23/10/17

Redox Reactions

Redox

Reduction — Oxidation

Those reacⁿ in which ~~reduct~~ oxidation & reduction takes places simultaneously.

or

Those reacⁿ in which transfer of el⁻ from one chemical substance to another takes place is c/a redox reacⁿ.

or

Those reacⁿ in which ↑se of weight of one substance & ↓se of weight of another substance takes place simultaneously.

Oxidation Number :- (O.N.)

The no. of el⁻ lost or gain by an atom in formⁿ of molecule is c/a O.N.

eg $FeCl_3 \rightarrow Fe^{3+}$ & $3Cl^-$

$Fe \longrightarrow Fe^{3+} + \underbrace{3e^\ominus}_{\text{loss}}$

$3Cl + \underbrace{3e^\ominus}_{\text{(gain)}} \longrightarrow 3Cl^\ominus$

O.N. of Fe → +3

O.N. of Cl → -1

Oxidation state : O.N. per atom

$KMnO_4$

O.S. of Mn in $KMnO_4 \rightarrow Mn^{7+}$

O.N. of Mn in $KMnO_4 \rightarrow +7$

$FeCl_3$ O.S. of $Fe \rightarrow Fe^{3+}$
O.N. of $Fe \rightarrow +3$
O.S. of $Cl \rightarrow Cl^-$
O.N. of $Cl \rightarrow -1$

$HgCl_2$ Hg^{2+} O.N. of $Hg = +2$
Hg_2Cl_2 Hg_2^{2+} O.N. of $Hg = +1$
$CuCl_2$ Cu^{2+} O.N. of $Cu = +2$
Cu_2Cl_2 Cu_2^{2+} O.N. of $Cu = +1$
O_3^- O.N. of $O = -1/3$

Most Important Points :-

1. O.S. is formed due to E.N. difference.
   $\dot{X} - \dot{X}$ eg : H_2, Cl_2, F_2
   $\dot{X} = \dot{X}$ eg : O_2
   $\dot{X} \equiv \dot{X}$ eg : N_2

   E.N. Y > E.N. X
   $X^{+1} - Y^{-1}$ eg HF, HCl
   $X^{+2} = Y^{2-}$
   $X^{3+} \equiv Y^{3-}$

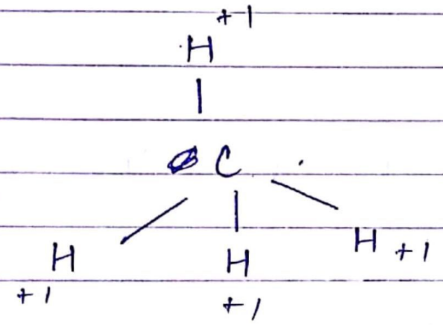
2. E.N. of 2 elements is not same.
   Cl > N
   P > H
   S > C
   C > H

3. O.S. may be zero, +ve, -ve or fractional value
   eg $Ni(CO)_4$ O.N. of $Ni = 0$
   N_3H O.N. of $N = -1/3$
   HCl O.N. of $H = +1$
   O.N. of $Cl = -1$

4. O.S. of same atom may be same or different in different compounds.

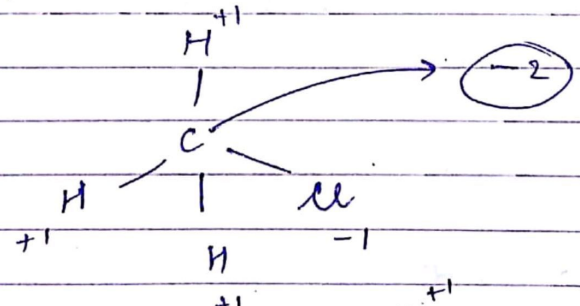
N_2O O.S. of N = +1
NO = +2
N_2O_3 = +3 HNO_2 → +3
NO_2 +4
N_2O_5 +5 HNO_3 = +5

H_2S → −2
H_2SO_4 → +6
H_2SO_3 → +4

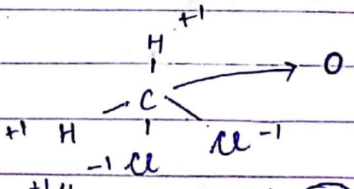


O.N. of C = −4

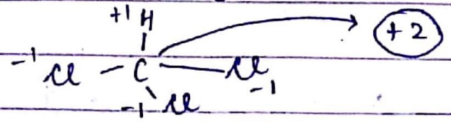
CH_3Cl



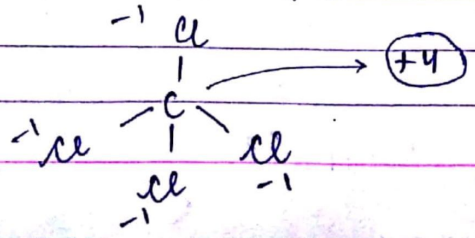
CH_2Cl_2



$CHCl_3$



CCl_4



Calculation of O.N. :-

Case-I : for Covalent compound :-

(a) O.N. for an atom in free state = 0
eg : H, O, Fe, C, N

(b) O.N. for an atom in homoatomic molecule is zero
eg H_2, Cl_2, N_2, O_2, O_3, S_8, P_4

(c) O.N. of an atom in its allotrophic form
eg $C_{grap.}$, $C_{diamond}$, C_{60}, $S_{rhombic}$, $S_{monoclinic}$

(d) O.N. of metal in metal carbonyl is zero.
eg $Ni(CO)_4 \rightarrow Ni = 0$
$Fe(CO)_5 \rightarrow Fe = 0$

(e) O.N. of an atom in alloy & amalgam (Na-Hg) is zero.

(f) O.N. of a ~~metal~~ neutral molecule is zero.
eg : CO, NH_3, H_2O

(g) O.N. of F is always -1

(h) Hydrogen
- (+1) when attached to more E.N.
  eg HF, HCl, NH_3, H_2O
- free state H = 0
- molecule H_2 = 0
- (−1) attached to more electropositive
  eg Hydrides
  $\overset{+1}{Li}\overset{-1}{H}$ $MgH_2 \rightarrow -1$
  $\overset{+1}{Na}\overset{-1}{H}$ $CaH_2 \rightarrow -1$

(i) Oxygen :-

+2 ← OF_2

+1 ← O_2F_2

$2x + 2(-1) = 0$

$x = +1$

Oxygen →
- Oxides (O^{-2}) O.N. = −2
  eg H_2O, NO, CO_2
- Peroxide (O_2^{2-}) O.N. = −1
  eg H_2O_2, Na_2O_2, BaO_2
- Superoxide (O_2^-) O.N. = −1/2
  eg KO_2
- Suboxide :
  $C^{+2}O^{-2}$, C_3O_2

