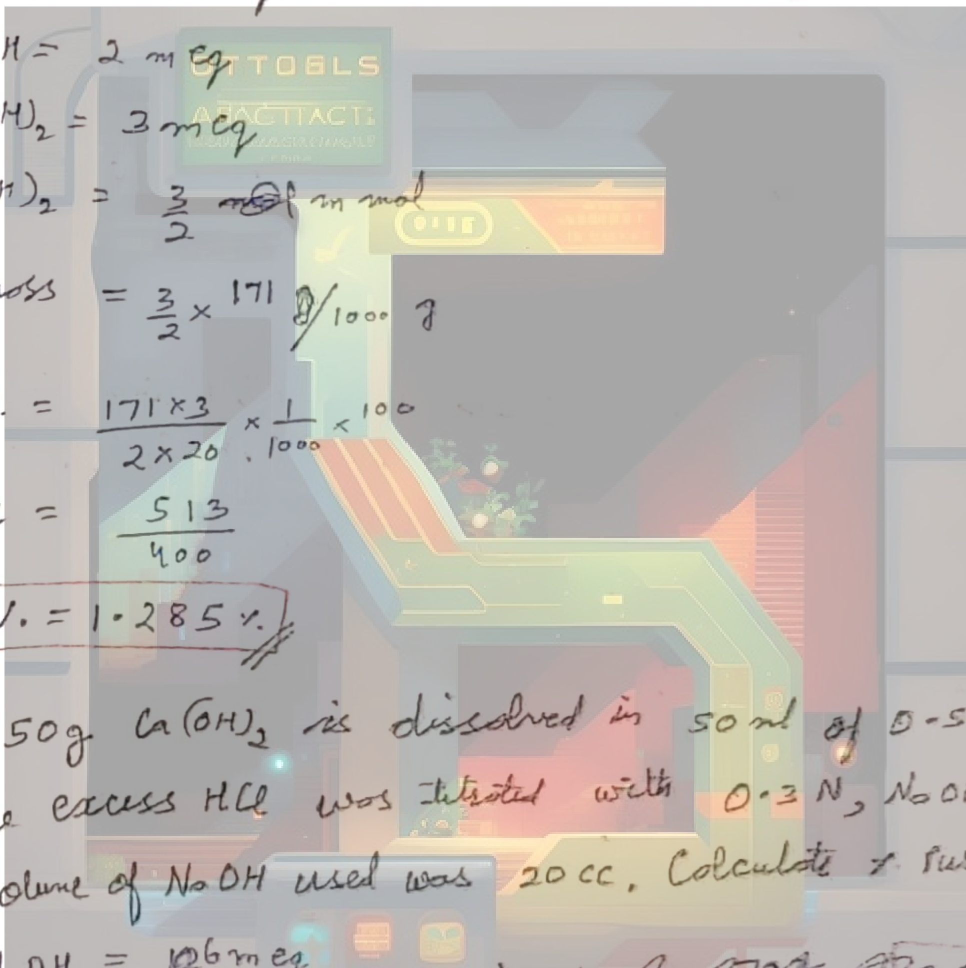
$Ba(OH)_2 = \frac{3}{2}\ m\,mol$

$mass = \frac{3}{2} \times 171 / 1000\ g$

$\% = \frac{171\times 3}{2\times 20} \times \frac{1}{1000} \times 100$

$\% = \frac{513}{400}$

$\boxed{\% = 1.285\ \%}$



Q27. 50g $Ca(OH)_2$ is dissolved in 50ml of 0.5 N HCl solⁿ. The excess HCl was titrated with 0.3 N, NaOH. The Volume of NaOH used was 20 cc. Calculate % purity of $Ca(OH)_2$

$NaOH = 6\ meq$

$HCl = 25\ meq$

$Ca(OH)_2 = 19\ meq$

$Ca(OH)_2 = \frac{19}{2}\ m\,mol$

$Ca(OH)_2 = \frac{19}{2} \times 74$

$\% = \frac{19 \times 37}{500 \times 1000} \times 100$

$\% = \frac{703}{500} = \boxed{1.405\ \%}$

// Estimation of Iodine

① Iodimetry

→ Used to find out the amount of Reducing Agent (R.A)

$$RA + I_2 \longrightarrow I^- + \text{Product}$$

i) I_2 is taken in excess

ii) Left I_2 from above reaction is estimated by Hypo sol^n ($Na_2S_2O_3$)

$$\underset{n\text{-}f=2}{I_2} + \underset{n\text{-}f=1}{Na_2\overset{+2}{S_2}O_3} \longrightarrow NaI + Na_2\overset{+2.5}{S_4}O_6$$

Q> 8. when $Na_2C_2O_4$ (Sodium Oxalate) reacted with 3 moles of I_2, left I_2 requires 0.5M, 2 L $Na_2S_2O_3$ sol^n. find moles of $Na_2C_2O_4$ initially taken.

