Oxidation-reduction and Redox reactions.

(1) **Oxidation :** Oxidation is a process which involves; addition of oxygen, removal of hydrogen, addition of non-metal, removal of metal, Increase in +ve valency, loss of electrons and increase in oxidation number.

(i) **Addition of oxygen**

(a) $2Mg + O_2 \rightarrow 2MgO$ (Oxidation of magnesium)

(b) $S + O_2 \rightarrow SO_2$ (Oxidation of sulphur)

(c) $2CO + O_2 \rightarrow 2CO_2$ (Oxidation of carbon monoxide)

(d) $Na_2SO_3 + H_2O_2 \rightarrow Na_2SO_4 + H_2O$ (Oxidation of sodium sulphite)

(ii) **Removal of hydrogen**

(a) $H_2S + Cl_2 \rightarrow 2HCl + S$ (Oxidation of hydrogen sulphide)

(b) $4HI + O_2 \rightarrow 2H_2O + 2I_2$ (Oxidation of hydrogen iodide)

(c) $C_2H_5OH \xrightarrow{Cu\,/\,300^oC} CH_3CHO + H_2$ (Oxidation of ethanol)

(d) $4HCl + MnO_2 \rightarrow MnCl_2 + 2H_2O + Cl_2$ (Oxidation of hydrogen chloride)

(iii) **Addition of an electronegative element or addition of Non-metal**

(a) $Fe + S \rightarrow FeS$ (Oxidation of iron)

(b) $SnCl_2 + Cl_2 \rightarrow SnCl_4$ (Oxidation of stannous chloride)

(c) $2Fe + 3F_2 \rightarrow 2FeF_3$ (Oxidation of iron)

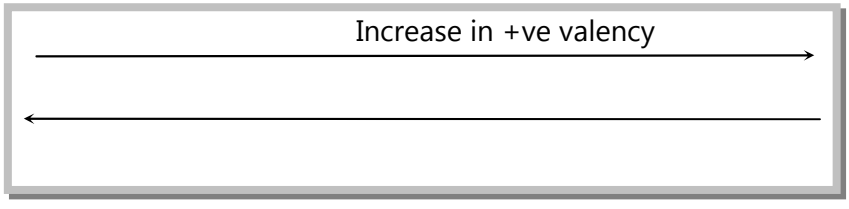
(iv) **Removal of an electropositive element or removal of metal**

(a) $2KI + H_2O_2 \rightarrow 2KOH + I_2$ (Oxidation of potassium iodide)

(b) $2K_2MnO_4 + Cl_2 \rightarrow 2KCl + 2KMnO_4$ (Oxidation of potassium magnate)

(c) $2KI + Cl_2 \rightarrow 2KCl + I_2$ (Oxidation of potassium iodide)

(v) **Increase in +ve valency and Decrease in – ve valency**



–4, –3, –2, –1, 0, +1, +2, +3, +4

Decrease in –ve valency

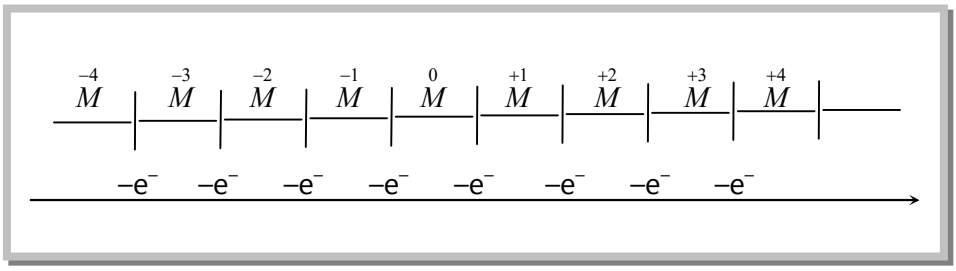
(a) $Fe^{2+} \rightarrow Fe^{3+} + e^-$ (+ve valency increases)

(b) $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$ (+ve valency increases)

(c) $[Fe(CN)_6]^{4-} \rightarrow [Fe(CN)_6]^{3-} + e^-$ (–ve valency decreases)

(d) $MnO_4^{2-} \rightarrow MnO_4^- + e^-$ (–ve valency decreases)

(vi) **Loss of electrons** (also known as de-electronation)



Loss of electrons

(a) $H^0 \rightarrow H^+ + e^-$ (Formation of proton)

(b) $H_2^0 \rightarrow H_2^+ + e^-$ (De-electronation of hydrogen)

(c) $Fe^{2+} \rightarrow Fe^{3+} + e^-$ (De-electronationof Fe^{2+})

(d) $Mg \rightarrow Mg^{2+} + 2e^-$ (De-electronation of Magnesium)

(e) $MnO_4^{2-} \rightarrow MnO_4^- + e^-$ (De-electronationof MnO_4^{2-})