$O^{-2} = C^{+2} = C^{0} = C^{0} = C^{+2} = O^{-2}$

C_5O_2 $\quad O^{-2} = C^{+2} = C^{0} = C^{0} = C^{0} = C^{+2} = O^{-2}$

(j) O.N. of IA = +1 O.N. of II A = +2

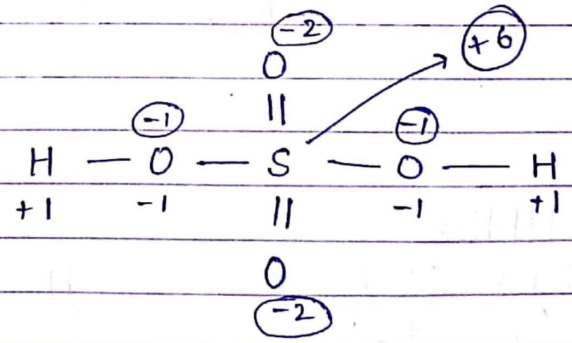
p block & d-block → variable valency

➡ The algebraic sum of O.N. of all atoms in a neutral molecule is zero,

$H_2\underline{S}O_4$

$2(+1) + x + 4(-2) = 0$

$x = +6$



$H_2S_2O_8$ (peroxydisulphuric acid / Marshall acid)

$2(+1) + 2x + 8(-2) = 0$

$x = +7$ X

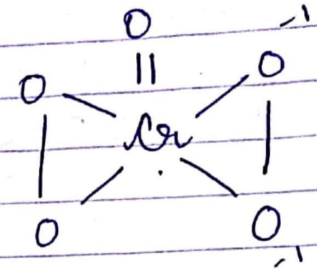
कभी भी O.N. Max.m को exceed कर जाये तो उसका Max. O.N. ही consider किया जाएगा।

$x = +6$

CrO_5

$x + 5(-2) = 0$

$x = +10$ ✗



$Cr \rightarrow +6$ max^m

$x = +6$

➡ The algebraic sum of O.N. of all atom in a polyatomic ion is equal to total charge on that ion.

SO_4^{2-}

$x + 4(-2) = -2$

$x = +6$

CO_3^{2-}

$x + 3(-2) = -2$

$x = +4$

PO_4^{3-}

$x + 4(-2) = -3$

$x = +5$

Case- II : For coordinate Bond :-

$X^{+2} \longrightarrow X^{-2}$ $\quad$ $Y^{+2} \longrightarrow Y^{-2}$

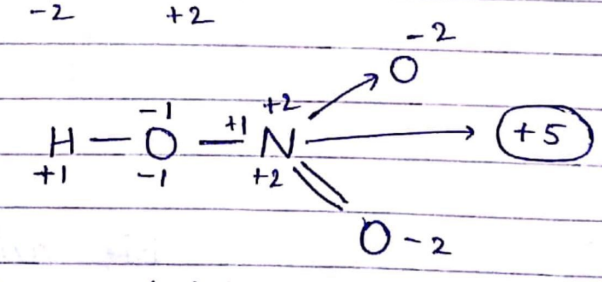
E.N.y > E.N.x

$X^{+2} \longrightarrow Y^{-2}$ $\quad$ $\overset{+2}{\overset{-2}{Y}} \longrightarrow \overset{-2}{\overset{+2}{X}}$

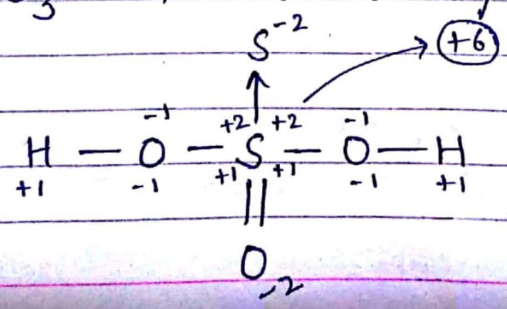
HNO_3

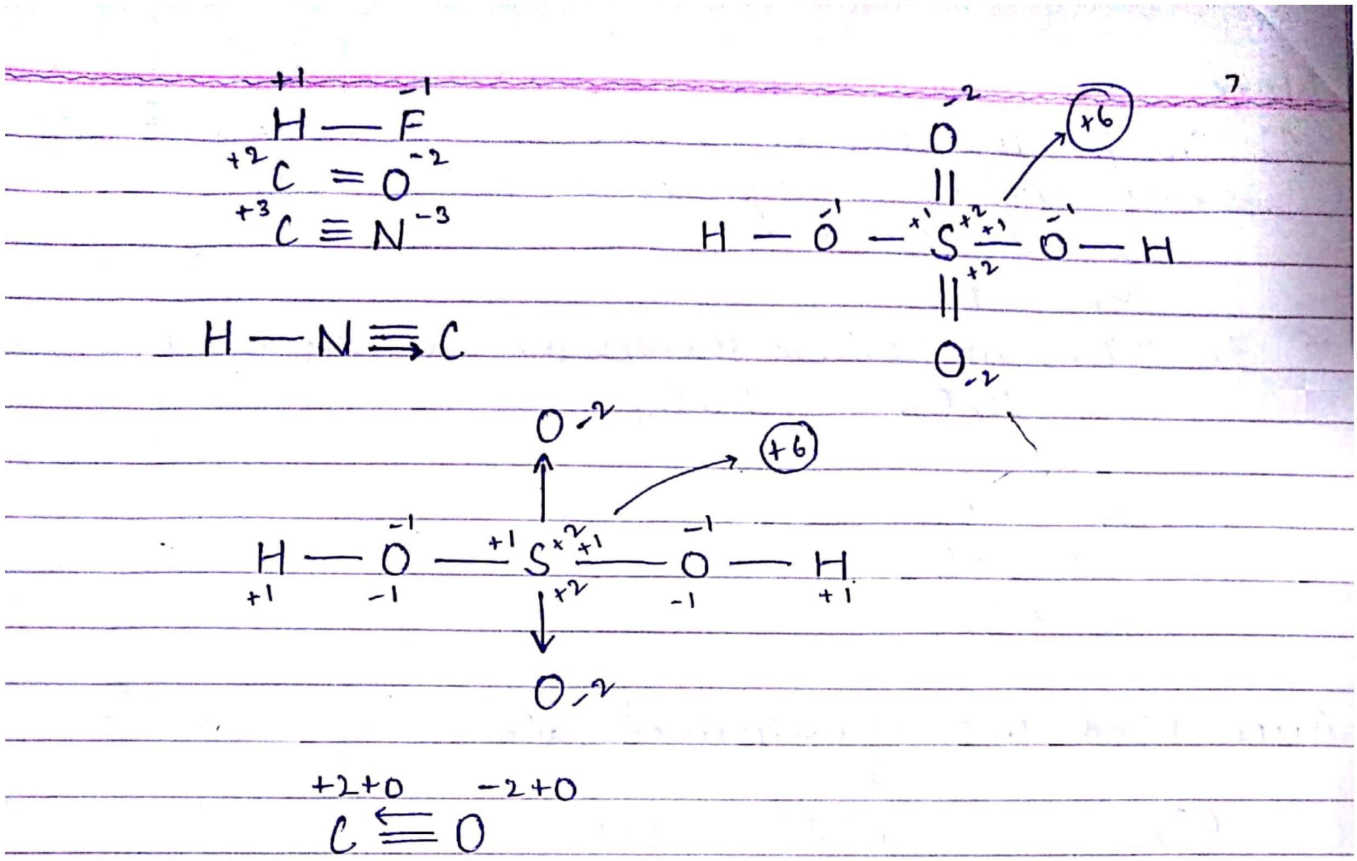
$+1 + x + 3(-2) = 0$

$x = +5$



$H_2S_2O_3$ Thionic acid / Thiosulphuric acid





Case - III for ionic compounds :-

$Na^{+1}Cl^{-1}$

$CuCl_2 \rightarrow Cu^{2+}$, Cl^{-1}

$Cu_2Cl_2 \rightarrow Cu_2^{2+} \rightarrow Cu^{+1}$, Cl^{-1}

$HgCl_2$

Hg_2Cl_2

Compound which are not pure ionic, sum of O.S. of all elements is equal to charge on that ionic compounds.

