Toppersnotes
Unleash the topper in you

NEET - UG

NATIONAL TESTING AGENCY

Chemistry

Physical Chemistry - 2

SIERRA INNOVATIONS

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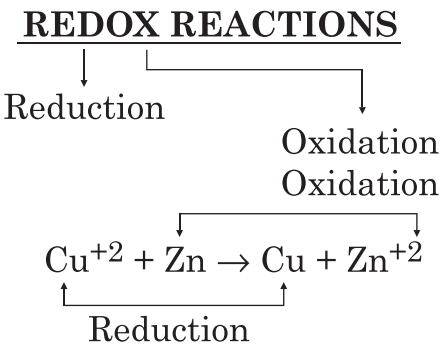
Physical Chemistry - 2

Toppersnotes
Unleash the topper in you

Redox Reactions



Classical Concept

Oxidation	Reduction
→ Addition of O	→ Removal of oxygen
$2M_g + O_2 \rightarrow 2M_gO$	$ZnO + C \rightarrow Zn + CO$
→ Removal of H	→ Addition of H
$H_2S + O \rightarrow H_2S + S$	$C + 2H_2 \rightarrow CH_4$
→ Removal of electropositive	→ Addition of electropositive
Element	Element
$K_2M_nO_4 \rightarrow KM_nO_4$	$2H_gCl_2 + SnCl_2 \rightarrow H_gCl_2 + SnCl_4$
→ Addition of electronegative Element	→ Removal of electronegative Element
$FeCl_2 + Cl_2 \rightarrow FeCl_3$	$FeCl_2 + H_2 \rightarrow FeCl_2 + HCl$

Modern Concept : - (Electronic Concept)

Oxidation	Reduction
→ Loss of 1 or more e^-	→ Gain of 1 or more e^-

$Ag \rightarrow Ag^{+}e^{-}$	$Ag^{+}e^{-} \rightarrow Mn^{+2}$
$Mn^{+2} \rightarrow M^{+7} + 5e^{-}$	$Mn^{+7} + 5e^{-} \rightarrow Mn^{+2}$
$M^{+H_1} \rightarrow M^{H_2} + (H_2 - H_1)e^{-}$	$M^{+H_1}(H_1 - H_2)e^{-} \rightarrow$
$n_2 > n_1$	$n_1 > n_2$
$Fe^{+2} \rightarrow Fe^{+3} + e^{-}$	
$\rightarrow$ Increase in O.S.	$\rightarrow$ Decrease in O.S.

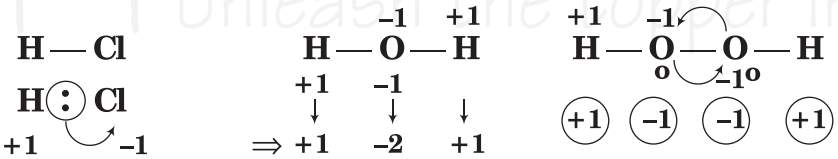
Oxidation Number

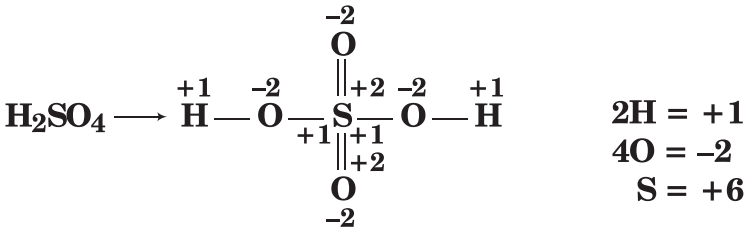
* Real or imaginary charge on bonded atom.
* Free atoms $\rightarrow$ Real Charge = ON

