REDOX REACTION

① Hydrogen Economy → Use of liquid hydrogen as a fuel.
② Ozone Hole → Depletion of ozone layer due to CFC's.
} Redox

Trick → OP (Oxidation product (loss of e⁻) product Rt side.) | RR (Reduction Reactant (gain of e⁻) Reactant Lt side)

Classical Idea of Redox Reaction

Oxidation	Reduction
Addition of Oxygen	Removal of Oxygen
Removal of Hydrogen	Addition of Hydrogen
Addition of more electro-negative atom.	Removal of electro-negative atom.
Removal of electro-positive element.	Addition of electro-positive element.

$Mg + O_2 \rightarrow MgO$
$S + O_2 \rightarrow SO_2$
$CH_4 + O_2 \rightarrow CO_2 + H_2O$
$H_2S + O_2 \rightarrow S + H_2O$
$Mg + F_2 \rightarrow MgF_2$
$Mg + Cl_2 \rightarrow MgCl_2$
$Mg + S \rightarrow MgS$
$K_4[Fe(CN)_6] + H_2O_2 \rightarrow K_3[Fe(CN)_6] + 2KOH$

$HgO \xrightarrow{\Delta} Hg_{(l)} + O_{2(g)}$
$FeCl_3 + H_2 \rightarrow FeCl_2 + HCl$
$CH_2=CH_2 + H_2 \xrightarrow{Ni} CH_3-CH_3$
$HgCl_2 + SnCl_2 \rightarrow Hg_2Cl_2 \downarrow + SnCl_4$ (red^n, oxi^n) — Redox rx^n

Electronic Concept / Mordern Concept

Trick → OIL RIG
Oxidation is loss of e⁻ — Reduction is gain of e⁻

$2Na^0 + Cl_2^0 \rightarrow 2Na^{+1}Cl^{-1}$
gain of e⁻(2); loss of 2e⁻

$2Na^0 + O_{2(g)} \rightarrow Na_2^{+1}O_{(s)}$
loss of 2e⁻; gain of 2e⁻

Half-Reaction

OH $2Na^0_{(s)} \rightarrow 2Na^{+1}_{(g)} + 2e^-$ Oxd^n
RH $2e^- + Cl_{2(g)}^0 \rightarrow 2Cl^{-1}_{(g)}$ Red^n

Oxidizing Agent (Oxidant) → Oxidizes others and reduces itself (gain of e⁻)
$Cu + H^+ + NO_3^- \rightarrow Cu^{+2} + H_2O + NO_2$
Reduces itself → Oxidizing agent.

Reducing agent (Reductant) → Reduces others and oxidises itself (loss of e⁻)
Reduc^n → Ox^n agent
$Sn^{+2} + Fe^{+3} \rightarrow Sn^{+4} + Fe^{+2}$
Oxidize → Reducing agent

Oxidation Number

Oxidation State → charge present on atom in a molecule

→ Rules for Oxidation Number →
Oxidation number of element in elemental/free state is zero.
$H_2, O_2, N_2, Fe, Cu, P_4, S_8, Na, Mg, Al$

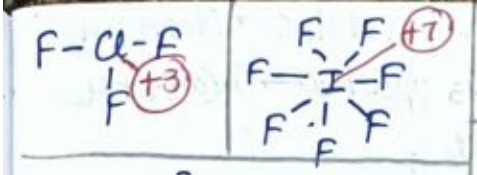
Alkali Metal: Gr-1 → (+1) — Li, Na, K, Rb, Cs, Fr.
Alkaline Earth metal: Gr-2 → (+2) — Be, Mg, Ca, Sr, Ba, Ra

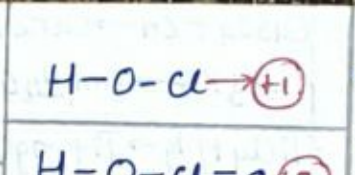
Al → (+3)
Ions → Oxidation number = Charge
$Na^+ = (1)$, $Mg^{+2} = (+2)$, $O^{-2} = (-2)$, $F^- = (-1)$