$Na_2S_2O_3 = 1$ eq

$I_2 = 3$ mol

I_2 left $= 3 - (1)(2)$

$= \cancel{1 \text{ mol}}$

$= \cancel{2 \text{ eq}}$

$= 5$ eq

$Na_2C_2O_4 = 5$ eq

$= \frac{5}{2}$ mol

$\boxed{= 2.5 \text{ mol}}$

(28)

H.W. - 24-9

S1 - Back Titration
JA

(2) Iodometry

→ used to determine amount of O.A (Oxidising Agent)

$$O.A + I^- \longrightarrow I_2 + \text{Product}$$

I^- ↓ n-f = 1; I_2 (formed)

formed

$$I_2 + Na_2S_2O_3 \longrightarrow NaI + Na_2S_4O_6$$

I_2 ↓ n-f = 2; $Na_2S_2O_3$ ↓ n-f = 1

Q.27. 50 ml $KMnO_4$ sol^n is mixed with excess of KI sol^n. The liberated I_2 requires 30 ml, 0.1 M $Na_2S_2O_3$ for titration. Find Normality of $KMnO_4$ sol^n used.

equivalents($Na_2S_2O_3$) = $30 \times 0.1 \times 1$

$= 3$ m eq

equivalents I_2 = 3 meq

equivalents $KMnO_4$ = 3 m eq

$$N = \frac{3}{50} N$$

$$\boxed{= 0.06 N}$$

Q30. A certain amount of KIO_3 (O.A) reacts with excess KI. The liberated I_2 requires 50 ml 2M hypo sol^n for titration. find moles of KIO_3 used.

$$\overset{+5}{K I O_3} + \overset{-1}{K I} \longrightarrow \overset{0}{I_2} + \cancel{\ldots}$$

