Oxidizing and Reducing agents (Oxidants and Reductants).

(1) **Definition:**The substance (atom, ion or molecule) that gains electrons and is thereby reduced to a low valency state is called an **oxidizing agent,** while the substance that loses electrons and is thereby oxidized to a higher valency state is called a **reducing agent.**

Or

An **oxidizing agent** is a substance the oxidation number of whose atom or atoms decreases while a reducing agent is a substance the oxidation number of whose atom increases.

(2) **Important oxidizing agents**

(i) Molecules made up of electronegative elements, e.g. O_2, O_3 and X_2 (halogens).

(ii) Compounds containing an element which is in the highest oxidation state e.g. $KMnO_4, K_2Cr_2O_7,$

$Na_2Cr_2O_7$, CrO_3, H_2SO_4, $HNO_3, NaNO_3, FeCl_3, HgCl_2, KClO_4, SO_3, CO_2, H_2O_2$ etc.

(iii) Oxides of elements e.g. $MgO, CuO, CrO_3, CO_2, P_4O_{10}$, etc.

(iv) Fluorine is the strongest oxidizing agent.

(3) **Important reducing agents**

(i) All metals e.g. Na, Zn, Fe, Al, etc.

(ii) A few non-metals e.g. C, H_2, S etc.

(iii) Hydracids: HCl, HBr, HI, H_2S etc.

(iv) A few compounds containing an-element in the lower oxidation state (ous), e.g. $FeCl_2$, $FeSO_4$,

$SnCl_2$, Hg_2Cl_2, Cu_2O Etc.

(v) Metallic hydrides e.g. NaH, LiH etc.

(vi) Organic compounds like HCOOH and $(COOH)_2$ and their salts, aldehydes, alkanes etc.

(vii) Lithium is the strongest reducing agent in solution.

(viii) Cesium is the strongest reducing agent in absence of water. Other reducing agents are $Na_2S_2O_3$ and KI.

(ix) Hypo prefix indicates that central atom of compound has the minimum oxidation state so it will act as a reducing agent. e.g., H_3PO_2 (hypophosphorous acid).

(4) **Substances which act as oxidizing as well as reducing agents**

Example: H_2O_2, SO_2, H_2SO_3, HNO_2, $NaNO_2$, Na_2SO_3, O_3 etc.

(5) **Tips for the identification of oxidizing and reducing agents**

(i) If an element is in its highest possible oxidation state in a compound, the compound can function as an oxidizing agent, e.g. $KMnO_4$, $K_2Cr_2O_7$, HNO_3, H_2SO_4, $HClO_4$ etc.

(ii) If an element is in its lowest possible oxidation state in a compound, the compound can function only as a reducing agent, e.g. H_2S, $H_2C_2O_4$, $FeSO_4$, $Na_2S_2O_3$, $SnCl_2$ etc.

(iii) If an element is in its intermediate oxidation state in a compound, the compound can function both as an oxidizing agent as well as reducing agent, e.g. H_2O_2, H_2SO_3, HNO_2, SO_2 etc.

(iv) If a highly electronegative element is in its highest oxidation state in a compound, that compound can function as a powerful oxidizing agent, e.g. $KClO_4$, $KClO_3$, $KBrO_3$, KIO_3 etc.

(v) If an electronegative element is in its lowest possible oxidation state in a compound or in Free State, it can function as a powerful reducing agent, e.g. I^-, Br^-, N^{3-} etc.

(6) **Tests for oxidizing agents**

(i) Aqueous solutions of oxidizing agents react with,

(a) Hydrogen sulphide to give a milky yellow precipitate of sulphur.

H_2S + Oxidizing agent $\rightarrow$ S (milky yellow ppt.)

(b) Potassium iodide solution and evolve iodine which gives intense blue color with starch solution

KI + Oxidizing agent $\rightarrow I_2 \xrightarrow{Starch\ solution}$ intense blue color

(c) Freshly prepared solution of ferrous ammonium sulphate in presence of dil. H_2SO_4. Ferric ions (Fe^{3+}) can be detected by adding ammonium thiocyanate solution when a deep red coloration is produced.

Oxidizing agent + $Fe^{2+} \rightarrow Fe^{3+} \xrightarrow{CNS^-} Fe(CNS)_3$ (deep red coloration)

(ii) Insoluble oxidizing agents on,

(a) Strong heating evolve oxygen which relights a glowing splinter.

(b) Warming with concentrated hydrochloric acid evolve chlorine which bleaches the moist litmus paper.

(7) **Tests for reducing agents**

(i) Aqueous solutions of reducing agents react with,

(a) Acidified potassium permanganate solution and decolorize it.

(b) Few drops of acidified potassium dichromate solution, green coloration is produced.

(c) Few drops of ferric chloride solution. The ferrous ions thus formed give a deep blue coloration with potassium ferricyanide $(K_3[Fe(CN)_6])$.

Insoluble reducing agents on,

(d) Heating with concentrated nitric acid, evolve brown fumes of nitrogen dioxide.

(e) Heating with powdered cupric salt, form a red deposit of copper which does not dissolve in warm dilute sulphuric acid.

(8) **Equivalent weight of oxidizing and reducing agents**

(i) Equivalent weight of a substance (Oxidant or Reductants) is equal to molecular weight divided by number of electrons lost or gained by one molecule of the substance in a redox reaction.

$$\text{Equivalent weight of oxidizing agent} = \frac{\text{Molecular weight}}{\text{No. of electrons gained by one molecule}}$$

$$\text{Equivalent weight of reducing agent} = \frac{\text{Molecular weight}}{\text{No. of electrons lost by one molecule}}$$

(ii) In other words, it is equal to the molecular weight of oxidant or Reductants divided by the change in oxidation number.

$$\text{Equivalent weight of oxidizing agent} = \frac{\text{Molecular weight}}{\text{Change in O.N. per mole}}$$

$$\text{Equivalent weight of reducing agent} = \frac{\text{Molecular weight}}{\text{Change in O.N. per mole}}$$

Equivalent weight of few oxidizing/reducing agents

Agents	**O. N.**	**Product**	**O. N.**	**Change in O. N. per atom**	**Total Change in O. N. per mole**	**Eq. wt.**
$Cr_2O_7^{2-}$	+ 6	Cr^{3+}	+ 3	3	3 × 2 = 6	Mol. wt./6
$C_2O_4^{2-}$	+ 3	CO_2	+ 4	1	1 × 2 = 2	Mol. wt./2
$S_2O_3^{2-}$	+ 2	$S_4O_6^{2-}$	+ 2.5	0.5	0.5 × 2 = 1	Mol. wt./1
H_2O_2	– 1	H_2O	– 2	1	1 × 2 = 2	Mol. wt./2
H_2O_2	– 1	O_2	0	1	1 × 2 = 2	Mol. wt./2
MnO_4^- **(Acidic medium)**	+ 7	Mn^{2+}	+ 2	5	5 × 1 = 5	Mol. wt./5
MnO_4^- **(Neutral medium)**	+ 7	MnO_2	+ 4	3	3 × 1 = 3	Mol. wt./3
MnO_4^- **(Alkaline medium)**	+ 7	MnO_4^{2-}	+ 6	1	1 × 1 = 1	Mol. wt./1