ELECTROCHEMISTRY

ELECTROCHEMICAL CELLS

❖ INTRODUCTION OF ELECTROCHEMISTRY: -

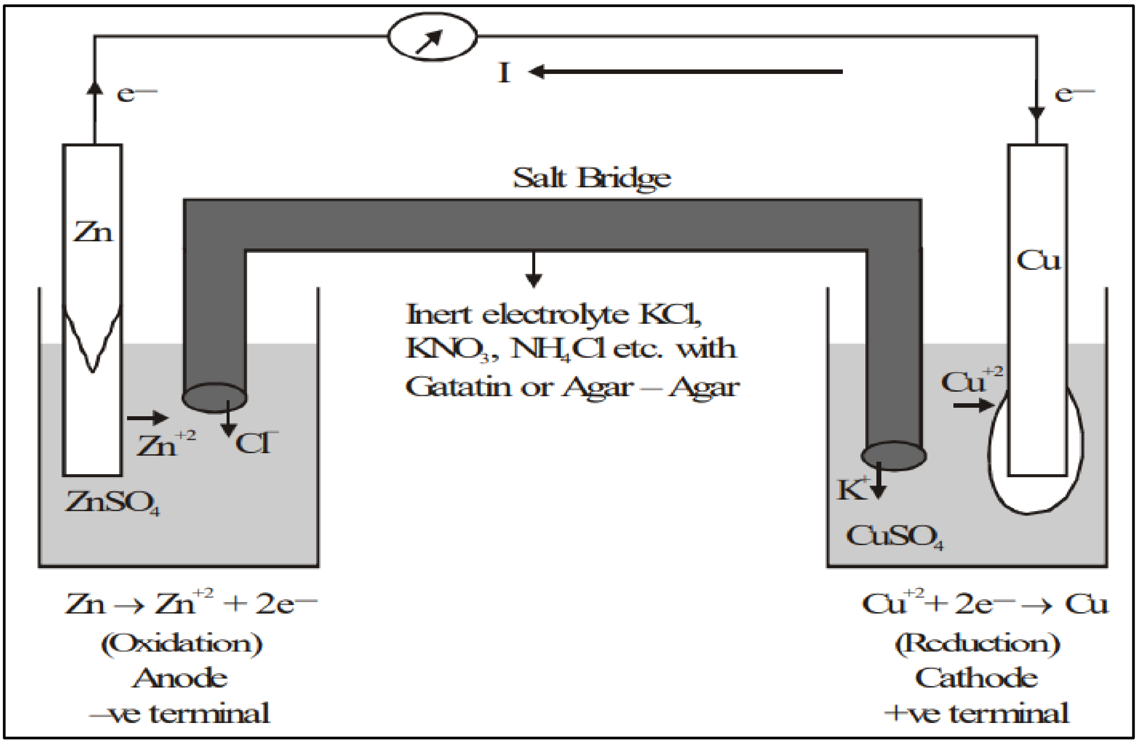
Electrochemistry deals with the study of electrical properties of solutions of electrolytes and with the inter-relation of chemical phenomenon and electrical energies. Electrical energy is carried through matter in the form of electric current with the help of suitable source and charge carriers (ions or electrons)

ELECTROCHEMICAL CELLS: USES, DESCRITPTION: -

Electro chemical cell/ Galvanic cell/ Voltaic cell: -

Example – Daniel Cell

- A cell in which the chemical energy is transformed into electrical energy.
- The chemical reaction occurring in a galvanic cell is always a redox reaction.
- During the chemical process, the reduction in free energy will obtain as a result in the form of electrical energy.



Salt bridge: -

1. It allows to flow of current by completing the circuit.

2. It maintains electrical neutrality of electrolytes in two half cells.

Characteristics of electrolyte used in salt bridge: -

1. The electrolyte should be inert

2. The cations and anions of the electrolyte used should be of the same ionic modality

Cell reaction –

$$Zn + Cu^{+2} \longrightarrow Zn^{+2} + Cu$$

Representation of Galvanic cell.

Zn/Zn^{+2} // Cu^{+2}/ Cu

(C_1) (C_2)

Anode Cathode

salt bridge

Electrode potential : When a strip of metal is brought in contact with the solution containing its own ions then the strip of metal gets positively charged or negatively charged and results into a potential being developed between the metallic strip and its solution which is known as electrode potential.

At anode $M \rightarrow M^{+n} + ne^-$ (Oxidation Potential)

At cathode $M^{+n} + ne^- \rightarrow M$ (Reduction Potential)

- The value of electrode potential depends upon:
  (1) the nature of electrode
  (2) the concentration of solution
  (3) the temperature

Standard electrode potential (E^0) : If the concentration of ions is unity, temperature is 25^0C and pressure is 1 atom (standard conditions), the potential of the electrode is called standard electrode potential.

- The given value of electrode potential be regarded as reduction potential unless it is specifically mentioned that it is oxidation potential.

Electro motive force of cell or cell voltage: The difference in the electrode potentials of the two electrodes of the cell is termed as electro motive force [EMF] or cell voltage.

$$E_{cell} = E_{red}\ (\text{cathode}) - E_{red}\ (\text{anode})$$

or $$E_{cell} = E_{oxi.}(\text{anode}) - E_{oxi.}(\text{Cathode})$$

or $$E_{cell} = E_{oxi.}(\text{anode}) + E_{red}(\text{cathode})$$

Electro chemical series: -

The arrangement of various elements in order of increasing values of standard reduction potentials is called electrochemical series.