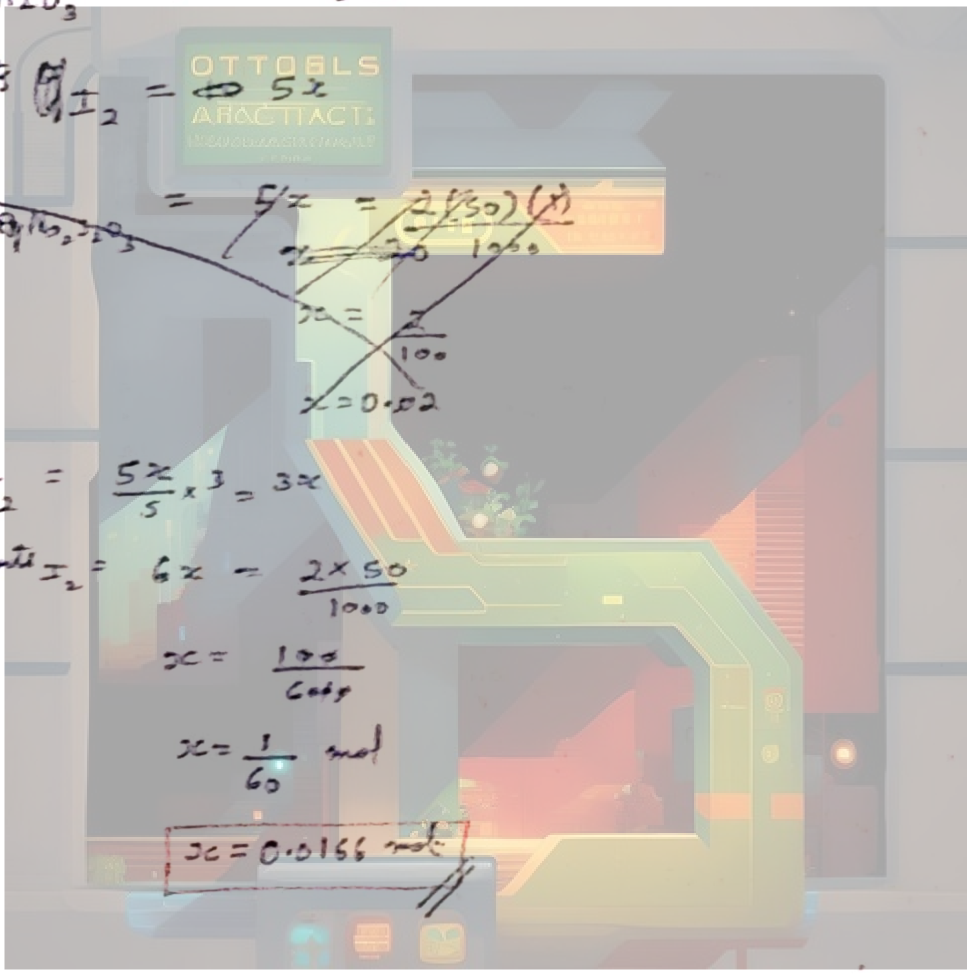
KIO_3: n-f = 5, x moles

KI: n-f = 1

I_2: n-f = $\frac{10 \times 2}{12} = \frac{5}{3}$

equivalents$_{KIO_3}$ = (x)(5) = 5x

equivalents$_{I_2}$ = 5x



~~equivalents$_{Na_2S_2O_3}$ = 5x = $\frac{2(50)(x)}{1000}$~~

~~$x = \frac{2}{100}$~~

~~$x = 0.02$~~

$n_{I_2} = \frac{5x}{5} \times 3 = 3x$

equivalents$_{I_2}$ = $6x = \frac{2 \times 50}{1000}$

$x = \frac{100}{6000}$

$x = \frac{1}{60}$ mol

$\boxed{x = 0.0166 \text{ mol}}$

Hardness of Water

→ A sample of water containing soluble salt of calcium or magnesium is called Hard water.

→ Hard water does not give lather with soap it forms scum or precipitate.

$$2C_{17}H_{35}COO^-Na^+ + Ca^{2+} \rightarrow (C_{17}H_{35}COO)_2Ca + 2Na^+$$

or Mg^{2+} — Scum or PPT ↓

$$\rightarrow (C_{17}H_{35}COO)_2Mg + 2Na^+$$

Hardness of water

Temporary Hardness

→ It is due to the presence of bicarbonates of 'Ca' & 'Mg'.

→ It can be easily removed by

a) By Boiling :-

~~Ca(HCO₃)~~

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 + CO_2 + H_2O_{(l)}$$

white PPT ↓ (Separated by Filter)

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_{3(s)} + CO_2 + H_2O$$

white PPT ↓ → filter

b) Clark's process → To remove temporary hardness on large scale

$$Ca(HCO_3)_2 + CaO \rightarrow 2CaCO_3 + H_2O$$

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O$$

Permanent Hardness

→ It is due to presence of sulphates (SO_4^{2-}) & Chlorides (Cl^-) of Ca & Mg

→ Cannot be removed by simple boiling

→ It can be removed in industries by

A) washing soda :-

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2NaCl$$

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4$$

$$Ca(HCO_3)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaHCO_3$$

b) Calgon :-

Calgon is a commercial name of Sodium Hexa meta phosphate which may be represented by as $Na_2[Na_4(PO_3)_6]$

$$2Ca^{+} + Na_2[Na_4(PO_3)_6] \rightarrow Na_2[Ca_2(PO_3)_6] + 4Na^+$$

$$\downarrow$$

$$2Na^+ + [Ca(PO_3)]$$

c) Permutis or (Zeolite)

→ Permutit is the name of Sodium Aluminium ortho silicate $[Na_2Al_2Si_2O_8 \cdot xH_2O]$

Permanent Hardness:-

$Na_2Al_2Si_2O_5 \cdot xH_2O + Ca^{2+} \rightarrow CaAl_2Si_2O_8 \downarrow + 2Na^+ + xH_2O$

Q.31. Calculate wt of CaO required to remove the hardness of 1000 l ($1m^3$) of H_2O with 1.62 g $Ca(HCO_3)_2$ per lit.