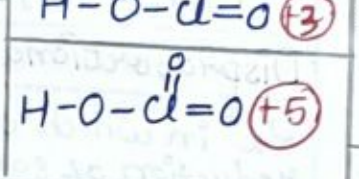
Oxygen → general Oxidation no. = (-2)
peroxide → O^{-1} → H_2O_2, Na_2O_2
Superoxide → $O^{-1/2}$ → KO_2, RbO_3, C_3O_2
Oxyfluoride → (+1) (+2) → OF_2, O_2F_2

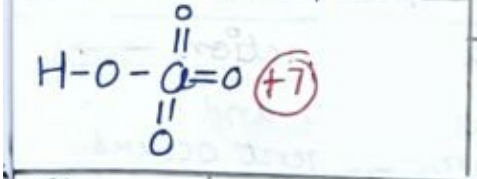
Hydrogen → Generally it shows (+1)
in metal Hydride = (-1).
LiH, NaH, CaH_2, MgH_2

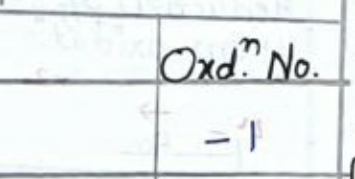
Halogen → Generally (-1) F, Cl, Br, I (-1)
But Cl, Br, I → +ve Oxidation state. (Bonded with more E.N.)











→ Sum of Oxidation number of all elements present in a molecule is equal to charge on molecule.

e.g. $-SO_4^{-2} \rightarrow (ON)_S + 4.(ON)_O = -2$

$NH_4^+ \rightarrow (ON)_N + 4.(ON)_H = +1$

$H_2O \rightarrow 2.(ON)_N + (ON)_O = 0$

Radical		Oxd.^{n} No.
X^- (F^-, Cl^-, Br^-, I^-)	Halide	−1
O^{-2}	Oxide	−2
N^{-3}	Nitride	−3
P^{-3}	Phosphide	−3
S^{-2}	Sulphide	−2
OH^-	Hydroxide	−1
CN^-	Cyanide	−1
NC^-	Isocyanide	−1
SO_3^{-2}	Sulphite	−2
SO_4^{-2}	Sulphate	2
PO_3^{-3}	phosphite	−3
PO_4^{-3}	phosphate	−3
NO_2^{-1}	Nitrite	−1
NO_3^-	Nitrate	−1
$C_2O_4^{-2}$	Oxalate	−2
$S_2O_3^{-2}$	Thiosulphate	−2
$S_4O_6^{-2}$	Tetrathionate	−2
ClO^-	Hypochlorite	−1
ClO_2^-	chlorite	−1
ClO_3^-	Chlorate	−1
ClO_4^-	perchlorate	−1
MnO_4^{-2}	Mangate	−2
MnO_4^-	permagnate	−1
CrO_4^{-2}	chromate	−2
$Cr_2O_7^{-2}$	dichromate	−2
SCN^-	thiocyanate	−1
NCS^-	Isothiocyanate	−1
NH_4^+	Ammonium	+1
NO^+	Nitrosylium	+1

$\underline{Cr_2O_7}^{-2} \rightarrow 2x + (-14) = -2 \Rightarrow \boxed{x = 6}$

$\underline{NH_4}^+ \rightarrow x + 4 = 1 \Rightarrow \boxed{x = -3}$

$[\underline{Fe}(CN)_6]^{-3} \rightarrow (-3) - (-6) = \boxed{x = +3}$

$\underline{Ni}(Co)_5 \rightarrow x + 5\times 0 = 0 \quad \boxed{x = 0}$

$Fe_3O_4 \rightarrow 3x - 8 = 0 \quad \boxed{x = \frac{8}{3}}$ → fractional ON = avg ON.

