REDOX REACTION

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Redox = Reduction and oxidation both simultaneously.

Oxidation State :

→ Kisi atom par aya uska khudka charge.

• Let EN of B > EN of A ⇒ $\overset{\delta+}{A}—\overset{\delta-}{B}$

→ charge arises on each atom individually / Real / Hypothetical

Oxidation Number:

→ Average charge on each atom.

Eg:- $B-\overset{+2}{A}-\overset{+3}{A}-B-C$

ON of A = 5/2

→ ON can be +ve, -ve or zero, fractional

→ OS can be 0, +ve or -ve, but not fractional

Methods to calculate OS and ON:

Method:1 Structural Rule (Never fails)

Method:2 Summation Rule (Have limitation)

① Structural Rule: (① Structure ② Bond)

• **Ionic Bond**

Cation :- charge on it

Anion :- charge on it

$\overset{+1}{Na}\overset{-1}{Cl}$

$\overset{+3}{Al}\overset{-1}{Cl_3}$ (common)

• **Covalent Bond**

$\overset{+1}{A}—\overset{-1}{B}$ $\quad \overset{+2}{A}=\overset{-2}{B}$ $\quad \overset{+3}{A}\equiv\overset{-3}{B}$ $\quad (\overset{EN}{B>A})$

[Hetero atoms]

For Homoatoms; $\mathring{A}-\mathring{A}$ $\quad \mathring{A}=\mathring{A}$

Charge → zero, Bic EN diff = 0

***Order of EN:-**

F > O > Cl > N > Br > S > C > I > P > H

• **Coordinate Bond**

For Homoatoms :- $\overset{+2}{A}\longrightarrow\overset{-2}{A}$ $\quad \overset{+2}{B}\longrightarrow\overset{-2}{B}$

For Heteroatoms :-

1) If there is donation of e⁻ towards more EN atom then charge considered as +2 and -2

$\overset{+2}{A}\longrightarrow B^{-2}$ [EN B > EN of A]

• If there is donation of e⁻ towards less EN atom, then charge arises will be 0.

$\mathring{A}\longleftarrow\mathring{B}$ (EN B > EN A)

ex:- $\overset{+1}{H}—\overset{+3}{C}\equiv\overset{-3}{N}$ (cyanide) $\quad \overset{+1}{H}—\overset{-2}{N}\rightleftharpoons\overset{+2}{C}$ (Isocyanide)

• ON C = +2	• ON N = -3
• ON N = -3	ON C = +2
• ON H = +1	ON H = +1

② Summation Rule

a) Normal compounds :-

eg. $\overset{+1}{A}\,\underline{B}\,\overset{+2}{C}$ $\quad 1+x+2=0$ $\quad (x=-3)$ [B]

• $\overset{+1}{A}\underline{B_2}\overset{+2}{C}$ $\quad 1+2x+2=-2$ $\quad 2x=-5$ $\quad \boxed{x=-5/2}$

b) Complex compounds :-

ML_x $\quad M$ = Central metal Atom $\quad L_x$ = Ligand

Neutral	+ve	-ve
$CO, H_2O, NH_3, C_2H_2, C_2H_4$	$NO^+, NO_2^+, CH_3^+, C_2H_5^+$	CN^-, SCN^-, X^-.

eg:- $\underline{Ni}(CO)_4$ $\quad x+0=0$ $\quad x=0$

$[\underline{F}e(CN)_6]^{-4}$ $\quad x+(-1)6=-4$ $\quad x-6=-4$ $\quad x=+2$

RULES TO DETERMINE OS and ON :-

1) ON of neutral ligands = 0
2) ON of Elements in free state = 0
   [Non Bonded atoms i.e Au, Ag, Ca(s)]
3) ON of elements in Homopolyatomic = 0
   ([Br_2, F_2, P_4, S_8, etc] → ON will be zero but OS may or may not be)
4) ON of elements in allotrophic form = 0
5) ON of each atoms in amalgam = 0
   [Na-Hg]
6) ON of elements in Alloys = 0
   [Brass, Bronze, Duralumin]
7) ON of Flourine = -1 (Always) (Bonded)
8) ON of Alkali metals = +1
9) ON of Alkaline Earth Metals = +2
10) ON of Hydrogen = 1 except [Metal Hydride = -1]

11) ON of oxygen is from +2 to −2.

oxide $= O^{-2}$ (CaO) Superoxide $= O_2^{-1}$ (KO_2)

Peroxide $= O_2^{-2}$ (H_2O_2) Ozonoid $= -1/3$ (KO_3)

- $OF_2 = +2$ [oxygen difluoride]
- $O_2F_2 = +1$ [Dioxygen difluoride]

12) ON of sulphur in sulphide (S^{-2}) $= -2$

While calculation of charge we always use summation Rule

ON → fractional = Draw structure

↓

[OS will be different from ON] (Mixed oxide)