  $Na = 0,\ Zn = 0,\ Fe^{+2} = +2,\ S^{-2} = -2,\ S = 0$

* **Bonded atoms** $\rightarrow$ Free the atoms, charge developed = ON

E.g.,





Q. Determine Oxidation number of underlined atom in following species.

1. $H\underline{N}O_3 \rightarrow 1 + x - 6 = 0 \Rightarrow x = +5$

2. $\underline{Fe}O \rightarrow x - 2 = 0 \Rightarrow x = +2$

3. $H_2\underline{S} \rightarrow 2 + x = 0 \Rightarrow x = -2$

4. $K\underline{Mn}O_4 \rightarrow 1 + x - 8 = 0 \Rightarrow x = +7$

5. $K_2\underline{Cr}O_4 \rightarrow 2+x-8=0 \Rightarrow x=+6$

6. $H_3\underline{P}O_4 \rightarrow 3+x-8=0 \Rightarrow x=+5$

7. $K\underline{Cl}O_4 \rightarrow 1+x-8=0 \Rightarrow x=+7$

8. $\underline{Fe}_2O_3 \rightarrow 2x-6=0 \Rightarrow x=+3$

9. $\underline{S}O_3 \rightarrow x-6=0 \Rightarrow x=+6$

10. $\underline{N}H_3 \rightarrow x+3=0 \Rightarrow x=-3$

11. $\underline{Fe}_3O_4 \rightarrow 3x-8=0 \Rightarrow x=\frac{8}{3}$, **OS** $\rightarrow +2,+3,+3$

$(+2)FeO \quad Fe_2O_3(+3)$

12. $\underline{C}_6H_{12}O_6 \rightarrow 6x+12-12=0 \Rightarrow x=0$

13. $H_2\underline{S}O_5 \rightarrow 2+x-10=0 \Rightarrow x=+8\ (\times)\ x=+6$ **(max.)** **[2 'O' in peroxide bonds]**

14. $H_2\underline{S}_2O_7 \rightarrow 2+2x-14=0 \Rightarrow x=+6$

15. $H_2\underline{S}_2O_8 \rightarrow 2+2x-16=0 \Rightarrow x=+7\ (\times)\ x=+6$ **(max.)**

16. $\underline{N}H_4^{+1}\underline{N}O_3^{-1} \rightarrow 2x+4-6=0 \Rightarrow x=1 \rightarrow 7\ (\times)$

$x+4=+1 \Rightarrow x=-3, \quad x-6=-1 \Rightarrow x=+5$

17. $K\underline{I}_3 \rightarrow 1+3x=0 \Rightarrow x=-\frac{1}{3}\left(K^+ + I_3^-\right)$

Note :- Oxidation number can be fractional but Oxidation state "can not" be fractional.

18. $\underline{N}_3H \rightarrow 3x+1=0 \Rightarrow x=-\frac{1}{3}$

$H—N=\overset{+}{N}=\overset{-}{N}$

19. $CaO\underline{Cl}_2 \rightarrow 2-2+2x=0 \Rightarrow x=0$ **or** $x=+1,-1$ **(Oxidation State)**

$Ca^{+2} + (OCl)^- + Cl^-$

20. $\underline{Cr}_2O_3 \rightarrow 2x-6=0 \Rightarrow x=+3$

21. $\underline{Cr}O_3 \rightarrow x-6=0 \Rightarrow x=+6$

22. $\underline{Cr}O_5 \rightarrow x - 10 = 0 \Rightarrow x = +10\ (\times)\ x = +6$ **[Peroxide linkage in O]**

23. $H_2\underline{O}_2 \rightarrow 2x + 2 = 0 \Rightarrow x = -1$

24. $H_3\underline{P}O_3 \rightarrow 3 + x - 6 = 0 \Rightarrow x = +3$

25. $Ba(H_2\underline{P}O_4)_2 \rightarrow 2 + 4 + 2x - 16 = 0 \Rightarrow x = +5$

$(H_2PO_4)^- \Rightarrow +2 + x - 8 = -1 \Rightarrow x = +5$

26. $K_3\underline{Cr}O_8 \rightarrow 3 + x - 16 = 0 \Rightarrow x = 13\ (\times)\ x = +5$