$[Ag(S_2O_3)_2]^{-3} \rightarrow (-3) - (-4) = \boxed{-1}$

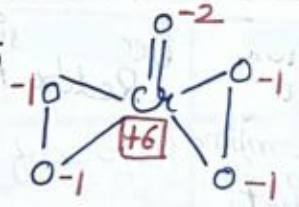
$(NH_4)(NO_3) \rightarrow (\underline{N}H_4)^+ = x + 4 = 1 \quad \boxed{x = -3}$

$(\underline{N}O_3)^- = x - 6 = -1 \quad \boxed{x = 5}$

$Fe_3O_4 \rightarrow \underline{FeO}^{+2}$, $\underline{Fe_2O_3}^{+3}$ $\quad \frac{1\times(+2) + 2\times(+3)}{3} = \boxed{\frac{8}{3}}$

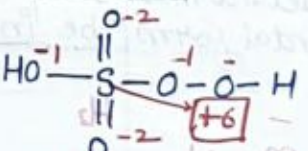
Exceptional Oxidation Number

→ CrO_5



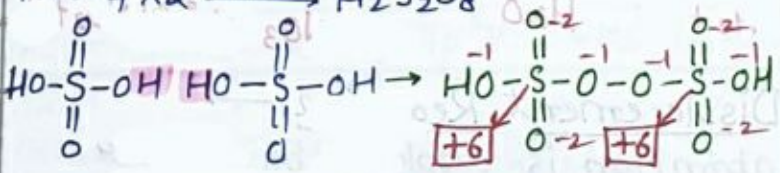
Deep Blue Butterfly Shape.

→ $H_2SO_5 \rightarrow H_2SO_4 + O$ — Caro's Acid



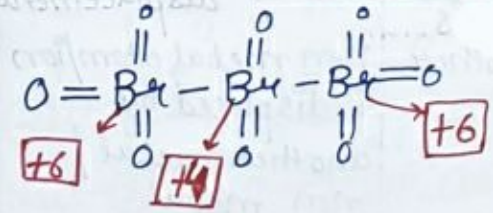
→ $H_2S_2O_8$ → Marshall's Acid.

$H_2SO_4 \times 2 \xrightarrow{-H_2} H_2S_2O_8$

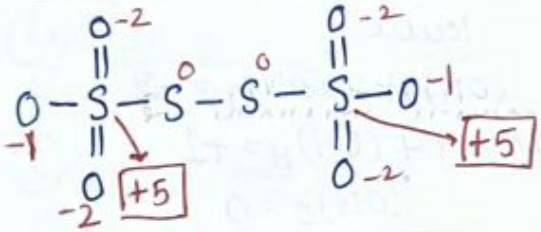


→ C_3O_2 → Carbon Suboxide

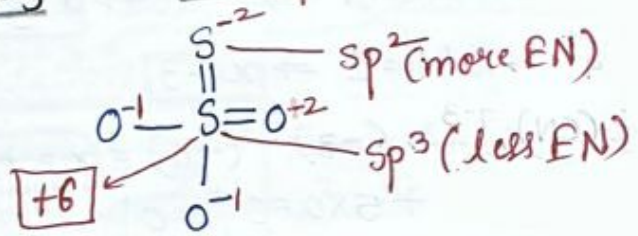
→ Br_3O_8 → Tribromo-octaoxide



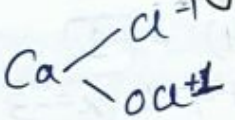
$S_4O_6^{-2}$ → Tetrathionate



$S_2O_3^{-2}$ → Thiosulphate ion (V. imp)



→ Bleaching Powder → $CaOCl_2$



→ Brown Ring Complex →

$[Fe^{+1}(H_2O)NO^{+1+2}]SO_4^{-2}$

Types of Redox Reaction

Combination Redox Reaction	Decomposition Redox Reaction
2 atoms/molecules combine together to form a product.	Reverse of Combination
atleast 1 reactant must be in elemental form	One product should be in elemental form
$C + O_2 \rightarrow CO_2$	$H_2O \rightarrow H_2 + O_2$
$Mg + N_2 \rightarrow Mg_3N_2$	$NaH \rightarrow Na + H_2$
$CH_4 + O_2 \rightarrow CO_2 + H_2O$	$KClO_3 \rightarrow KCl + 3O_2$
$H_2 + O_2 \rightarrow H_2O$	$LiNO_3 \rightarrow Li_2O + NO_2 + O_2$

Displacement Reaction →

atom/ion is displaced by another metal atom/ion.