wt of $Ca(HCO_3)_2$ = 1.62×1000

$= 1620$ g

$n_{Ca(HCO_3)_2} = \frac{1620}{162} = 10$ mol

n CaO = 10 mol

wt CaO = 10×56

$\boxed{= 560 \text{ g}}$

Note:- Permanent Hardness

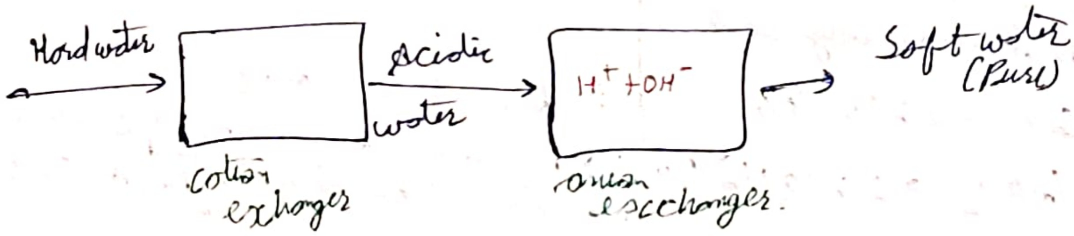
d) Ion-exchange Resins

Cation exchanger → Has giant organic molecule have $-SO_3H$, $-COOH$ grp.

→ removes cations like Ca^{2+}, Mg^{2+}, Na^+ replaces it with H^+

Anion exchanger → has giant organic molecule have $-NH_2$, $-OH$ grp

→ removes anions such as Cl^-, SO_4^{2-} & replace with OH^-



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Degree of Hardness of water ~~(...)~~ (η)

→ Measure in terms of PPM of $CaCO_3$

→ It is defined as number of parts of $CaCO_3$ by mass present in 10^6 parts of mass of water whose equivalent is equal to the gram equivalent of various calcium and magnesium salts.

$$\eta = \frac{\text{wt of } CaCO_3}{\text{wt of water sample}} \times 10^6$$

<u>note:-</u> If wt of water is not given then assume density of water to be 1 g/ml if volume is given.

Q.32. ~~1l of water of~~ 1l sample of water contains 9.5 mg of $MgCl_2$, 16.2 mg of $Ca(HCO_3)_2$ and 5.85 mg of NaCl, find.

i) Degree of Temporary Hardness

ii) Degree of ~~...~~ Hardness.

equivalents of ~~$MgCl_2$~~ $Ca(HCO_3)_2$ $= \frac{16.2}{162} = 0.1$ meq

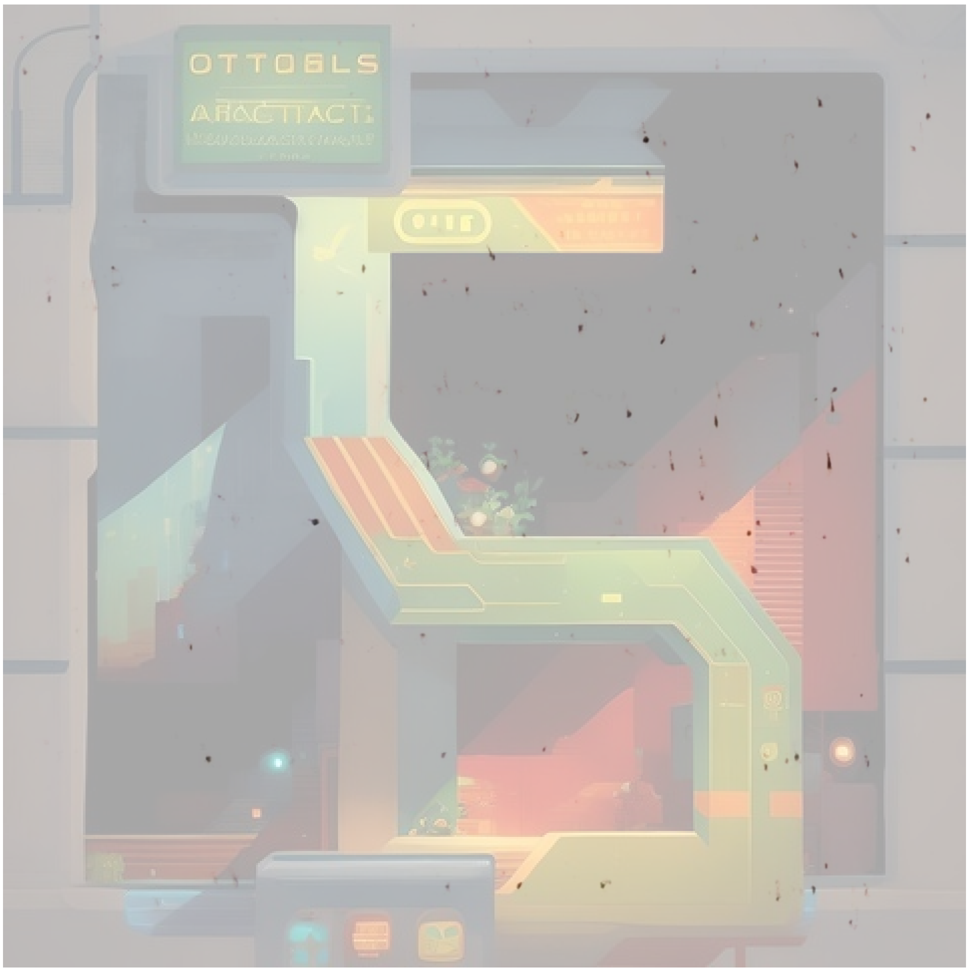
mass of $CaCO_3$ $= 100 \times 0.1 = 10$ mg $= 10^{-2}$ g