Standard electrode Potential	**E°_{red} (Volt)**	**Standard electrode Potential**	**E°_{red} (Volt)**
Li	−3.05	Ni	−0.25
K	−2.925	Sn	−0.14
Ba	−2.90	Pb	−0.13
Ca	−2.87	H	0.00
Na	−2.714	Cu	+0.337
Mg	−2.37	I_2	+0.535
Al	−1.66	Ag	+0.799
Mn	−1.305	Hg	+0.885
Zn	−0.7628	Br_2	+1.08
Cr	−0.74	Cl_2	+1.36
Fe	−0.44	Pt	+1.20
Cd	−0.403	Au	+1.50
Co	−0.28	F_2	+2.87

Important points about series: -

1. Electrode whose standard reduction potential is less, act as anode, and other one which has high reduction potential acts as cathode.
2. Metals near the top of the series are strongly electropositive.
3. Metals near the top of the series can displace more electronegative metal below them from their salt.

   for example: $2AgNO_3 + Cu$ ® $Cu\ (NO_3)_2 + 2Ag$

   $CuSO_4 + Ag$ ® Reaction is not observed

4. Metal above hydrogen can displace H_2 from dilute acid

   For example: $Na + H_2SO_4$ ® $Na_2SO_4 + H_2$-

   $Cu + H_2SO_4$ ® Reaction is not observed

5. Hydro oxides of metal in the upper part of series are strongly basic while hydro oxides of a metal in lower part are weakly basic.
6. The activity of non-metals increases from top to bottom.
7. The metals which come below copper form unstable oxides, i.e., these are decomposed on heating.

ELECTROCHEMICAL CELLS: WORKING PROCESS AND IUPAC CONVENTION

Electrochemical Cell Working

The working of electrochemical cells is explained below:

Principle of Working of Electrochemical Cell

1. The basic principle of working of an electrochemical cell is the transfer of electrons generated from a redox reaction occurring in it that results in the production of electric current.
2. Electrons are released from metals used as electrodes.
3. On losing electrons, metals get oxidised. On the other hand, if they gain electrons, they get reduced.
4. When such redox reactions occur, free energy decreases and appear as electrical energy.

Define Electrochemical Cell: Working Mechanism

After the complete setup of an electrochemical cell, a deflection is observed in the external circuit's galvanometer when the switch is put on. The needle of the galvanometer moves towards the beaker containing copper sulphate solution. It indicates that current has flown from the beaker containing copper sulphate solution to the beaker containing zinc sulphate solution. The change happens when the circuit gets completed and causes oxidation of zinc atoms of zinc electrode and reduction of copper atoms of copper rod. Zinc releases two electrons that get accepted by copper via an external circuit. The complete redox reaction that occurs in the system is:

$Zn+Cu^{2+}\rightarrow Zn^{2+}+Cu$

Cell Reaction Representation

Electrochemical cell representation can be done by following the mentioned conventions recommended by the International Board of Chemistry:

1. Reduction half-reaction is represented as: Cu_{2+}(0.1M)|$CuCu_2$+(0.1M)|Cu
2. Oxidation half-reaction is represented as Zn|Zn_2+(0.1M)Zn|Zn_2+(0.1M)
3. Salt bridge is represented as ||||
4. The anode is always written on LHS and cathode on RHS.
5. Thus, the Electrochemical cell can be represented as Zn||Zn_{2+}(0.1M)‖Cu_{2+}(0.1M)||CuZn|Zn_2+(0.1M)‖Cu_2+(0.1M)|Cu

Applications of Electrochemical Cell

In metallurgy, electrolytic cells are used in the electrorefining of many non-ferrous metals, producing highly pure metals such as lead, zinc, aluminium, and copper. Electrolytic cells are used in the electrowinning of these metals.

It is used to extract pure sodium metal from molten sodium chloride by keeping it in an electrolytic cell.

Electrochemical cells convert chemical energy into electrical energy. This process is used in the daily use batteries that are of two types:

(i) Primary cells – These cells are of use and throw types of batteries. They are non-rechargeable and irreversible, used in remotes and torches. The electrochemical reactions are irreversible.

(ii) Secondary cells – The cells are rechargeable and reversible, i.e., they can function as both galvanic and electrolytic cells. The most widely used battery is a Lithium-ion battery used in automobiles and electronic gadgets.

Silver oxide batteries are used in hearing aids devices.

Thermal batteries are used for military purposes, such as in Navy devices.

Fuel cells work on conventional combustion-based technologies and have a wide range of applications in transportation, material handling, stationary, power backup applications, and power plants.

IUPAC CONVENTION:

- Write the anode on the L.H.S and the cathode on the R.H putting a vertical line in between the symbol of the metal formula of the electrolyte in the pollution.
- And put a double vertical line in between the solutions. i.e.,

Anode || Cathode $\Rightarrow$

R P R P

Metal | Electrolyte || Electrolyte | Metal

(Where R = Reactant & P = Product)

For Example:

Cell reaction:

$Zn_{(s)} + Cu^{+2}_{(aq)} \rightarrow Zn^{+2}_{(aq)} + Cu_{(s)}$

Cell representation:

$Zn_{(s)} \mid Zn^{+2}_{(aq)} \parallel Cu^{+2}_{(aq)} \mid Cu_{(s)}$