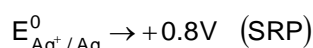
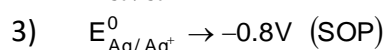
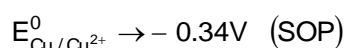
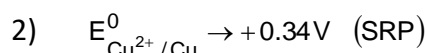
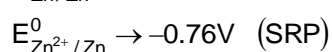
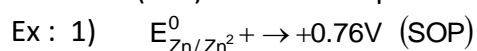


**Electrode potential :** The potential difference that develops between metal atoms and its ions (or) non – metal molecules and the ions is called ‘Electrode potential’.

- 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.

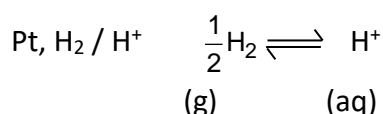
**Standard electrode potential :** The potential exhibited by a single electrode in the solution of unit concentration of metal ion or non-metal ion at 25°C is called standard single electrode potential.

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



- 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  $E^\circ = \pm 0.00\text{V}$ .

**Representation of SHE :**



- A platinum foil coated with platinum black is half dipped in 1 M HCl( $1\text{mH}^+$ ) and  $\text{H}_2$  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  $\text{H}_2$ , now SHE is replaced by other reference electrodes.

Ex. Calomel electrode  $\rightarrow \text{Hg/ Hg}_2\text{Cl}_{2(s)}, \text{KCl}_{(\text{sat})}$

$$E^\circ = -0.2422\text{V}$$

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

$$E_{\text{cell}}^0 = E_{\text{right}}^0 - E_{\text{left}}^0$$

$$\begin{aligned}
 &= E_{\text{cathode}}^0 - E_{\text{anode}}^0 \\
 &= \text{SRP of cathode} - \text{SRP of anode} \\
 &= \text{SOP of anode} - \text{SOP of cathode} \\
 &= \text{SOP of anode} + \text{SRP of cathode}
 \end{aligned}$$

### 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 <sup>+</sup>   Li	– 3.045	Li <sup>+</sup> + e <sup>–</sup> ⇌ Li
K <sup>+</sup>   K	– 2.925	K <sup>+</sup> + e <sup>–</sup> ⇌ K
Ca <sup>2+</sup>   Ca	– 2.870	Ca <sup>2+</sup> + 2e <sup>–</sup> ⇌ Ca
Na <sup>+</sup>   Na	– 2.714	Na <sup>+</sup> + e <sup>–</sup> ⇌ Na
Zn <sup>2+</sup>   Zn	– 0.762	Zn <sup>2+</sup> + 2e <sup>–</sup> ⇌ Zn
Fe <sup>2+</sup>   Fe	– 0.441	Fe <sup>2+</sup> + 2e <sup>–</sup> ⇌ Fe
Cd <sup>2+</sup>   Cd	– 0.403	Cd <sup>2+</sup> + 2e <sup>–</sup> ⇌ Cd
Co <sup>2+</sup>   Co	– 0.277	Co <sup>2+</sup> + 2e <sup>–</sup> ⇌ Co
Ni <sup>2+</sup>   Ni	– 0.250	Ni <sup>2+</sup> + 2e <sup>–</sup> ⇌ Ni
Sn <sup>2+</sup>   Sn	– 0.140	Sn <sup>2+</sup> + 2e <sup>–</sup> ⇌ Sn
Pb <sup>2+</sup>   Pb	– 0.126	Pb <sup>2+</sup> + 2e <sup>–</sup> ⇌ Pb
H <sup>+</sup> + H <sub>2</sub>   Pt	± 0.00	H <sup>+</sup> + e <sup>–</sup> ⇌ 1/2 H <sub>2</sub>
Cu <sup>2+</sup>   Cu	+ 0.337	Cu <sup>2+</sup> + 2e <sup>–</sup> ⇌ Cu
Pt, O <sub>2</sub> / OH <sup>–</sup>	+ 0.401	1/2 O <sub>2</sub> + H <sub>2</sub> O + 2e <sup>–</sup> ⇌ 2OH <sup>–</sup>
I <sub>2</sub>   I <sup>–</sup> , Pt	+ 0.536	I <sub>2</sub> + 2e <sup>–</sup> ⇌ 2 I <sup>–</sup>
Fe <sup>3+</sup>   Fe <sup>2+</sup> , Pt	+ 0.771	Fe <sup>3+</sup> + e <sup>–</sup> ⇌ Fe <sup>2+</sup>
Ag <sup>+</sup>   Ag	+ 0.799	Ag <sup>+</sup> + e <sup>–</sup> ⇌ Ag
Pt, Br <sub>2</sub>   Br <sup>–</sup>	+ 1.065	Br <sub>2</sub> + 2e <sup>–</sup> ⇌ 2 Br <sup>–</sup>
Pt, Cl <sub>2</sub>   Cl <sup>–</sup>	+ 1.360	Cl <sub>2</sub> + 2e <sup>–</sup> ⇌ 2 Cl <sup>–</sup>
Pt, F <sub>2</sub>   F <sup>–</sup>	+ 2.87	F <sub>2</sub> + 2e <sup>–</sup> ⇌ 2 F <sup>–</sup>

- 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.