27. $Na(\underline{Ag}(CN)_2) \rightarrow 1 + x - 2 = 0 \Rightarrow x = +1$

28. $K_3[\underline{Fe}(CN)_6] \rightarrow 3 + x - 6 = 0 \Rightarrow x = +3$

$x - 6 = -3 \Rightarrow x = +3$

29. $[\underline{Co}(NH_3)_6]_2(SO_4)_3 \rightarrow 2x + 0 - 6 = 0 \Rightarrow x = +3$

30. $\underline{Fe}_4^{+3}[\underline{Fe}(CN)_6]_3 \rightarrow$ **(1)** $x = +3$ **(2)** $x - 6 = -4 \Rightarrow x = +2$

Rules for Determination of Oxidation Number

1. oxidation number = 0 for all Neutral atoms.

E.g., Zn, Cu, Na, S $\rightarrow$ ON = 0

2. For ions, oxidation number = charge present.

E.g., $O^{-2} = -2$, $Fe^{+2} = +2$, $S^{-2} = -2$, $NH_4^+ = +1$,

$CO_3^- = -2$, $OH^- = -1$, $O_2^{-2} = -2$ (peroxide),

$SO_4^{-2} = -2$, $O_2^- = -1$ (super oxide), $CN^- = -1$

3. Bonded atoms

A. Homoatomic molecule :

oxidation number = 0

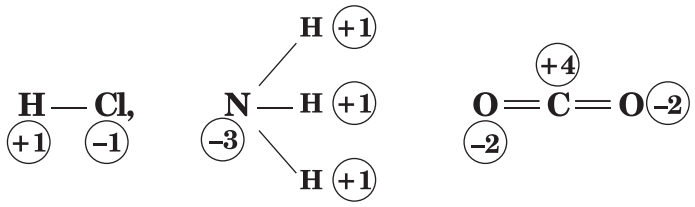
E.g., $\underset{o}{H}—\underset{o}{H}$, Br_2, F_2, N_2, O_2, P_4, S_8, Diamond, Graphite etc.

B. Heteroatomic molecule :

More electro –ve ON $= -1$

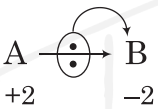
Less electro –ve ON $= +1$

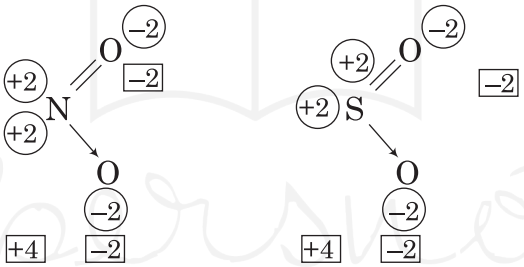
w.r.t. one bond

E.g., 

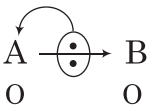
4. Co-ordinate Bond

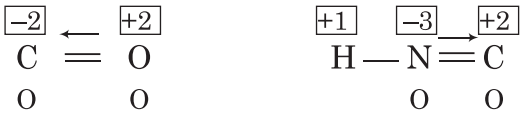
A. If donor atom is less electronegative

$\Rightarrow$ 

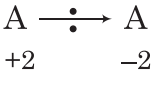
E.g., 

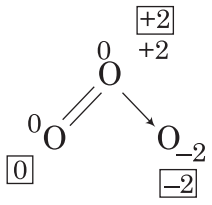
B. If donor atom is more electronegative :

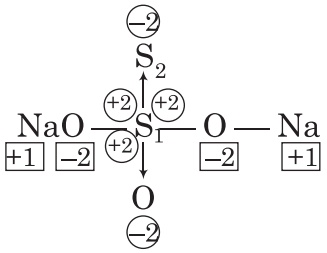
$\Rightarrow$ 

E.g., 

C. Between 2 same atoms :

$\Rightarrow$ 

E.g., 

$Na_2S_2O_3$ 

$S_1 \longrightarrow +6$

$S_2 \longrightarrow -2$

5. IA group elements $= +1\,(ns^1)$

IIA group elements $= +2\,(ns^2)$

6. Hydrogen : $(1s^1)$

General oxidation number $= +1$

But in metal Hydrides $= -1$

E.g., NaH $\quad CaH_2$

+1 −1 $\quad$ +2 −1

−1

7. Oxygen : $(2s^2 2p^4)$, General oxidation number $= -2$

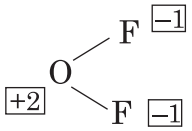
But in peroxide, $O_2^{-2} \Rightarrow O = -1$