$KMnO_4$

$+1 + x + 4(-2) = 0$

$x = +7$

$KCr_2O_7^-$

$+1 + 2x + 7(-2) = -1$

$x = +6$

Note

① In d-block elements, max^m O.S. of an element is equal total no. of unpaired $e^\ominus$ in its E.S.

$Cr \rightarrow 3d^5 4s^1 \rightarrow +6$

$Mn \rightarrow +7$

② In P.T., max^m O.S. is shown by Os & Ru i.e. +8

OsO_4 RuO_4

Fe_2O_3

$2x + 3(-2) = 0$

$x = +3$

Ques Find O.S. of underlined atom :-

① $\underline{C}O_2$ $x = +4$

② $H\underline{N}O_3$, $1 + x + 3(-2) = 0 \Rightarrow x = +5$; $H\underline{N}O_2 \rightarrow +1 + x + 2(-2) = 0$, $x = 3$

③ $H_2\underline{S}O_4$, $2 + x + 4(-2) = 0$, $x = 6$; $Na_2\underline{S}O_3$, $2 + x + 3(-2) = 0$, $x = +4$; $\underline{S}O_4^{2-}$, $x + 4(-2) = -2$, $x = +6$

④ $H_3\underline{P}O_4$, $x = +5$; $Na_2H\underline{P}O_4$, $x = +5$; $\underline{P}O_4^{3-}$, $x - 8 = -3$, $x = 5$; $Na_2H\underline{P}O_3$, $x = +3$; $H_3\underline{P}O_2$, $x = +1$

⑤ $H\underline{Cl}O_4$, $x = 7$; $Na\underline{Cl}O_4$, $x = 7$; $\underline{Cl}O_4^-$, $x - 8 = -1$, $x = 7$; $NO\underline{Cl}O_4$, $+1 + x + 4(-2) = 0$, $x = +7$

⑥ $H\underline{Cl}O_3$, $x = 5$; $H\underline{Cl}O_2$, $x = 3$; $H\underline{Cl}O$, $x = 1$

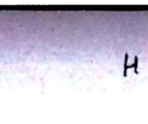
⑦ $H_2\underline{S}_2O_8$, $2 + 2x + 8(-2) = 0$, $x = 6$; $Na_2\underline{S}_4O_6$, $2 + 4x + 6(-2) = 0$, $x = 10/4 = 2.5$; $Na_2\underline{S}_2O_3$, $2 + 2x + 3(-2) = 0$, $x = 4/2 = 2$; $\underline{S}_2O_3^{2-}$, $2(-2) + 3x = -2$, $3x = 2$

⑧ $\underline{N}_2O_3$, $x = +3$; $\underline{N}_2O_4$, $x = 4$; $\underline{Fe}O$, $x = +2$; $\underline{Fe}_2O_3$, $x = 6/2 = 3$; $\underline{Fe}_3O_4$, $x = 8/3$

$\underline{Fe}_{0.94}O$

$0.94x + (-2) = 0$

$x = \frac{2}{0.94}$



peroxide O_2^{2-} → $Ba^{2+} + O_2^{2-}$

(9) Na_2O_2, $2x+2(-1)=0$, $2x=2 \Rightarrow x=1$; KO_2, $1+2x=0$, $x=-1/2$; BaO_2, $2+2x=0$, $x=-2/2=-1$

(10) Mn_2O_7, $2x+7(-2)=0$, $x=7$; Cr_2O_3, $2x+3(-2)=0$, $x=3$

(11) NH_3, $x+3\times1=0$, $x=-3$; PH_3, $x+3\times1=0$, $x=-3$; H_2S, $2x-2=0$, $x=1$; NaH, $x-1=0$, $x=+1$; CaH_2, $+2+2x=0$, $x=-2/2=-1$

(12) N_2H_4, $2x+4=0$, $x=-4/2=-2$; $NOCl$, $x-2-1=0$, $x=+3$; NH_4NO_3, $x+4=-1$, $x=-3$; $x+3(-2)=1$, $x=5$; NH_4^+ NO_3^-

(13) $KMnO_4$, $1+x+4(-2)=0$, $x=7$; MnO_4^{2-}, $x+4(-2)=-2$, $x=6$; $K_2Cr_2O_7$, $2+2x+7(-2)=0$, $x=6$; OsO_4, $x+4(-2)=0$, $x=8$

CrO_5, $x+5(-2)=0$, $x=+10$ ⇒ $x=+6$

(14) $K_4[Fe(CN)_6]$, $4+x-6=0$, $x=+2$; $K_3[Fe(CN)_6]$, $3+x-6=0$, $x=3$

(15) $K_3[Cu(CN)_4]$, $3+x-4=0$, $x=1$

(16) $FeSO_4(NH_4)_2 \cdot SO_4 \cdot 6H_2O$, $x+(-2)+2(+1)+(-2)+0=0$, $x=+2$

(17) $Fe.NO.(H_2O)_5.SO_4$, $x+1+0+(-2)=0 \Rightarrow x=1$ — Brown Ring Test → for NO_3^-

(18) $Na_2[Fe(CN)_5NO]$, $2+x-5+1=0 \Rightarrow x=2$

(19) KI_3, $1+3x=0$, $x=-1/3$; KIO, $1+x-2=0$, $x=1$; KIO_3, $1+x+3(-2)=0$, $x=5$; KIO_4, $1+x+4(-2)=0$, $x=7$

(20) FeC_2O_4, $x-2=0 \Rightarrow x=2$; $Fe_2(C_2O_4)_3$, $2x+3(-2)=0 \Rightarrow x=6/2=3$

(21) $C_2O_4^{2-}$, $2x+4(-2)=-2$, $x=6/2=3$; $H_2C_2O_4$, $2+2x+4(-2)=0 \Rightarrow x=6/2=3$

(22) P_4O_{10}, $4x+10(-2)=0$, $x=20/4=+5$; SO_3, $x+3(-2)=0$, $x=6$

(23) $S_4O_6^{2-}$, $4(-2)$, 2.5 ; H_2SO_5 → Caro's acid, $2+x+5(-2)=0$, $x=8$, $x=6$; $Ca_3(PO_4)_2$, $3(+2)+2x+8(-2)=0$, $6+2x-16=0$, $-10+2x=0$, $x=5$

Application of O.N.:-

To determine strength of acid or base :-

A.S. $\propto$ O.N. of C.A.

$$B.S. \propto \frac{1}{\text{O.N. of C.A.}}$$

A.S.