~~$\eta(\text{temp}) = \frac{10}{1000} \times 10^6 = 10^6 \times 10^{-2} = 10^4$~~

$\eta(\text{Temp}) = 10^{-2} \times 10^6 \times 10^{-3} = \boxed{10 \text{ PPM}}$ i)

$\eta(\text{permanent}) = \boxed{10 \text{ PPM}}$

$\eta = 10 + 10 = \boxed{20 \text{ PPM}}$ ii)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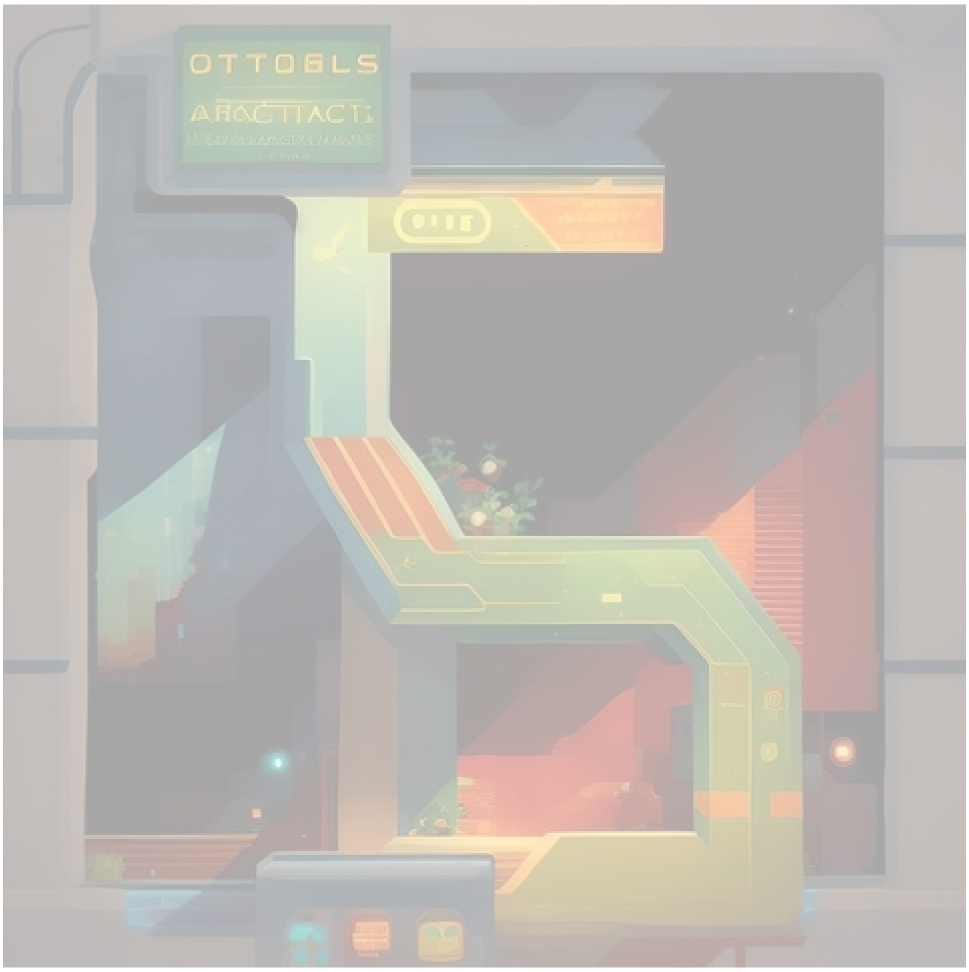
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