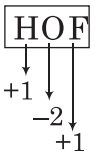
In superoxide, $O_2^- \Rightarrow O = -\frac{1}{2}$

E.g., $\overset{+1\ -1}{KO_2}$, $\quad \underset{+2}{Ba}(O_2)^{-2} \Rightarrow -1$

with F, shows +ve

E.g., OF_2



except 

8. Halogen : $(ns^2 np^5)$

General ON $= -1$

But $F = -1$ (always)

Others (C, Br, I) show variable ON.

Variable Oxidation Number : [Max/Min]

i. For p-block elements

Maximum Oxidation Number = Number of valence e^-

Minimum Oxidation Number = Number of valence $e^- - 8$

E.g., 1. Cl [2, 8, 7] → Max = +7, Min = –1

E.g., $\overset{(-1)}{HCl}$, $\overset{(+1)}{ClF}$, $\overset{(+3)}{ClF_3}$, $\overset{(+1)}{HOCl}$, $\overset{(+3)}{HClO_2}$, $\overset{(+5)}{HClO_3}$, $\overset{(+7)}{HClO_4}$

E.g., 2. $\overset{(-1)}{HBr}$, $\overset{(+3)}{BrF_3}$, $\overset{(+5)}{BrF_5}$, $\overset{(-1)}{HI}$, $\overset{(+3)}{IF_3}$, $\overset{(+5)}{IF_5}$, $\overset{(+7)}{IF_7}$

E.g., 3. N [2, 5] → Max = +5, Min = –3

$\overset{(-3)}{NH_3}$, $\overset{(-2)}{N_2H_4}$, $\overset{(-1)}{NH_2OH}$, $\overset{(+1)}{N_2O}$, $\overset{(+2)}{NO}$, $\overset{(+3)}{N_2O_3}$, $\overset{(+4)}{N_2O_4}$, $\overset{(+5)}{N_2O_5}$

ii. For d-block elements : $[(n-1)d^{1-10}ns^{1-2}]$

Minimum Oxidation Number = ns e^- Number.

Maximum Oxidation Number = ns e^- Number + $(n-1)$ d unpaired e^-.

E.g., 1. M_n [$3d^5 4s^2$] → Min = +2, Max = +7

$\overset{(+2)}{MnO}$, $\overset{(+3)}{Mn_2O_3}$, $\overset{(+4)}{MnO_2}$, $\overset{(+6)}{MnO_3}$, $\overset{(+7)}{Mn_2O_7}$

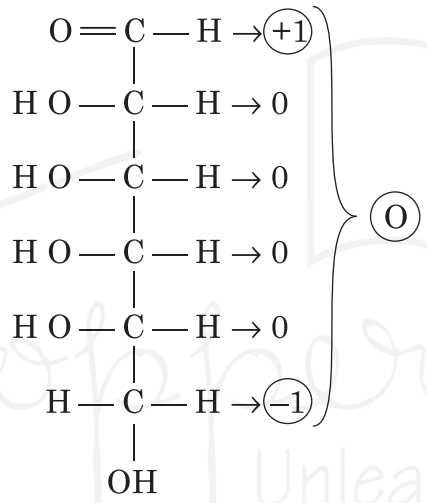
2. Fe $(3d^6 4s^2)$ — Min = +2, Max = +6 $\quad Fe^{+2}$, Fe^{+3} → Practical

3. Cr $(3d^5 4s^1)$ — Min = +2, Max = +6

10. Oxidation number for neutral molecules (ligand) is 0.

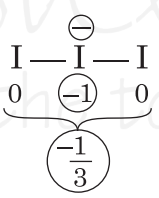
E.g., NH_3, H_2O, CO, NO, C_2H_5N etc.