$$\overset{+5}{H}\overset{+5}{N}O_3 > \overset{+3}{H}\overset{+3}{N}O_2$$

$$H_2\overset{+6}{S}O_4 > H_2\overset{+4}{S}O_3$$

$$\overset{+1}{H}\overset{+1}{Cl}O < \overset{+3}{H}\overset{+3}{Cl}O_2 < \overset{+5}{H}\overset{+5}{Cl}O_3 < \overset{+7}{H}\overset{+7}{Cl}O_4$$

* $\overset{+5}{H_3}\overset{+5}{P}O_4 < \overset{+3}{H_3}\overset{+3}{P}O_3 < \overset{+1}{H_3}\overset{+1}{P}O_2$

pKa: 2.1 < 1.5 < 1.3

B.S.

$$\overset{+1}{Na}OH > \overset{+2}{Ca}(OH)_2 > \overset{+3}{Al}(OH)_3$$

To determine oxidising agent & Reducing Agent

Oxidising Agent :- which accept $e^{\ominus}$ in chemical reac^n is c/a O.A.

generally O.A. जो अपनी Max^m O.S. मे हो।

Reducing Agent : which donate $e^{\ominus}$ in chemical reac^n is c/a R.A.

generally R.A. जो अपनी Min^m O.S. मे हो।

Max^m O.S.	+1	+4	+5	+2	0	+5	+6	+7	+6	+7	+3	+8	+8
elements	H	C	N	O	F	P	S	Cl	Co	Mn	Fe	Os	Ru
min^m O.S.	-1	-4	-3	-2	-1	-3	-2	-1	0	0	0	0	0

$KMnO_4$, $K_2Cr_2O_7$, $HClO_4$, H_2SO_4, HNO_3 → works as O.A.
→ max. O.S.

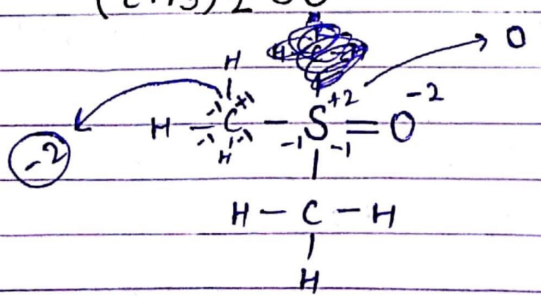
$\underline{N}H_3$, $H_2\underline{S}$, $H\underline{Cl}$, $\underline{C}H_4$, PH_3 → work as R.A.
min^m O.S.

SO_2 , HNO_2 , $HClO_2$, MnO_2 → work as O.A./R.A.
+4 +3 +3 +4 → b/w max^m & min^m O.S.

Ques Which of the following work as O.A./R.A. or both

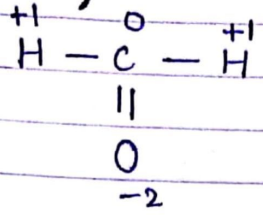
1. $\overset{+3}{H_3}\overset{+5}{P}\overset{-8}{O_4}$ O.A.
2. $\overset{+2}{H_2}\overset{+6}{S}\overset{-8}{O_4}$ O.A.
3. $\overset{+2}{K_2}\overset{+6}{Cr_2}\overset{-14}{O_7}$ O.A.
4. $\overset{+5}{N_2}O_5$ O.A.
5. $\overset{+1}{H_2}S$ O.A
6. $\overset{-3}{N}H_3$ R.A.
7. $\overset{+1}{H_2}O_2$ O.A.
8. $\overset{+1}{H_2}O$ O.A
9. $\overset{+1}{H}Br$ O.A
10. $\overset{+1}{H}I$ O.A
11. $\overset{+3}{N_2}O_3$ both
12. $H_2\overset{+4}{S}O_3$ both
13. $K\overset{+7}{Mn}O_4$ O.A.
14. $\overset{+4}{Mn}O_2$ both
15. $\overset{+3}{Cr_2}O_3$ both

* $(CH_3)_2SO$



E.N. :- $C_{sp} > C_{sp^2} > C_{sp^3}$
3.25 2.75 2.5

Ques Find O.N. of C in oxalic acid & formaldehyde H-CHO



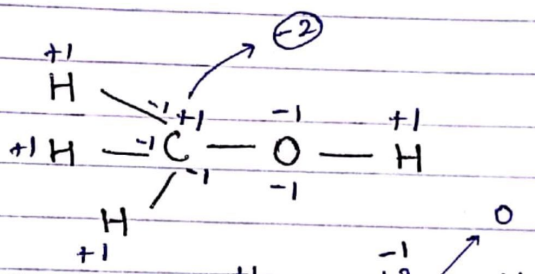
COOH
|
COOH

$H_2C_2O_4$

$2(+1) + 2x + 4(-2) = 0$

$x = 3$

*

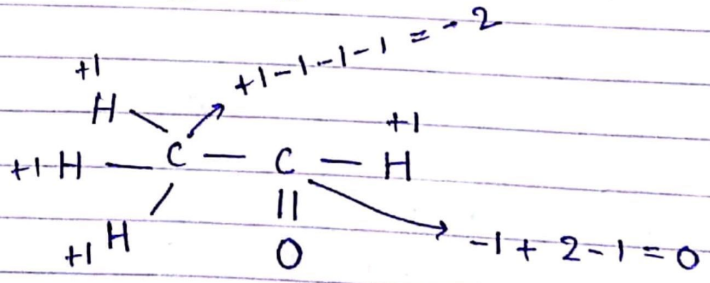


$CH_3^{\oplus}$

$x + 3 = +1$

$x = -2$

CH_3-CHO

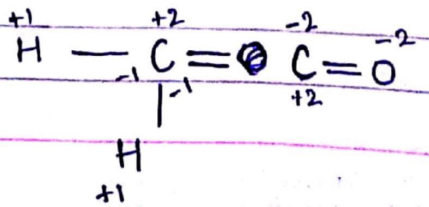


H_2C_2O

$x = -1$

$2 + 2x - 2 = 0$

$2x = 0$



To determine M.F. of a compound :-

Sum of O.S. of all atoms in a molecule is zero

Ques A compound consist of elements X, Y & Z has O.S. +1, +6 & −2 on X, Y & Z resp. then what is M.F. of that compound.

(1) $X_2Y_2Z_7$
(2) XYZ
(3) X_2YZ
(4) both 1 & 3

$X_2YZ_4 \rightarrow 2(+1) + (+6) + 4(-2) = 0$

eg $X \rightarrow +1$
$Y \rightarrow +7$
$Z \rightarrow -2$

XYZ_4

To determine equivalent weight :-

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

n-factor = no. of $e^{\ominus}$ lost or gained in 1 mol compd. (OA / R.A.)