$AB + C \rightarrow AC + B$

metal displacement
metal atom/ion is displaced by another metal.

non-metal displacement
non metal atom/ion is displaced by another metal / non metal

$CuSO_4 + Zn \rightarrow Cu + ZnSO_4$
$Cr_2O_3 + Al \rightarrow Cr + Al_2O_3$
$TiCl_4 + Mg \rightarrow Ti + MgCl_2$
$Na + H_2O \rightarrow NaOH + H_2$
$Ca + H_2O \rightarrow Ca(OH)_2 + H_2$

Disproportionation Reaction →

Rxⁿ in which oxidation and reduction of same element occurs from oxidation number.

$H_2O_2^{-1} \rightarrow H_2O^{-2} + O_2^{0}$ (Red.ⁿ, Oxy.ⁿ)

$P_4^{0} + NaOH \rightarrow PH_3^{-3} + NaH_2PO_2^{+1}$ (Redⁿ, Oxy.ⁿ)

$S_8 + NaOH \rightarrow S^{-2} + Na_2S_2O_3$ (Red.ⁿ, Oxy.ⁿ)

$Cl_2^{0} + NaOH \rightarrow NaCl^{-1} + NaOCl^{+1}$ (cold and dilute) ✱

$Cl_2^{0} + NaOH \rightarrow NaCl^{-1} + NaClO_3^{+5}$ (hot & conc.) ✱

$4KClO_3^{+5} \rightarrow 3KClO_4^{+7} + KCl^{-1}$

Hypochlorite	$HClO \rightarrow HCl + HClO_2$
Chlorite	$HClO_2 \rightarrow HCl + HClO_3$
Chlorate	$HClO_3 \rightarrow HCl + HClO_4$
perchlorate	$HClO_4 \rightarrow X$

Comproportationation Reaction →

Reverse of disprop. Rxⁿ

$NH_4^{-3}NO_2^{+3} \rightarrow N_2^{0} + H_2O$

Balancing of Redox →

→ atom, charge balance.

ion e⁻ method
1st → atom balance
2nd → charge balance.

Oxidation no. method
1st → charge balance
2nd → atom balance.

Ion e⁻ Method →

eg Balance Rxⁿ in Basic medium

$Zn^{0} + NO_3^{-} \rightarrow Zn^{+2} + NH_4^{+}$

Step-1 → Breakup (Oxy.^{n} Half and Red^n Half)

$Zn \longrightarrow \overset{+2}{Zn}$ (O.H.)

$\overset{+5}{NO_3^-} \longrightarrow \overset{-3}{NH_4^+}$ (R.H.)

Step-2 → Balance atom other than O and H.

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

$\overset{+5}{NO_3^-} \longrightarrow \overset{-3}{NH_4}$

Step-3 → Balance O → H_2O, H → H^+.

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

$10H^+ + NO_3^- \longrightarrow NH_4^+ + 3H_2O$

Step-4 → (Basic Medium) add OH^-

$Zn \longrightarrow Zn^{+2}$

$10H^+ + NO_3^- \longrightarrow NH_4^+ + 3H_2O + \cancel{10OH^-}$

$\cancel{10OH^-}$

$\cancel{10}H_2O + NO_3^- \longrightarrow NH_4^+ + 3H_2O + 10OH$

$7H_2O + NO_3^- \longrightarrow NH_4^+ + 10OH^-$

Step-5 → Charge Balance,

$(Zn^0 \longrightarrow Zn^{+2} + 2e^-) \times 4$

$8e^- + 7H_2O + \overset{+5}{NO_3^-} \longrightarrow \overset{-3}{NH_4^+} + 10OH^-$