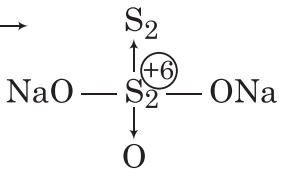
* Glucose ⟶



* $H-N=N=N$ (+1, −1, +1, −1) → $-\frac{1}{3}$

* $KI_3 \rightarrow -K^+ + I_3^-$



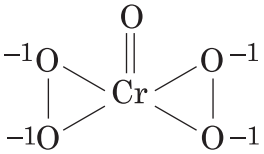
* NaS_2O_3 ⟶ 

$S_1 = +6$, $S_2 = -2$ → +2

* CrO_5 :

$x = +10$ (×) Cr = +6

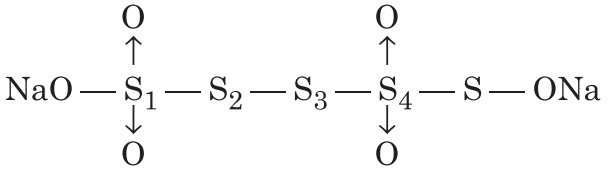
$5\,O \rightarrow 6e^- \Rightarrow 1\,O^{-2} + 4\,O^{-1}$ → 2 peroxide B



* $Na_2S_4O_6$

$2 + 4x - 12 = 0$

$x = 2.5$

* 

Diff of OS = 5

$S_1 = +5$

$S_2 = 0$

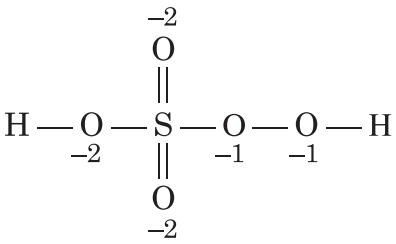
$S_3 = 0$

$S_4 = +5$

* H_2SO_5

$+2+x+5\times(-2)=0$

$\boxed{x=+8}$ (×)



$+2\times1+x+3\times-2$

$+2\times-1=0$

$\Rightarrow x=+6$

* $H_2S_2O_8$

$+2+2x+8\times(-2)=0$

$2x=14$

$\boxed{x=+7}$ (×)

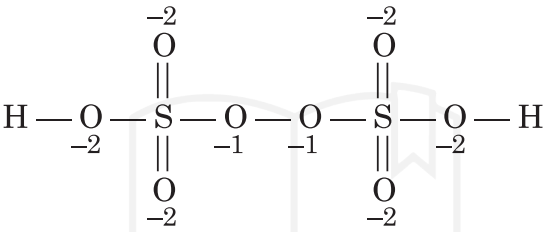
$2e^- + 12e^- = 14e^- \rightarrow 8O$

$(16e^-)$

$6O \rightarrow -2$

$2O \rightarrow -1$

Peroxide bonds = 1



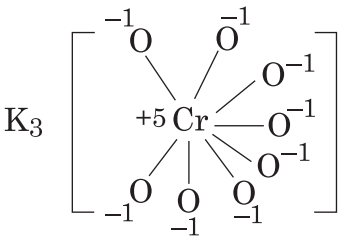
* $K_3Cr\cdot O_8$

$x = 13 \Rightarrow$ Period bonds.

(×)

$3+6e^- = 9e^- \rightarrow 8O \Rightarrow 10^{-2}+7O^{-1}$ (×)

$3+5e^- = 8e^- \rightarrow 8O \Rightarrow 8O^{-1}$



$\Rightarrow \boxed{x=+5}$

Stability Order : Oxide > Peroxide > Superoxide

Q. Identify oxide, peroxide and superoxide in following molecules.

1. $K_2O \rightarrow$ Oxide.

2. $H_2O_2 \rightarrow$ Peroxide.

3. $PbO_2 \rightarrow$ Oxide (Pb^{+4})

4. $KO_2 \rightarrow$ Superoxide.

5. $BaO_2 \rightarrow$ Peroxide.