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

$Cl_2 + 2e^{\ominus} \rightarrow 2Cl^-$

$E_{Cl_2} = \frac{M_{Cl_2}}{2}$ $\qquad E_{Cl^-} = \frac{M_{Cl^-}}{2/2} = \frac{M_{Cl^-}}{1}$

$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^{\ominus}$

$E_{C_2O_4^{2-}} = \frac{M_{C_2O_4^{2-}}}{2}$

$E_{CO_2} = \frac{M_{CO_2}}{2/2} = \frac{M_{CO_2}}{1}$

$2NH_3 \longrightarrow N_2 + 6H^+ + 6e^\ominus$

$E_{NH_3} = \frac{M_{NH_3}}{3} = \frac{M_{NH_3}}{3}$

$E_{N_2} = \frac{M_{N_2}}{6}$

$K_2\overset{+6}{Cr_2}O_7 + 6e^\ominus \longrightarrow 2Cr^{3+}$

$E_{K_2Cr_2O_7} = \frac{M_{K_2Cr_2O_7}}{6}$

$E_{Cr^{3+}} = \frac{M_{Cr^{3+}}}{3} = \frac{M_{Cr^{3+}}}{3}$

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

$x - 8 = -1$, $x = 7$

$E_{MnO_4^-} = \frac{M_{MnO_4^-}}{5}$

$E_{Mn^{2+}} = \frac{M_{Mn^{2+}}}{5}$

$Ba(MnO_4)_2 + 10e^- \longrightarrow 2Mn^{2+}$

$BaMn_2O_8$, $+7$

$E_{Ba(MnO_4)_2} = \frac{M_{Ba(MnO_4)_2}}{5}$

$E_{Mn^{2+}} = \frac{M_{Mn^{2+}}}{5}$

$CuSO_4 \longrightarrow Cu^+$

$E_{CuSO_4} = \frac{M_{CuSO_4}}{1}$

$\overset{+4}{Mn}O_2 \longrightarrow Mn^{2+}$

$E_{MnO_2} = \frac{M_{MnO_2}}{2}$

$\overset{+2}{Na_2}\overset{+2}{S_2}O_3 + \overset{0}{I_2} \longrightarrow \overset{2.5}{Na_2}S_4O_6 + 2\overset{-1}{NaI}$

$E_{Na_2S_2O_3} = \frac{M_{Na_2S_2O_3}}{0.5 \times 2}$

$E_{I_2} = \frac{M_{I_2}}{1}$ $\qquad E_{NaI} = \frac{M_{NaI}}{1/2}$

$E_{Na_2S_4O_6} = \frac{M_{Na_2S_4O_6}}{0.5 \times 4}$

$-1e^{\ominus}$

$\overset{+2}{Fe}\overset{-2}{S} \longrightarrow Fe^{3+} + \overset{+6}{S}O_3$

$+8e^{\ominus}$

$E_{FeS} = \frac{M_{FeS}}{1+8}$ $\qquad E_{SO_3} = \frac{M_{SO_3}}{8}$

$E_{Fe^{3+}} = \frac{M_{Fe^{3+}}}{1}$

$\overset{+2}{Fe}\overset{-1}{S_2} \longrightarrow Fe^{3+} + \overset{+6}{S}O_3$ ($-1e^{-}$)

$-7e^{\ominus} \times 2$

$E_{FeS_2} = \frac{M_{FeS_2}}{1+14} = \frac{M_{FeS_2}}{15}$

$S + \overset{+3}{Fe_2}\overset{-2}{O_3} \longrightarrow 2\overset{+2}{Fe}\overset{-2}{SO_4}$ (S: 0 → −2)

$+1e \times 2$

$E_{Fe_2O_3} = \frac{M_{Fe_2O_3}}{2}$

$\overset{+3}{Fe_2}(C_2O_4)_3 \longrightarrow 2Fe^{3+} + \overset{+4}{C}O_2$ (C: 0 → +4)

$-1e \times 2$

$E_{Fe_2(C_2O_4)_3} = \frac{M_{Fe_2(C_2O_4)_3}}{2}$

V. Imp

$KMnO_4$

in acidic medium :-

$Mn^{7+}O_4^- \longrightarrow Mn^{2+}$ $\quad E = \frac{M}{5}$

in neutral medium :-

$Mn^{7+}O_4^- \longrightarrow Mn^{4+}O_2$ $\quad E = \frac{M}{3}$

in basic medium :-

$Mn^{+7}O_4^- \longrightarrow Mn^{+6}O_4^{2-}$ $\quad E = \frac{M}{1}$

$K_2Cr_2O_7$

in acidic medium :-

$Cr_2^{+6}O_7^{2-} \longrightarrow 2Cr^{3+}$ $\quad E = \frac{M}{6}$

$KI^{-1} \xrightarrow[\text{basic}]{OH^-} KI^{+3}O_2$ $\quad E = \frac{M}{4}$

30/10/17

Oxidation

Modern Concept loss of $e^\ominus$

O.S. ↑

$C^0 \rightarrow C^{4+} + 4e^\ominus$

$A \rightarrow A^{n+} + ne^\ominus$

$Mn^{2+} \rightarrow Mn^{7+} + 5e^\ominus$

$A^{n_1+} \rightarrow A^{n_2+} + (n_2-n_1)e^\ominus \quad n_2>n_1$

$Cl^{-1} \rightarrow Cl^0 + e^\ominus$

$A^{-n_1} \rightarrow A^0 + n_1e^\ominus$

$O^{2-} \rightarrow O^- + e^\ominus$

$A^{-n_1} \rightarrow A^{-n_2} + (n_1-n_2)e^\ominus$

$n_1>n_2$

Reduction

gain of $e^\ominus$

O.S. ↓

$F^0 \longrightarrow F^-$

$A^0 + n_1e^\ominus \longrightarrow A^{-n_1}$

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

$A^{-n_1} + (n_2-n_1)e^\ominus \longrightarrow A^{-n_2} \quad n_2>n_1$

$Fe^{2+} + 2e^\ominus \longrightarrow Fe^0$

$A^{+n_1} + n_1e^\ominus \longrightarrow A^0$

$Cl^{+7} + 6e^\ominus \longrightarrow Cl^{+1}$

$A^{+n_1} + (n_1-n_2)e^\ominus \longrightarrow A^{n_2+} \quad n_1>n_2$

Oxidation

Old concept

- addition of oxygen

$\overset{0}{C} + O_2 \longrightarrow \overset{+4}{CO_2}$

$\overset{0}{Zn} + O \longrightarrow \overset{+2}{ZnO}$

- removal of H

$H_2\overset{-2}{S} + Cl_2 \longrightarrow \overset{0}{S} + HCl$

- addition of E.N. atom

$\overset{0}{H_2} + \overset{0}{F_2} \longrightarrow 2\overset{+1}{H}\overset{-1}{F}$

$\overset{0}{Mg} + Cl_2 \longrightarrow \overset{+2}{Mg}Cl_2$

- removal of electropositive element

$\overset{-3}{N}H_3 \longrightarrow \overset{0}{N_2}$

Reduction

- addition of Hydrogen

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

$H_2 + \frac{1}{2}\overset{0}{O_2} \longrightarrow \overset{-2}{H_2O}$

- removal of O

$\overset{+2}{MgO} + C \longrightarrow \overset{0}{Mg} + CO$

$\overset{0}{C} + \overset{+1}{H_2}O \longrightarrow \overset{+2}{CO} + \overset{0}{H_2}$

- addition of electropositive element

$\overset{+2}{Hg}Cl_2 + Hg \longrightarrow \overset{+1}{Hg_2}Cl_2$

$\overset{+2}{Cu}Cl_2 + Cu \longrightarrow \overset{+1}{Cu_2}Cl_2$

- removal E.N. atom

$\overset{+1}{H}I \longrightarrow \overset{0}{H_2} + I_2$

Type of Redox reactions :-

1. Inter Molecular Redox Reac^n :-

In these type of reac^n, oxidation & reduction takes place b/w different molecule simultaneously.

eg $\overset{+2}{Sn}Cl_2 + \overset{+3}{Fe}Cl_3 \longrightarrow \overset{+4}{Sn}Cl_4 + \overset{+2}{Fe}Cl_2$

$Sn^{2+} \longrightarrow Sn^{4+}$ (ox.)