ON > Maximum Range (Peroxy debho)

eg. Fe_3O_4 $\quad 3x + 4(-2) = 0$

$3x - 8 = 0$

$x = 8/3$ [ON]

- CrO_5 without structure

$x + (-2)5 = 0$ (max = +6)

$x = +10$ (X)

1 peroxy

$Cr(O_3)(O_2)$

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

$x - 6 - 2 = 0$

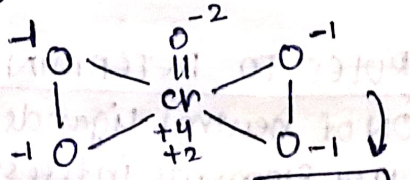
$x = +8$ (X)

2 peroxy

$Cr(O)[O_4]$

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

$x = +6$ (✓)



$x = +6$

Oxidation

→ Increase in ON

$A^0 \longrightarrow A^{+2} + 2e^-$

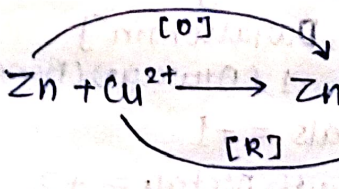
- Loss of e^-
- Addn of EN atom
- Addn of Oxygen

Reduction

→ Decrease in ON

$B^0 + 2e \longrightarrow B^{-2}$

- Gain of e^-
- Addn of EP atom
- Addn of Hydrogen



O + R

↓

Redox

Types of Redox Reaction :-

a) Intramolecular Redox

↳ within same molecule

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

b) Intermolecular Redox

↳ Between 2 different molecules.

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

1) Combination Rxn
2) Decomposition Rxn
3) Displacement Rxn (Electrochem)
4) Disproportionation Rxn
5) Comproportionation Rxn.

① Combination Reaction

$A + B \longrightarrow C$

→ Either A or B or both must be in elemental form.

eg: $H_2 + O_2 \longrightarrow H_2O$

$CH_4 + O_2 \longrightarrow CO_2 + H_2O$

② Decomposition Reaction

→ Reverse of combination

$C \longrightarrow A + B$

→ Either A or B or both must be in elemental form.

$KClO_3 \longrightarrow KCl + \overset{0}{O_2}$ (Elemental)

$CaCO_3 \longrightarrow CaO + CO_2$ [Not Redox]

→ Neutral Products hone chahiye Decomp ✗

③ Disproportionation Reaction

→ When single atom in a molecule is getting oxidise as well as reduced simultaneously.

$\overset{-1}{H_2O_2} \longrightarrow \overset{-2}{H_2O} + \overset{0}{O_2}$

F show nhi karta

④ Comproportionation Rxn

→ Reverse of Disproportionation

APPLICATIONS

1) Identification of OA and RA

Oxidising Agent: Oxidises other and reduces itself.

- Elements in their max^m OS behaves as OA

Reducing Agent: Reduces other oxidises itself

→ Element in their minimum OS = RA

Intermediate : OA as well as RA

eg:- $KMnO_4$ (Mn^{+7}) → OA; NH_3 (N^{-3}) → RA

$K_2Cr_2O_7$ (Cr^{+6}) → OA; PH_3 (P^{-3}) → RA

H_2O_2 → Both; Alkali metal = +1

Equivalent Weight

- Classical Method
- n-factor method
  - Redox
  - Non Redox

Eq wt = $\frac{M\,wt}{n\,factor}$

Non Redox: Acid : H^+ (aq); Base : OH^- (aq); Salt : either total +ve or -ve charge

Equivalent wt :- weight which is obtained by loosing or gaining 1 mole of electrons

$A^{+1} + 1e^- \longrightarrow A^\circ$ Mwt = 20

1 mole e⁻ give rise to 1 mole of A i.e 20g

$A^{+3} + 3e^- \longrightarrow A^\circ$

3 mole⁻ gives 1 mole A

1 mole e⁻ give $\frac{1}{3}$ moles A i.e $\frac{20}{3}$ = Eq wt

Case : 1 When species either oxidises or Reduced.

Reaction	n factor	Eq wt
$K_2\overset{+6}{Cr_2}O_7 \longrightarrow 2\overset{+3}{Cr}$	6	M/6
1 Cr_2 → 3 change; 2 Cr_2 → 6 change		
$\overset{0}{N_2} \longrightarrow \overset{-3}{N}H_3$	6	M/6
$\overset{-3}{N}H_3 \longrightarrow \overset{0}{N_2}$	3	M/3
$\overset{0}{O_2} \longrightarrow O^{-2}$	4	M/4
$O^- \longrightarrow \overset{0}{O_2}$	2	M/2
$H_2\overset{-1}{O_2} \longrightarrow \overset{0}{O_2}$	2	M/2