Q. Calculate % of Fe^{+3} ion in $Fe_{0.94}O_1$.

Soi. $FeO \rightarrow 1:1$

$Fe_2O_3 \rightarrow 2:3 \Rightarrow 0.67:1$

$$100\ O \rightarrow 94\ Fe$$

$$200e^- = 2 \times x + 3 \times (94 - x)$$

$$\Rightarrow \quad 2x + 282 - 3x = 200$$

$$-x = -82 \Rightarrow x = 82$$

$$\% \ Fe^{+3} = \frac{12}{94} \times 100 = 12.76\%$$

$$\Rightarrow \quad 2x + 282 - 3x = 200$$

$$x = 82$$

$$\% \ Fe^{+3} = 12.76\%$$

$Fe_{94}O_{100}$

Fe

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

x $\quad$ $94 - x$

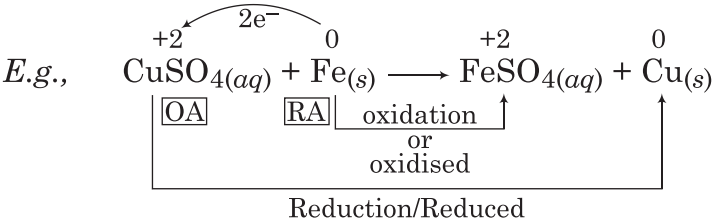
$\downarrow$ $\quad$ $\downarrow$

$2x$ $\quad$ $(94 - x)3$

$\downarrow$

$282 - 3x$

Oxidising Agent and Reducing Agent



Oxidising Agent/Oxidant :

* Substance which oxidise the others but itself reduced.
* Substance which gain the e^-.
* Substance which show decrement in its ON.

Reducing Agent/Reductant

* Substance which reduces the stress but self oxidised (loses the e^-).
* Substance which show increment in its oxidation no.

Q. Identify OA and RA in following Redox reactions.

Q. Identify the following species behaving as only oxidant/only reductant both in redox reactions.

1. $HNO_3 \rightarrow N^{+5}$ $\boxed{ON}\downarrow$
   $\Rightarrow$ OA
2. $H_2S \rightarrow S^{-2}\uparrow$
   $\Rightarrow$ RA
3. $H_3PO_3 \rightarrow P^{+3}\uparrow\downarrow$ RA $\uparrow$ OA $\downarrow$
   $\Rightarrow$ Both
4. $HCl \rightarrow Cl^{-1}\uparrow$
   $\Rightarrow$ RA
5. $KMnO_4 \rightarrow Mn^{+7}\downarrow$
   $\Rightarrow$ OA
6. $K_2Cr_2O_7 \rightarrow Cr^{+6}\downarrow$
   $\Rightarrow$ OA
7. $HNO_2 — N^{+3}\uparrow\downarrow$
   $\Rightarrow$ Both
8. $NH_3 \rightarrow N^{-3}\uparrow$
   $\Rightarrow$ RA
9. $H_3PO_4 \rightarrow P^{+5}\downarrow$
   $\Rightarrow$ OA
10. $HClO_4 \rightarrow Cl^{+7}\downarrow$
    $\Rightarrow$ OA
11. $SO_3 \rightarrow S^{+6}\downarrow$
    $\Rightarrow$ OA
12. $PH_3 \rightarrow P^{-3}\uparrow$
    $\Rightarrow$ RA
13. $H_2O_2 \rightarrow O^{-1}\overset{0}{\uparrow}\underset{-2}{\downarrow}$
    $\Rightarrow$ Both
14. $PbO_2 \rightarrow Pb^{+4}\downarrow$
    $\Rightarrow$ OA

Q. Which of the following substance cannot be oxidised by O_3?

$\Rightarrow$ 1. $H_2\underset{-2\ \uparrow}{\underline{S}}$ 2. $\underset{+4\ \uparrow}{\underline{S}}O_2$ 3. $H_3\underset{+3\ \uparrow}{\underline{P}}O_3$ 4. $K\underset{+7\quad\uparrow\times}{\underline{Mn}}O_4$

