Electrode potential : The potential difference that develops between metal atoms and its ions (or) non – metal molecules and the ions is called 'Electrode potential'.

- The tendency of an electrode to undergo oxidation is called oxidation potential (or) the tendency to lose electrons, is called oxidation potential.
- The tendency of an electrode to undergo reduction (or) the tendency to gain electron is called reduction potential.

Standard electrode potential : The potential exhibited by a single electrode in the solution of unit concentration of metal ion or non-metal ion at 25°C is called standard single electrode potential.

- The electrode potential measured at 25°C, 1 atm pressure become standard potentials [E°].
- For any electrode the Standard Oxidation Potential(SOP) and Standard Reduction Potential (SRP) values are equal in magnitude and opposite in sign.

  Ex : 1) $E^0_{Zn/Zn^{2+}} \rightarrow +0.76V \ (SOP)$

  $E^0_{Zn^{2+}/Zn} \rightarrow -0.76V \ (SRP)$

  2) $E^0_{Cu^{2+}/Cu} \rightarrow +0.34V \ (SRP)$

  $E^0_{Cu/Cu^{2+}} \rightarrow -0.34V \ (SOP)$

  3) $E^0_{Ag/Ag^{+}} \rightarrow -0.8V \ (SOP)$

  $E^0_{Ag^{+}/Ag} \rightarrow +0.8V \ (SRP)$

- Single Electrode Potentials (SEP) cannot be directly determined because only the potential difference between the two electrodes can be measured by using 'potential metre' or 'volt metre'.
- SEP's can be determined by using 'standard' or 'reference electrodes' (whose potentials are known).
- **Primary reference electrodes:** Standard Hydrogen Electrode (SHE) or Normal Hydrogen Electrode (NHE). It's E° = ± 0.00V.

Representation of SHE :

$$Pt, H_2 / H^+ \qquad \frac{1}{2}H_2 \rightleftharpoons H^+$$
$$(g) \qquad (aq)$$

- A platinum foil coated with platinum black is half dipped in 1 M HCl(1mH^+) and H_2 gas is bubbled through it at 1atm. This arrangement is called as standard hydrogen electrode. The electrode whose potential has to be determined is connected with SHE.
- Since, it is difficult to maintain 1atm pressure with light gas like H_2, now SHE is replaced by other reference electrodes.

  Ex. Calomel electrode $\rightarrow$ Hg/ $Hg_2Cl_{2(s)}$, $KCl_{(sat)}$

  E° = - 0.2422 V

  Calculating EMF of cell: The potential difference between the two electrodes is called 'cell EMF'.

  $E^0_{cell} = E^0_{right} - E^0_{left}$

$= E^0_{cathode} - E^0_{anode}$

= SRP of cathode – SRP of anode

= SOP of anode – SOP of cathode

= SOP of anode + SRP of cathode

Electrochemical series (or) EMF series (or) Activity series :

It is the series of electrodes arranged in the increasing water of SRP values.

Electrode system	E°(V) vs (NHE)	Electrode reaction
Li^+ | Li	– 3.045	$Li^+ + e^- \rightleftharpoons Li$
K^+ | K	– 2.925	$K^+ + e^- \rightleftharpoons K$
Ca^{2+} | Ca	– 2.870	$Ca^{2+} + 2e^- \rightleftharpoons Ca$
Na^+ | Na	– 2.714	$Na^+ + e^- \rightleftharpoons Na$
Zn^{2+} | Zn	– 0.762	$Zn^{2+} + 2e^- \rightleftharpoons Zn$
Fe^{2+} | Fe	– 0.441	$Fe^{2+} + 2e^- \rightleftharpoons Fe$
Cd^{2+} | Cd	– 0.403	$Cd^{2+} + 2e^- \rightleftharpoons Cd$
Co^{2+} | Co	– 0.277	$Co^{2+} + 2e^- \rightleftharpoons Co$
Ni^{2+} | Ni	– 0.250	$Ni^{2+} + 2e^- \rightleftharpoons Ni$
Sn^{2+} | Sn	– 0.140	$Sn^{2+} + 2e^- \rightleftharpoons Sn$
Pb^{2+} | Pb	– 0.126	$Pb^{2+} + 2e^- \rightleftharpoons Pb$
$H^+ + H_2$ | Pt	± 0.00	$H^+ + e^- \rightleftharpoons 1/2\ H_2$
Cu^{2+} | Cu	+ 0.337	$Cu^{2+} + 2e^- \rightleftharpoons Cu$
Pt, O_2 / OH^-	+ 0.401	$1/2O_2+H_2O+2e \rightleftharpoons 2OH^-$
I_2 | I^-, Pt	+ 0.536	$I_2 + 2e^- \rightleftharpoons 2\ I^-$
Fe^{3+} | Fe^{2+}, Pt	+ 0.771	$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$
Ag^+ | Ag	+ 0.799	$Ag^+ + e^- \rightleftharpoons Ag$
Pt, Br_2 | Br^-	+ 1.065	$Br_2 + 2e^- \rightleftharpoons 2\ Br^-$
Pt, Cl_2 | Cl^-	+ 1.360	$Cl_2 + 2e^- \rightleftharpoons 2\ Cl^-$
Pt, F_2 | F^-	+ 2.87	$F_2 + 2e^- \rightleftharpoons 2\ F^-$

- In the above activity series from top to bottom, SRP value increases.
- SOP values decreases.
- Metallic or electro positive nature decreases.
- Non– metallic or electro negative nature increases.
- Tendency to reduce or reducing nature decreases.
- Tendency to undergo reduction increases.
- Tendency to oxidise (or) oxidising nature, increases.
- Tendency to undergo oxidation decreases.
- The ability to lose electrons decreases.

- The ability to gain electrons increases.
- Above element reduces all the elements below it.
- Below element oxidizes all the elements above it.
- Above metal displaces the below metal from the salt solution.
- Below non – metal displaces the above non – metal from its solution.
- Metals above hydrogen liberate H_2 gas from dil acids and water.
- Metals below hydrogen cannot liberate H_2 gas from dil acids and H_2O.
- Aqueous solution of metals above hydrogen will liberate H_2 but not metal on electrolysis.

Fused or aq.solution of metal salts below hydrogen will give metal at cathode but not H_2 gas.