$Fe^{3+} \longrightarrow F^{2+}$ (Red.)

$$\overset{+7}{K}\overset{+7}{Mn}O_4 + \overset{+2}{Fe}SO_4 + H_2SO_4 \longrightarrow \overset{+2}{Mn}SO_4 + K_2SO_4 + \overset{+3}{Fe_2}(SO_4)_3 + H_2O$$

2. Intramolecular Redox Reac^n :-

In these type of reac^n, oxidation & reduction takes place within a same molecule.

$KClO_3 \xrightarrow{\Delta} KCl + 3/2\,O_2$

$Cl^{5+} \longrightarrow Cl^{-1}$ (red.)

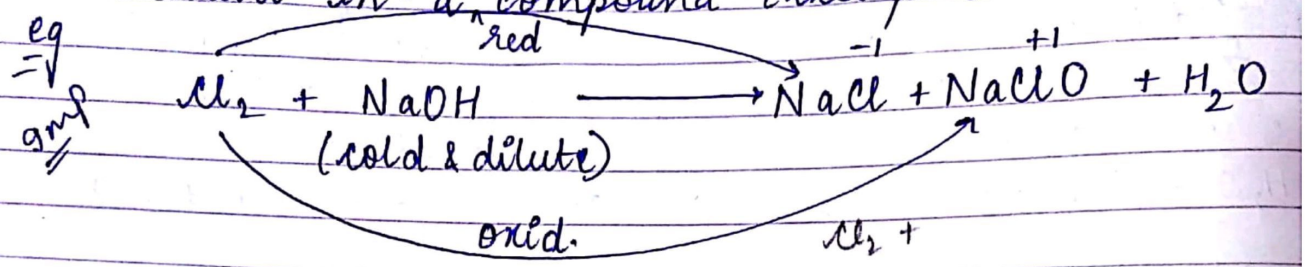
$O^{2-} \longrightarrow O^{0}$ (oxid.)

3. Disproportionation reacⁿ :-

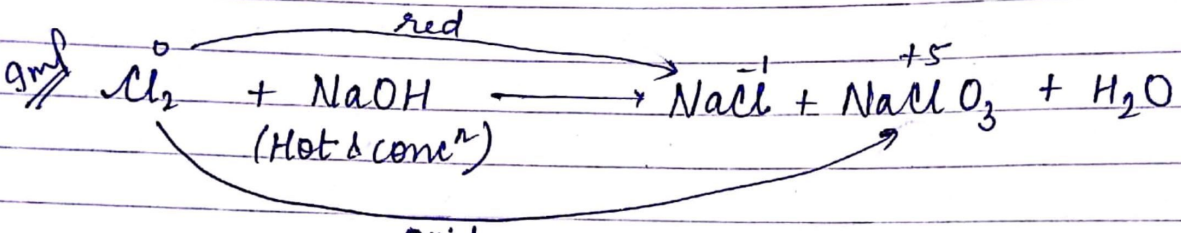
In these type of reacⁿ, oxidation & reduction of an element in a single compound takes place.

eg

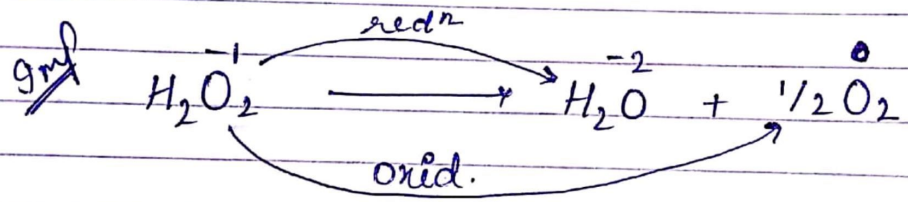
gmf



gmf

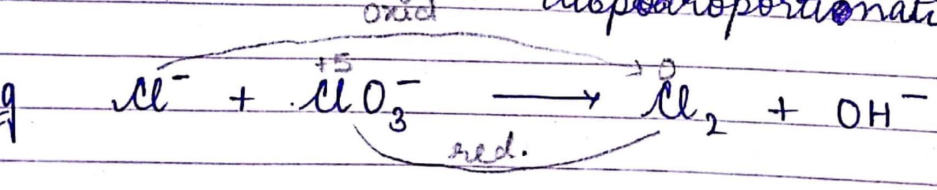


gmf



4. Comproportionation reacⁿ :- It is reverse of disproportionation.

eg



Balancing of Redox Reac^n :-

Step-1 Balance the following reac^n and find spectator ion.

$KMnO_4 + FeSO_4 + H_2SO_4 \rightarrow MnSO_4 + K_2SO_4 + Fe_2(SO_4)_3 + H_2O$

$K^+ + MnO_4^- + Fe^{2+} + SO_4^{2-} + 2H^+ + SO_4^{2-} \rightarrow Mn^{2+} + SO_4^{2-} + 2K^+ + SO_4^{2-} + Fe^{3+} + 3SO_4^{2-} + H_2O$

Spectator ion : K^+, SO_4^{2-}

↳ Those ions which do not undergo any reduction & oxidation in chemical reac^n

$$MnO_4^- + Fe^{2+} + 2H^+ \longrightarrow Mn^{2+} + Fe^{3+} + H_2O$$

1. Ion Electron Method :

In acidic Medium :

① Write 2 half reac^n — Oxid. / Red.

② balance 1st half reac^n

balance
- central atom
- oxygen (addition of H_2O on another side)
- hydrogen (addition of H^+ on another side)
- charge (addition of $e^\ominus$)

③ Similarily balance 2nd half reac^n

④ Add both reac^{n}s by multiplying proper stoichiometry coefficients so that $e^\ominus$ get cancelled out.

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

eg $MnO_4^- + Fe^{2+} + H^+ \longrightarrow Mn^{2+} + Fe^{3+} + H_2O$

1st half reac^n : $MnO_4^- \longrightarrow Mn^{2+}$ (red.)

$Fe^{2+} \longrightarrow Fe^{3+}$ (oxid.)