$4Zn \longrightarrow 4Zn^{+2} + \cancel{8e^-}$

$\cancel{8e^-} + 7H_2O + NO_3^- \longrightarrow NH_4^+ + 10OH^-$

$4Zn + 7H_2O + NO_3^- \longrightarrow 4Zn^{+2} + NH_4^+ + 10OH^-$

Ans//

Que) Balance Rx.^{n} in acidic Medium

Step1 → $Fe^{+2} + Cr_2O_7^{-2} \longrightarrow Fe^{+3} + Cr^{+3}$

Step1 → $Fe^{+2} \longrightarrow Fe^{+3}$ (O.H.)

$\overset{+6}{Cr_2}O_7^{-2} \longrightarrow Cr^{+3}$ (R.H.)

Step2 → $Fe^{+2} \longrightarrow Fe^{+3}$

$\overset{+6}{Cr_2}O_7^{-2} \longrightarrow 2Cr^{+3}$

Step3 → $Fe^{+2} \longrightarrow Fe^{+3}$ (Oxy.^{n})

$14H^+ + \overset{+6}{Cr_2}O_7^{-2} \longrightarrow 2Cr^{+3} + 7H_2O$ (Red.^{n})

Step4 → $(Fe^{+2} \longrightarrow Fe^{+3} + e^-) \times 6$

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

$6Fe^{+2} \longrightarrow 6Fe^{+3} + \cancel{6e^-}$

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

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

Que) Acidic Medium

$KMnO_4 + KI + HCl \rightarrow MnCl_2 + I_2 + KCl + H_2O$

Step I → Remove Spectator Ion

$MnO_4^- + I^- \longrightarrow MnCl_2 + I_2$

Oxidation Number Method →

$\overset{+7}{Mn}O_4^- + C_2O_4^{-2} + H^+ \longrightarrow CO_2 + \overset{+2}{Mn} + H_2O$

(5) (Reverse) (2)

$2MnO_4^- + 5C_2O_4^{-2} + H^+ \rightarrow 10CO_2 + 2Mn^{+2} + H_2O$

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

Ans//

Balancing of Disprop. →

(one method)

$P_4 + NaOH \longrightarrow PH_3 + NaH_2PO_2$

Step1 → $P_4 \longrightarrow PH_3 + H_2PO_2^-$

Step2 → $P_4^0 \longrightarrow \overset{-3}{P}H_3$ (R.H)

$P_4^0 \longrightarrow H_2\overset{+1}{P}O_2^-$ (O.H)

Step3 → $P_4^0 \longrightarrow 4\overset{-3}{P}H_3$

$P_4^0 \longrightarrow 4H_2\overset{+1}{P}O_2^-$

Step4 → $12H^+ + P_4^0 \longrightarrow 4\overset{-3}{P}H_3$

$8H_2O + P_4^0 \longrightarrow 4H_2PO_2^- + 8H^+$

$12e^- + 12H^+ + P_4^0 \longrightarrow 4\overset{-3}{P}H_3$

$(8H_2O + P_4^0 \longrightarrow 4H_2PO_2^- + 8H^+ + 4e^-) \times 3$

$\cancel{12e^-} + 12H^+ + P_4^0 \longrightarrow 4\overset{-3}{P}H_3$

$24H_2O + 3P_4^0 \longrightarrow 12H_2PO_2^- + 24H^+ + \cancel{12e^-}$

$12H^+ + 24H_2O + 3P_4^0 \longrightarrow 4\overset{-3}{P}H_3 + 12H_2PO_2^- + \underset{240H^-}{\underbrace{24H^+}}$

$\underset{120OH^-}{\underbrace{12H^+}} + 24H_2O + 3P_4^0 \longrightarrow 4\overset{-3}{P}H_3 + 12H_2PO_2^-$

Ans//

$12H_2O + 4P_4 + 12OH^- \rightarrow 4PH_3 + 12H_2PO_2^-$

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n-factor / Valence factor / x-factor Calculation →

① Ions → n factor = |charge|.