Sol. (4) $K\underline{Mn}O_4$

Balancing of a Redox Reactions :

$$\Rightarrow \underbrace{Cr_2O_7^{-2} + 6Fe^{+2} + 14\,H^{+}}_{-2+12+14=+24} \longrightarrow \underbrace{2Cr^{+3} + 6Fe^{+3} + 7H_2O}_{6+18=+24}$$

By Oxidation Number Method :

* Step 1 → Charge Balancing [Change only reactants coeff.]
* Step 2 → Atom balancing [First other atoms, then O, H]
* Step 3 → Medium balancing

E.g., $Cr_2O_7^{2-} + Fe^{2+} + H^{+} \longrightarrow Cr^{3+} + Fe^{3+} + H_2O$

Decrement in ON = 3 × 2 = 6

Charge balancing

+6

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

×6

Increment in On = 1

$Cr_2O_7^{2-} + 6Fe^{2+} \longrightarrow 2Cr^{+3} + 6Fe^{+3} + 7H_2O$

$+14H^{+}$

Q. $U^{+4} + MnO_4^{-} \xrightarrow{OH^{-}} UO_2^{+2} + Mn^{+2} + H_2O$

↑2

$5U^{+4} + 2MnO_4 - \longrightarrow 5UO_2^{+2} + 2Mn^{+2} + 4H^{+}$ (+6)

$+2H_2O$ ↓5 $(4H^{+} + 4OH^{-} \rightarrow 4H_2O)$

$4OH^{-}$ $4OH^{-}$

$$5U^{+4} + 2MnO_4 + 4OH^{-} \longrightarrow 5UO_2^{+2} + 2Mn^{+2} + 2H_2O$$

↑1 × 2

Q.2. $\overset{+7}{K}\overset{+7}{Mn}O_4 + 5H_2\overset{+3}{C}_2O_4 + 3H_2SO_4 \longrightarrow 1K_2SO_4^{+2} + \overset{+2}{Mn}SO_4 + \overset{+4}{C}O_2$ (10)

$+8H_2O$

2 5 ↓5

Q. $5H_2\overset{-1}{O_2} + \overset{0}{I_2} \longrightarrow 2HIO_3 + 4H_2\overset{-2}{O}$

↑10, +5, ↓2

$3H_2O_2 \longrightarrow 3O_2$ (Balance these O differently)

↓3

Q. $2KMn\overset{+7}{O_4} + 3H_2\overset{-1}{O_2} \xrightarrow{\text{Basic medium}} 2\overset{+4}{Mn}O_2 + 3\overset{0}{O_2} + 2KOH + H_2\overset{-2}{O}$

2 3 ↑1 × 2

$2KMnO_4 + 3H_2O_2 \xrightarrow{\text{Basic}} 2MnO_2 + 3O_2 + 2KOH + 2H_2O$

Q.3. $\overset{+7}{K}\overset{+7}{Mn}O_4 + 5\overset{+2}{Fe}\overset{+3}{C}_2O_4 + H_2SO_4 \longrightarrow \frac{3}{2}K_2SO_4 + 3\overset{+2}{Mn}SO_4 + \overset{+3}{Fe_2}(SO_4)_3 + \overset{+4}{C}O_2 + H_2O$

↓5, ↑3[1+2]

$6KMnO_4 + 10FeC_2O_4 + 24H_2SO_4 \longrightarrow 3K_2SO_4 + 6MnSO_4 + 5Fe_2(SO_4)_3 + 20CO_2 + 24H_2O$

24 96 160

Double Oxidation

124

12 + 24

60 + 40 + 24

160

Q. $61\overset{+7}{Mn}O_4^- + 5[\overset{+2}{Fe}(\overset{-4}{CN})_6]^{-4} \longrightarrow 61Mn^{+2} + 5Fe^{+3} + 30\overset{+4}{C}O_2 + 30\overset{+5}{N}O_3^- + 94H_2O$