$MnO_4^- \longrightarrow Mn^{2+}$ · central atom is balanced

balance O-atoms by adding H_2O on another side

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

balance H - atoms by adding $H^{\oplus}$ ion on another side

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

Balance charge

$5e^{\ominus} + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$ — ①

$5e^{\ominus} + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$ — ①

$5[Fe^{2+} \longrightarrow Fe^{3+} + e^{\ominus}]$ — ②

① + ② × 5

$8H^+ + MnO_4^- + 5Fe^{2+} \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

eg $Cr_2O_7^{2-} + C_2O_4^{2-} \xrightarrow{H^{\oplus}} Cr^{3+} + CO_2$

1st half $\overset{+6}{Cr_2O_7^{2-}} \longrightarrow \overset{+3}{Cr^{3+}}$ (red)

2nd half $\overset{+3}{C_2O_4^{2-}} \longrightarrow \overset{+4}{CO_2}$ (oxid)

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

$Cr_2O_7^{-2} \longrightarrow 2Cr^{3+} + 7H_2O$

$14H^+ + Cr_2O_7^{-2} \longrightarrow 2Cr^{3+} + 7H_2O$

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

$3 \times (C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-)$

$3C_2O_4^{2-} \longrightarrow 6CO_2 + 6e^{\ominus}$

$14H^+ + Cr_2O_7^{-2} + 3C_2O_4^{2-} \longrightarrow 2Cr^{3+} + 7H_2O + 6CO_2$

eg $Mn_3O_7 \xrightarrow{H^+} Mn^{2+} + \overset{+7}{MnO_4^-} + H_2O$

$17/3 = 4.$

$Mn_3O_7 \longrightarrow MnO_4^-$ (oxid.)

$Mn_3O_7 \longrightarrow Mn^{2+}$ (Red.)

$9e^{\ominus} + 6H^+ + Mn_3O_7 \longrightarrow 3MnO_4^- + 3H_2O$

$[8e^- + 14H^+ + Mn_3O_7 \longrightarrow 3Mn^{2+} + 7H_2O] \times 7$

$[5H_2O + Mn_3O_7 \longrightarrow 3MnO_4^- + 10H^+ + 7e^-] \times 8$

$98H^+ + 7Mn_3O_7 + 40H_2O + 8Mn_3O_7 \rightarrow 21Mn^{2+} + 49H_2O + 24MnO_4^- + 80H^+$

$18H^+ + 15Mn_3O_7 \longrightarrow 21Mn^{2+} + 24MnO_4^- + 9H_2O$

$E = \frac{M}{n\text{-factor}} = \frac{M}{56/15}$

eg $\overset{+3}{C_2}O_4^{2-} \xrightarrow{+1\times2} \overset{+4}{2CO_2} + 2e^-$ ($+1$ back)

$E = \frac{M}{2}$ $\qquad E = \frac{M}{2/2} = \frac{M}{1}$

eg $H_2O + SO_3^{2-} \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$

$E = \frac{M}{2}$ $\qquad E = M/2$

eg $\overset{+2\ -2}{FeS} \xrightarrow{-1e^-} Fe^{3+} + \overset{+6}{SO_3}$ ($-8e^-$)

$E = \frac{M}{1+8} = \frac{M}{9}$ $\qquad E = \frac{M}{1}$ $\qquad E = \frac{M}{8}$

eg $\overset{+2\ -1}{FeS_2} \xrightarrow{-1e^-} Fe^{3+} + 2\overset{+6}{SO_3}$ ($7e^- \times 2$)

$E = \frac{14}{15}$ $\qquad E = \frac{M}{14/2}$

eg $2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^-$

$E = \frac{M}{2/2}$ $\qquad E = \frac{M}{2}$

In basic medium :-

→ Write 2 half reacⁿ

→ Balancing of 1st half reacⁿ
- central atom
- O - atom (addition of H_2O)
- H - atom (addition of H^+)
- to balance H^+ ion add same no. of OH^- ions on both side
- balance charge (by adding $e^\ominus$)

→ Similarly balance 2nd half reacⁿ

- add both reacⁿ by multiplying proper stoichiometr coefficient so that $e^\ominus$ gets cancel out both by side.

eg $Cr(OH)_3 + IO_3^- \longrightarrow CrO_4^{2-} + I^-$

$\overset{+3}{Cr}(OH)_3 \longrightarrow \overset{+6}{Cr}O_4^{2-}$ oxid.

$\overset{+5}{I}O_3^- \longrightarrow I^-$ red.

~~$Cr(OH)_3 \Longrightarrow CrO_4^{2-}$~~

$\times \quad IO_3^- \longrightarrow I^- + 3H_2O$

$6H^+ + IO_3^- \longrightarrow I^- + 3H_2O$

~~$6OH^- + 6H^+ + IO_3^- \longrightarrow I^- + 3H_2O$~~ $+ 6OH^-$ (1)

$5OH^- + H_2O + Cr(OH)_3 \longrightarrow CrO_4^{2-} + 5H^+ + 5OH^-$

$5H^+ + 5OH^- \rightarrow 5H_2O$

$5OH^- + Cr(OH)_3 \longrightarrow CrO_4^{2-} + 4H_2O + 3e^-$

$(5OH^- + Cr(OH)_3 \longrightarrow CrO_4^{2-} + 4H_2O + 3e^{\ominus}) \times 2$ — ①

$10OH^- + 2Cr(OH)_3 \longrightarrow 2CrO_4^{2-} + 8H_2O + 6e^{\ominus}$

$6OH^- + 6H^+ + IO_3^- \longrightarrow I^- + 3H_2O + 6OH^-$

$6H_2O$

$6e^{\ominus} + 3H_2O + IO_3^- \longrightarrow I^- + 6OH^-$ — ②

$4OH^- + 2Cr(OH)_3 + IO_3^- \longrightarrow 2CrO_4^{2-} + 5H_2O$

eg $Cl_2 + OH^- \longrightarrow Cl^- + ClO^-$

$2e^{\ominus} + Cl_2 \longrightarrow 2Cl^-$ — ①

$4OH^- + 2H_2O + Cl_2 \longrightarrow 2ClO^- + 4H^+ + 4OH^-$

$4H_2O$

$4OH^- + Cl_2 \longrightarrow 2ClO^- + 2H_2O + 2e^{\ominus}$ — ②

① + ②

$4OH^- + 2Cl_2 \longrightarrow 2Cl^- + 2ClO^- + 2H_2O$

$2OH^- + Cl_2 \longrightarrow Cl^- + ClO^- + H_2O$

$Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$

cold & dil

eg $Cl_2 + OH^- \longrightarrow Cl^- + ClO_3^- + H_2O$

$5 \times (2e^- + Cl_2 \longrightarrow 2Cl^-)$ — ①

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

$12H_2O$

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

5 × ① + ②

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

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

$3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$

(hot & conc^n)

Neutral Medium :-

$$Ag^+ + Zn \longrightarrow Zn^{2+} + Ag$$

① $Zn \longrightarrow Zn^{2+} + 2e^{\ominus}$

② $Ag^+ + e^- \longrightarrow Ag$

① + 2 × ②

$$Zn + 2Ag^+ \longrightarrow Zn^{2+} + 2Ag$$

Oxidation No. Method :-

It is based on the fact that ↑se in O.N. = ↓se in O.N.