(f) $2Cl^- \rightarrow Cl_2 + 2e^-$ (De-electronation of chloride ion)

(g) $2Fe^0 \rightarrow 2Fe^{3+} + 6e^-$ (De-electronation of iron)

(vii) **Increase in oxidation number**

(a) $Mg^0 \rightarrow Mg^{2+}$ (From 0 to +2)

(b) $\left[Fe^{+2}(CN)_6\right]^{4-} \rightarrow \left[Fe^{+3}(CN)_6\right]^{3-}$ (From +2 to +3)

(c) $2Cl^- \rightarrow Cl_2^0$ (From –1 to 0)

(2) **Reduction:**Reduction is just reverse of oxidation. Reduction is a process which involves; removal of oxygen, addition of hydrogen, removal of non-metal, addition of metal, decrease in +ve valency, gain of electrons and decrease in oxidation number.

(i) **Removal of oxygen**

(a) $CuO + C \rightarrow Cu + CO$ (Reduction of cupric oxide)

(b) $\underset{Steam}{H_2O} + \underset{Coke}{C} \rightarrow \underbrace{CO + H_2}_{Water\ gas}$ (Reduction of water)

(c) $Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$ (Reduction of Fe_3O_4)

(d) $C_6H_5OH + Zn \rightarrow C_6H_6 + ZnO$ (Reduction of phenol)

(ii) **Addition of hydrogen**

(a) $Cl_2 + H_2 \rightarrow 2HCl$ (Reduction of chlorine)

(b) $S + H_2 \rightarrow H_2S$ (Reduction of sulphur)

(c) $C_2H_4 + H_2 \rightarrow C_2H_6$ (Hydrogenation of ethane)

(iii) **Removal of an electronegative element or removal of Non-metal**

(a) $2HgCl_2 + SnCl_2 \rightarrow Hg_2Cl_2 + SnCl_4$ (Reduction of mercuric chloride)

(b) $2FeCl_3 + H_2 \rightarrow 2FeCl_2 + 2HCl$ (Reduction of ferric chloride)

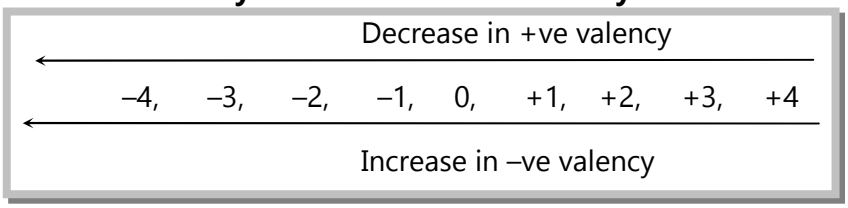
(c) $2FeCl_3 + H_2S \rightarrow 2FeCl_2 + 2HCl + S$ (Reduction of ferric chloride)

(iv) **Addition of an electropositive element or addition of metal**

(a) $HgCl_2 + Hg \rightarrow Hg_2Cl_2$ (Reduction of mercuric chloride)

(b) $CuCl_2 + Cu \rightarrow Cu_2Cl_2$ (Reduction of cupric chloride)

(v) **Decrease in +ve valency and Increase in –ve valency**



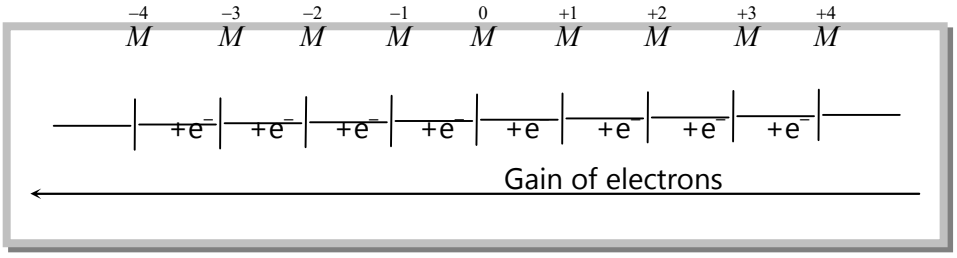
(a) $Fe^{3+} \rightarrow Fe^{2+}$ (+ve valency decreases)

(b) $Sn^{4+} \rightarrow Sn^{2+}$ (+ve valency decreases)

(c) $[Fe(CN)_6]^{3-} \rightarrow [Fe(CN)_6]^{4-}$ (–ve valency increases)

(d) $MnO_4^- \rightarrow MnO_4^{2-}$ (–ve valency increases)

(vi) **Gain of electrons** (also known as electronation)



(a) $Zn^{2+}(aq) + 2e^- \rightarrow Zn(S)$ (Electronation of Zn^{2+})

(b) $Pb^{2+} + 2e^- \rightarrow Pb^0$ (Electronation of Pb^{2+})