$188H^+$

Fe^{+2} → $-1e^-$ → Fe^{+3}

CN → C^{+2} ($-2e^- \times 6 = 12e^-$) → $+4\ CO_2$

CN → N^{-3} ($-8e^- \times 6 = 48e^-$) → $+5\ NO_3^-$

Total loss = $61e^-$

$$\Rightarrow\ 61MnO_4^- + 5[Fe(CN)_6]^{4} \xrightarrow{188H^+} 61Mn^{2+} + 5Fe^{+3} + 30CO_2 + 30NO_3^- + 94H_2O$$

Q. $\overset{+5}{As_2}\overset{-2}{S_5} + 40\overset{+5}{HNO_3} \longrightarrow 2H_3\overset{+5}{AsO_4} + H_2\overset{+6}{SO_4} + 40\overset{+4}{NO_2} + 12H_2O$

$\downarrow 1$

$\uparrow 8 \times 5 = 40$

$120O \longrightarrow 8 + 20 + 80 = 108$

$-12O$

$40H \longrightarrow 16H$

$-24H$

Q. $\overset{o}{Br_2} + NaOH \longrightarrow \overset{-1}{NaBr} + \overset{+5}{NaBrO_3} + H_2O$

$\downarrow 1 \times 2 = 2$

$\uparrow 5 \times 2 = 10$

Disproportionation Reaction

$\uparrow 2$

$Br_2 + 5Br_2 + 12NaOH \longrightarrow 10NaBr + 2NaBrO_3 + 6H_2O$

$\downarrow 10$

$$\Rightarrow\ 6Br_2 + 12NaOH \longrightarrow 10NaBr + 2NaBrO_3 + 6H_2O$$

$$\Rightarrow\ 3Br_2 + 6NaOH \longrightarrow 5NaBr + NaBrO_3 + 3H_2O$$

$1\overset{o}{Br} \xrightarrow{-5e^-} \overset{+5}{BrO_3^-}$

$5\overset{o}{Br} \xrightarrow{+5e^-} \overset{-1}{Br^-}$

Q. $\overset{o}{P_4} + NaOH + H_2O \longrightarrow PH_3 + \overset{+1}{NaH_2PO_2}$

$\downarrow 12$

-3

$\uparrow 4$

$+3 + x - 4 = 0$

$\boxed{x = +1}$

$1P_4 + 3P_4 + 12NaOH + 12H_2O \longrightarrow 4PH_3 + 12NaH_2PO_2$

$\downarrow 12$

$\uparrow 4$

$1\overset{o}{P} \xrightarrow{+3e^-} \overset{-3}{PH_3}$

$3\overset{o}{P} \xrightarrow{-3e^-} \overset{+1}{NaH_2PO_2}$

$$4P_4 + 12NaOH + 12H_2O \longrightarrow 4PH_3 + 12NaH_2PO_2$$

$$P_4 + 3NaOH + 3H_2O \longrightarrow PH_3 + 3NaH_2PO_2$$

⇛ Equivalent Weights of Oxidising Agents and Reducing Agents :

$\Rightarrow$ E.q., wt of OA/RA $= \dfrac{\text{Molecular wt/Atomic wt}}{\text{n-Factor}}$

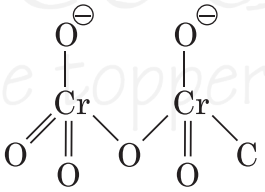
n-Factor
- OA
- RA

Total no. of e^- gained by 1 molecule or Total decrement in ON w.r.t. 1 molecule	Total no. of e^- lost by 1 molecule or Total increment in ON w.r.t. 1 molecule

Q. Determine the eq. wt of underlined species in following process :-

1. $\overset{+6}{K_2Cr_2O_7} \longrightarrow \overset{+3}{Cr}$ (↓2 × 3)

$w = \dfrac{M}{6}$



$$w = \frac{M}{6}$$

2. $\overset{+7}{KMnO_4} \xrightarrow{\downarrow 1} \overset{+6}{K_2MnO_4}$

$w = \dfrac{M}{1}$

$$w = \frac{M}{1}$$

3. $H_2\overset{-2}{S} \xrightarrow{\uparrow 8} \overset{+}{S}O_4^{-2}$

$w = \dfrac{M}{8}$

4.