1. Write O.N. of all Elements.
2. Write 2 half reac^{n}s
3. Balance charge by cross multiplication & add both half reac^{n}s.
4. Balance rest of atoms by hit & trial method.
   → O-atom by $H^{\oplus}$ & H_2O in acidic medium
   → O- atom by OH^- & H_2O in basic medium
5. Finally balance charge by addition of H^+

$$\overset{+1\ +5\ -2}{HNO_3} + \overset{+1\ -1}{HI} \longrightarrow \overset{0}{I_2} + \overset{+2\ -2}{NO} + \overset{+1\ -2}{H_2O}$$

(+3e⁻ : HNO₃ → NO ; −1e⁻ : HI → I₂)

$$[\overset{+5}{HNO_3} \longrightarrow \overset{+2}{NO}] \times 1 \quad \text{red}^n$$

(+3e⊖ × 1)

$$[\overset{-1}{HI} \longrightarrow 1/2\ \overset{0}{I_2}] \times 3 \quad \text{oxid.}$$

(−1e⊖ × 3)

$$HNO_3 + 3HI \longrightarrow NO + 3/2\ I_2 + 2H_2O$$

$$2HNO_3 + 6HI \longrightarrow 2NO + 3I_2 + 4H_2O$$

$+5e^-$

$\overset{+1}{K}\overset{+7}{Mn}\overset{-2}{O_4} + \overset{+1}{H_2}\overset{+3}{C_2}\overset{-2}{O_4} \longrightarrow \overset{+2}{Mn}\overset{-2}{O} + \overset{+1}{K_2}\overset{-2}{O} + \overset{+4}{C}\overset{-2}{O_2}$

$-1e^{\ominus} \times 2$

$+5e^-$

$[\overset{+7}{K}\overset{+7}{Mn}O_4 \longrightarrow \overset{+2}{Mn}O] \times 2$

$[H_2\overset{+3}{C_2}O_4 \longrightarrow 2\overset{+4}{C}O_2] \times 5$

$-1e \times 2$

$2KMnO_4 + 5H_2C_2O_4 \longrightarrow 2MnO + 10CO_2 + K_2O + 5H_2O$

$\overset{+1}{K_2}\overset{+6}{Cr_2}\overset{-2}{O_7} + \overset{+2}{Fe}\overset{+6}{S}\overset{-2}{O_4} + \overset{+1}{H_2}\overset{+6}{S}\overset{-2}{O_4} \longrightarrow \overset{+3}{Cr_2}(\overset{+6}{S}\overset{-2}{O_4})_3 + \overset{+3}{Fe_2}(\overset{+6}{S}\overset{-2}{O_4})_3 + \overset{+1}{K_2}\overset{+6}{S}\overset{-2}{O_4}$

$+3e^{\ominus} \times 2 = 6e^{\ominus}$

$[K_2\overset{+6}{Cr_2}O_7 \longrightarrow \overset{+3}{Cr_2}(SO_4)_3] \times 1$

$[2\overset{+2}{Fe}SO_4 \longrightarrow \overset{+3}{Fe_2}(SO_4)_3] \times 3$

$-1e \times 2 = 2e^{\ominus}$

$K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \rightarrow Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + K_2SO_4 + 7H_2O$

Equivalent Concept :-

no. of eq. $= \frac{w}{E} = N \times V(L)$

or

g. eq. $\qquad E = \frac{M}{n\text{-factor}}$

g. eq. $= \frac{w}{\frac{M}{n\text{-factor}}} = n \times n\text{-factor}$

g. eq. $= \frac{w}{E} = n \times n\text{-factor} = NV(\ell)$

Law of Chemical Equivalence :-

$m_1 A + m_2 B \longrightarrow n_1 C + n_2 D$

g.eq. of A = g.eq. of B = g.eq. of C = g.eq. of D

g.eq. of O.A. = g.eq. of R.A.

Note : If g.eq. of O.A. & R.A. are given then compd. which have less no. of g.eq. is c/a Limiting Reagent

Ques Find no. of moles of $KMnO_4$ required to oxidise 2 moles of ferrous oxalate in acidic medium

$KMnO_4 \longrightarrow Mn^{2+}$ acidic n-factor = 5

$KMnO_4 \longrightarrow Fe(C_2O_4)$

$Fe^{+2} C_2O_4^{+3} \longrightarrow Fe^{3+} + 2 C^{+4}O_2 + 2e^-$ n-factor = 3

g.eq. of $KMnO_4$ = g.eq. of $C_2O_4^{2-}$

$n \times 5 = 3 \times 2$

$n = 0.8$

$n = 6/5$

Ques Calculate Normality of a sol^n containing 15.8 g $KMnO_4$ in 50 ml acidic sol^n

$KMnO_4 \longrightarrow Mn^{2+}$ acidic n-factor = 5

$N = \frac{\text{no. of g.eq}}{V} = \frac{15.8/158 \times 5}{50/1000}$

$KMnO_4$ acidic n-factor = 5

$n \times n\text{-factor} = N \times V(L)$

$\frac{158}{158} \times 5 = N \times \frac{50}{1000}$

$N = 10N$

Ques Find vol^n of HNO_3 (2M) required to convert 8g ferrous ion to ferric ion if HNO_3 is converted to NO molecule.

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

$HNO_3 \xrightarrow{+3e^\ominus} NO$ (+5 → +2) n-factor = 3

g.eq. of HNO_3 = g.eq. of Fe^{2+}

M × n-factor × V = n × n-factor

$2 \times 3 \times V = \frac{8}{56} \times 1$

$V = \frac{8}{56 \times 6}$

Q. Find no. of moles of $KMnO_4$ required to oxidise 2 mol KI in basic medium.

$MnO_4^- \longrightarrow MnO_4^{2-}$ in basic medium n-factor = 1

$KI \longrightarrow IO^-$ (+1, −1 → +1) n-factor = 2 (−2e)

$n \times 1 = 2 \times 2$

$n = 4$

no. of g.eq. of $KMnO_4$ = g.eq. of KI

$n \times$ n-factor = n-factor $\times n$

$n \times 1 = 2 \times 2$

$n = 4$ mol

Ques Find no. of moles of Barium Permangnate required to oxidise 2 mol of oxalate ion. (↳ acidic)

$Ba(MnO_4)_2 \longrightarrow Mn^{2+}$ n-factor = 5

$C_2O_4^{2-} \longrightarrow 2CO_2$ (+3 → +4) n-factor = 2

$-1e^- \times 2 = 2$

g.eq. of $Ba(MnO_4)_2$ = g.eq. of $C_2O_4^{2-}$

n × n factor = n × n-factor

$n \times 5 = 2 \times 2$

$n = \frac{4}{5}$

Ques In the reaction $X + Y \rightarrow XY$ 10 g eq. of oxidant X require 5 g.eq. of Y to give 100 ml XY Find Normality of XY

L.R. = Y

$$\text{Normality}_{XY} = \frac{\text{no. of g.eq.}}{\text{Vol (L)}}$$

$$= \frac{5}{\frac{100}{1000}} = 50\ N$$

Ques Find wt. of MnO_2 reduced by 25 ml, 0.16 N oxalic acid.

$$\overset{+4}{MnO_2} \rightarrow Mn^{2+} \quad \text{n-factor} = 2$$

$$H_2\overset{+3}{C_2}O_4 \rightarrow 2\overset{+4}{C}O_2 \quad \text{n-factor} = 2$$

(-1e × 2)

g.eq. of MnO_2 = g.eq. of $H_2C_2O_4$

$\frac{W}{Mt} \times$ n-factor = N × V

$$W = \frac{0.16 \times 25}{2 \times 100 \times 1000} \times \frac{87}{5}$$

$$= \frac{1}{500} \times = 0.1$$