Conclusion: when a single atom is getting oxidised or reduced

uska 1 mole dekho, uske 1 mole par charge = nf

$KMnO_4$	Acidic Medium →	Mn^{+2}
$KMnO_4$	Basic Medium →	Mn^{+6}
$KMnO_4$	Alkaline / Neutral medium →	Mn^{+4}
Cr^{+6}	Acidic Med →	Cr^{+3}
I^-	Acidic Med →	I_2
I^-	Basic Med →	IO_3^-

Jiska pucha usko dekho uska 1 mole dekho uski 1 mole par charge dekho

Case : 2 When more than one species is getting oxidise or reduce

$\overset{+1}{A}\overset{+3}{B} \longrightarrow A^{+4} + B^{+6}$

oxi (n_1) = 5; oxi (n_2) = 3

$n_f = n_1 + n_2$ = 8

Case : 3 When single species is getting oxidised as well as Reduced :-

$A^\circ \longrightarrow A^{-n_1} + A^{+n_2}$

Red (n_1); oxi (n_2)

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

eg:- $Cl_2 \longrightarrow Cl^- + ClO_3^-$

Case : 4 Redox = Oxidation and Reduction occurs simultaneously.

In a balanced rxn : No. of e⁻ cancelout = nf

n_f → hamesha 1 mole ke liye defined hai

→ chahe koun oxidation se calculate ya reduction se, agar Rxn balanced hai to n_f will be same.

$$n_f(\text{species}) = \frac{n_f(\text{Rxn})}{\text{Stoichiometry of that sp}}$$

Law of Equivalence :-

$aA + bB \longrightarrow cC + dD$

$gE(A) = gE(B) = gE(C) = gE(D)$

for Gases:-

$$\text{Eq Vol.} = \frac{\text{Molar Volume}}{\text{n factor}}$$

Molar Volume = 1 mole ka volume = 22.4 L

$O^{-2} \longrightarrow \overset{\circ}{O}_2$	$n_f = 4$	Eq Vol = 5.6 L
$H^{+} \longrightarrow \overset{\circ}{H}_2$	$n_f = 2$	Eq Vol = 11.2 L
$Cl^{-} \longrightarrow \overset{\circ}{Cl}_2$	$n_f = 2$	Eq Vol = 11.2 L

$$gE = \frac{wt}{Eq\,wt} = n \times nf = M \times V(l) \times nf = NV = \frac{Vol}{Eq\,Vol}$$

Identification of correct formula of compound:-

Total OS add karne = charge on comp par aana chaiye

eg:- A, B, C, +6, -1, -2 respectively then formula will be.

$AB_2C_2 \longrightarrow +6 -2 -4 = 0$ Yes

$A_2BC_2 \longrightarrow +12 -1 -4 \neq 0$ NO.

Acidic and Basic Strength.

Acidic strength $\propto$ Oxidation state

- $\overset{+3}{H}NO_2 < \overset{+5}{H}NO_3$
- $H_2SO_3 < H_2SO_4$
- $H_3PO_2 > H_3PO_3 > H_3PO_4$

Basic strength $\propto \frac{1}{ON/OS}$

BALANCING OF REDOX RXN:-

a) Ions → ion electron method / ON change method.

b) charge

- **Ion electron method:** steps

1) Todege
2) Balance
   - other atom (O)
   - oxygen by H_2O (O)
   - Hydrogen → By H^+ (H)
   - charge = Jitne kachrge utne e^-
3) Todege
   ↓
   e^- cancel out hona chaiye
   ↳ nf

eg:- $Cr_2O_7 + C_2O_4 \longrightarrow CO_2 + Cr^{+3}$

Oxi: $(\overset{+3}{C_2}O_4 \longrightarrow 2\overset{+4}{C}O_2 + 2e^-) \times 3$

Red: $\overset{+6}{Cr_2}O_7 + 6e^- + 14H^+ \longrightarrow 2Cr^{+3} + 7H_2O$

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

- Jitne e^- cancel out = nf

* If we have to calculate/Balance in Basic medium then add OH^- in Both LHS and RHS
  ↓
  [Jitne H^+ hai utne OH^-]

and H^+ and OH^- Jis side bhi ayege last rxn me → H_2O banjayega

$a\overset{+7}{M}nO_4^- + b\overset{+3}{C}_2O_4^{-2} + cH^+ \longrightarrow \overset{+2}{Mn}^{+2} + \overset{+4}{C}O_2$

	a	b	c	
1)	2	8	5	
2)	3	5	8	
3)	2	5	16	✓
4)	6	2	F	

$$gE[MnO_4^-] = gE[C_2O_4^{-2}]$$
$$n \times nf = n \times nf$$
$$a \times 5 = b \times 2$$

If LHS = RHS (Answer)

* only valid when there is change in ON.
* When there is No change in ON Then use Normal Balancing Method or [Disproportionation]