Na^+, Mg^{+2}, Al^{+3}, SO_4^{-2}

1 2 3 4

② Salt → n factor = LCM of cationic charge and anionic charge

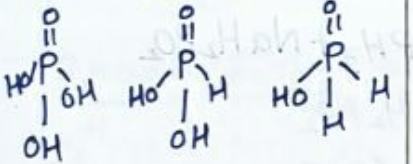
NaCl → ①, MgO → ②, $Al_2(SO_4)_3$ → ⑥

③ acid / Base →

Acid	Base
n-factor = basicity → no. of H^+ donated.	n-factor = acidity → no. of OH^- donated → no. of H^+ accepted.
HCl, HBr, HI, $HClO_4$, CH_3COOH nf = 1	NaOH, KOH, RbOH, CsOH, NH_3, RNH_2, $PhNH_2$ → nf = 1
H_2SO_4, H_2CO_3, $H_2C_2O_4$ nf = 2	$Mg(OH)_2$, $Ca(OH)_2$, en, $Zn(OH)_2$ → nf = 2
H_3PO_4 → nf = 3	$Al(OH)_3$, $Fe(OH)_3$ nf = 2

Phosphorus acid Series →

H_3PO_4	H_3PO_3	H_3PO_2
nf = 3	nf = 2	nf = 1
$3H^+$ donate	$2H^+$ donate	$1H^+$ donate



Boric Acid →

H_3BO_3 / $B(OH)_3$ → nf = 1

(1 Hydrogen donated from H_2O).

Oxidizing agent and Reducing agent →

$KMn^{+7}O_4$ → Mn^{+2} acidic (nf = 5) (n-factor)

→ $Mn^{+6}O_4^{-2}$ basic (nf = 1)

→ $Mn^{+4}O_2$ neutral (nf = 3)

$K_2Cr_2^{+6}O_7$ —acidic→ Cr^{+3} (nf = 6)

$Fe^{+2} \rightarrow Fe^{+3}$

$C_2O_4^{-2} \rightarrow CO_2$

$I^- \rightarrow I_2$

$H_2S \rightarrow S$

$Sn^{+2} \rightarrow Sn^{+4}$

$H_2O_2 \rightarrow O_2$

$SO_2 \rightarrow SO_4^{-2}$

H_2O_2 ←

Oxy.ⁿ agent	Red.ⁿ agent
Self red.ⁿ	Self oxyⁿ
$H_2O_2^{-1} \rightarrow H_2O^{-2}$	$H_2O_2^{-1} \rightarrow O_2^0$
nf = 1×2 = 2	nf = 2×1 = 2

$Na_2S_2O_3$ (Reducing agent)