(c) $Mn^{7+} + 5e^- \rightarrow Mn^{2+}$ (Electronation of Mn^{7+})

(d) $Fe^{3+} + e^- \rightarrow Fe^{2+}$ (Electronation of Fe^{3+})

(e) $Sn^{4+} + 2e^- \rightarrow Sn^{2+}$ (Electronation of Sn^{4+})

(f) $Cl + e^- \rightarrow Cl^-$ (Formation of chloride ion)

(g) $[Fe(CN)_6]^{3-} + e^- \rightarrow [Fe(CN)_6]^{4-}$ (Electronationof $[Fe(CN)_6]^{3-}$)

(vii) **Decrease in oxidation number**

(a) $Mg^{2+} \rightarrow Mg^0$ (From +2 to 0)

(b) $[Fe(CN)_6]^{3-} \rightarrow [Fe(CN)_6]^{4-}$ (From +3 to +2)

(c) $Cl_2^0 \rightarrow 2Cl^-$ (From 0 to –1)

(3) **Redox-reactions**

(i) An overall reaction in which oxidation and reduction takes place simultaneously is called **redox** or **oxidation-reduction reaction.** These reactions involve transfer of electrons from one atom to another. Thus every redox reaction is made up of two **half reactions;** One half reaction represents the oxidation and the other half reaction represents the reduction.

(ii) **The redox reactions are of following types**

(a) **Direct redox reaction:** The reactions in which oxidation and reduction takes place in the same vessel are called direct redox reactions.

(b) **Indirect redox reaction:** The reactions in which oxidation and reduction takes place in different vessels are called indirect redox reactions. Indirect redox reactions are the basis of electro-chemical cells.

(c) **Intermolecular redox reactions:** In which one substance is oxidized while the other is reduced. For example,

$$2\,Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$$

Here, Al is oxidized to Al_2O_3 while Fe_2O_3 is reduced to Fe.

(d) **Intramolecular redox reactions:** In which one element of a compound is oxidized while the other is reduced. For example,

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

Here, Cl^{+5} in $KClO_3$ is reduced to Cl^{-1} in KCl while O^{2-} in $KClO_3$ is oxidizedto O_2^0.

(iii) To see whether the given chemical reaction is a redox reaction or not, the molecular reaction is written in the form of ionic reaction and now it is observed whether there is any change in the valency of atoms or ions. If there is a change in valency, the chemical reaction will be a redox reaction otherwise not. For example,

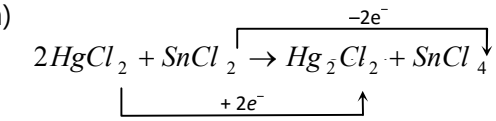
(a) $BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$

(b) $CuSO_4 + 4\,NH_3 \rightarrow [Cu(NH_3)_4]SO_4$

In above examples there is no change in the valency of any ion or atom, thus these are not redox reactions.

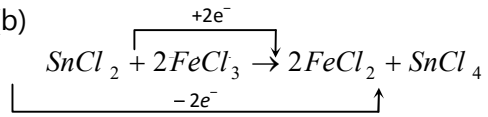
(iv) **Some examples of redox reactions are,**

(a)



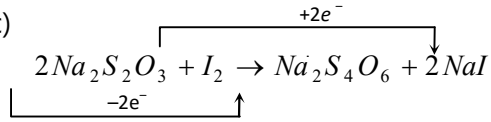
Here mercuric ion is reduced to mercurous ion and stannous ion is oxidized to stannic ion, i.e., mercuric ion acts as an oxidizing agent while stannous ion acts as a reducing agent.

(b)

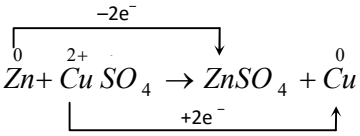


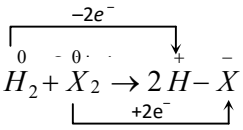
Here ferric ion is reduced to ferrous ion by gain of one electron while stannous ion is oxidized to stannic ion by loss of two electrons. The ferric ion acts as an oxidizing agent while stannous ion acts as a reducing agent.

(c)

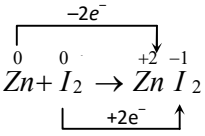


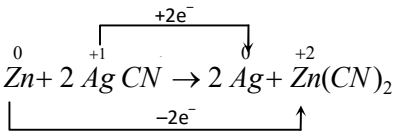
Here thiosulphate ion is oxidized to tetrathionate ion by loss of electrons while iodine is reduced to iodide ion by gain of electrons. Thiosulphate ion acts as a reducing agent and iodine acts as an oxidizing agent.

(d) 

(e) 

(Where X = F, Cl, Br, I)

(f) 

(g) 

(h)