$Na_2^{+2}S_2O_3 \rightarrow Na_2S_2^{+2.5}O_6$

nf = 0.5 × 2 = 1

nf = 0.5 × 4 = 2

$I_2^0 \rightarrow IO_3^-$ = nf = 5 × 2 = 10

$N_2^{-2}H_4 \rightarrow HN^{+3}O_2$ = nf = 5 × 2 = 10

$I^{+7}O_4^- \rightarrow I_2^0$ = nf = 7 × 1 = 7

$V^{+2}O \rightarrow V_2^{+5}O_5$ = nf = 3 × 1 = 3

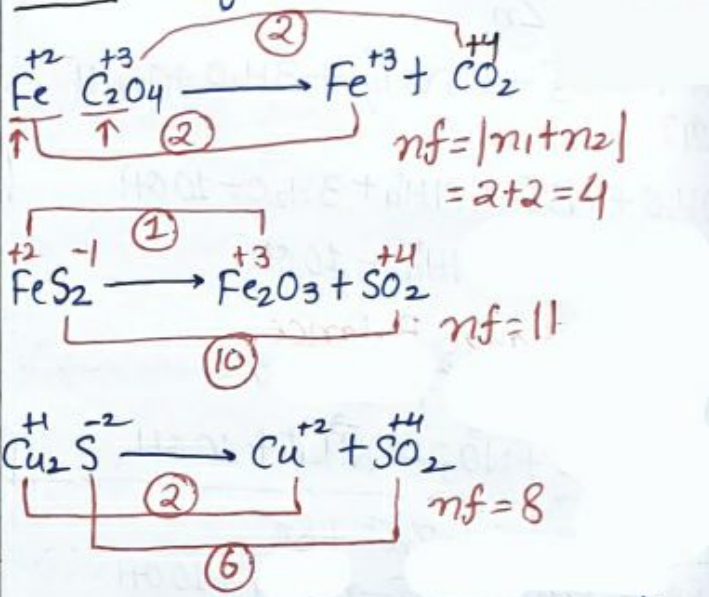
$Fe^{+3}(C_2O_4)_3^{+3} \rightarrow Fe^{+3} + CO_2^{+4}$ = nf = 6 × 1 = 6

$Na_2S_2^{+2}O_3 + I_2^0 \rightarrow Na_2S_4^{2.5}O_6 + 2NaI^{-1}$

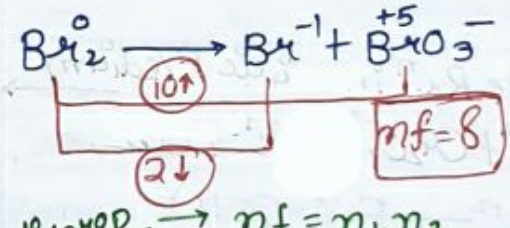
nf = 0.5 × 2 = 1 | nf = 1 × 2 = 2

when more than 1 oxidation state is changing →

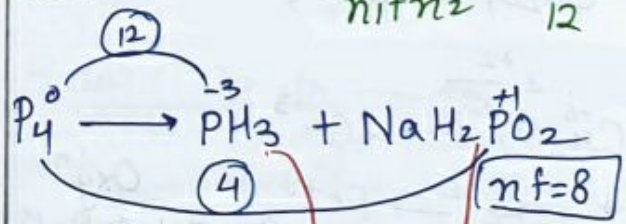
Case-1 → If oxdⁿ number either ↑ or ↓



Case-2 → If oxdⁿ number ↑ and ↓



disprop → $nf = \frac{n_1 \cdot n_2}{n_1 + n_2} = \frac{20}{12} = \frac{5}{3}$



disprop

nf = 3 nf = 1

nf = 48/16

nf = 3

Equivalent Mass

$$\text{Eq}^{t}\ \text{Mass} = \frac{\text{Molar mass}}{\text{n-factor}}$$

e.g.—

$$Mg^{0} + \frac{1}{2}O_2^{0} \longrightarrow \underset{nf=2}{Mg^{+2}O^{-2}}$$

$nf = 2$

$$\text{eq}^{t}\ \text{Mass} = \frac{24}{2} = 12$$

$nf = 4$

$$\text{eq}^{t}\ \text{Mass} = \frac{32}{4} = 8$$

$\text{no. of mole} = \frac{GM}{mm}$	$\text{No. of eq}^{t} = \frac{GM}{\text{eq}^{t}\ \text{Mass}} = \frac{GM}{MM} \times \text{n. factor}$ $\text{no. of Eq}^{t} = \text{mole} \times \text{n. fac.}$
Molarity → $= \frac{\text{no. of moles of solute}}{\text{Vol. of sol.}^{n}\ \text{in litre.}}$	Normality → $= \frac{\text{no. of eq}^{t}\ \text{of solute}}{\text{Vol. of sol.}^{n}\ (\text{litre})}$
no. of mole → $= M \times \text{Vol(lit)}$	No. of Eq^{t} → $= N \times \text{Vol(lit)}$.

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