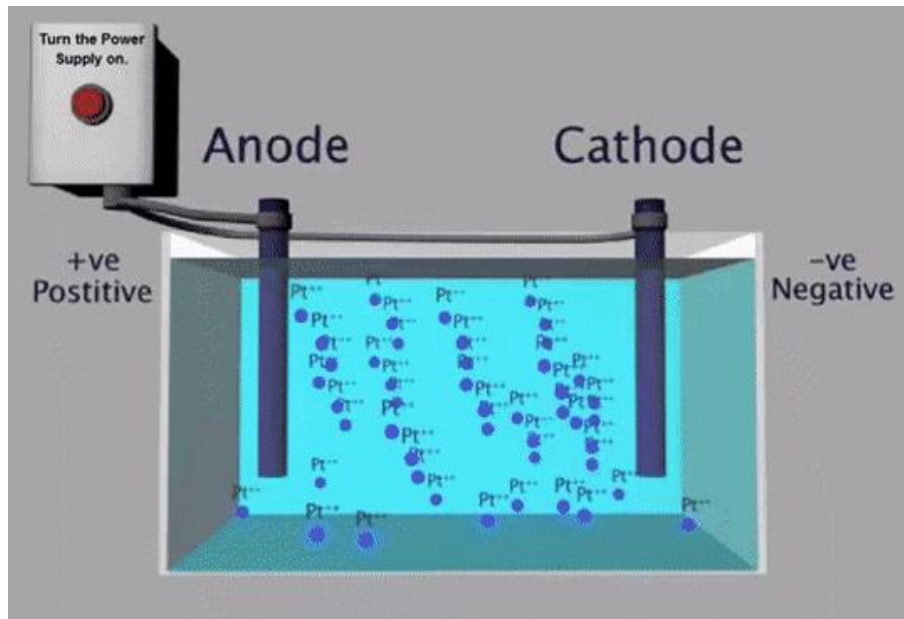


Module – 5: Electrochemical Energy Systems

Brief introduction to conventional primary and secondary batteries; High energy electrochemical energy systems: Lithium batteries – Primary and secondary, its Chemistry, advantages and applications.

Fuel cells – Polymer membrane fuel cells, Solid-oxide fuel cells- working principles, advantages, applications.

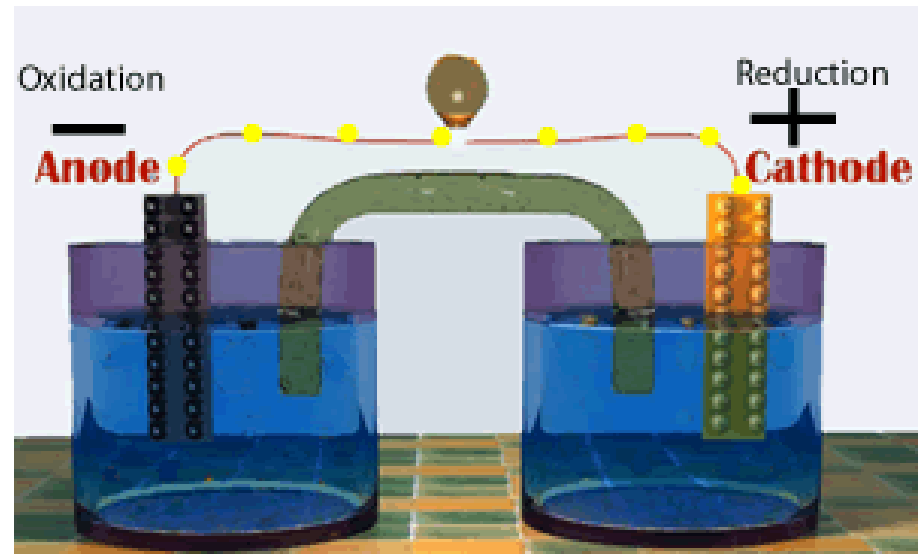
Introduction - Electrochemical Cell



Electrolytic Cell

Chemical reaction by passing electric current

Electrical energy is converted into chemical energy

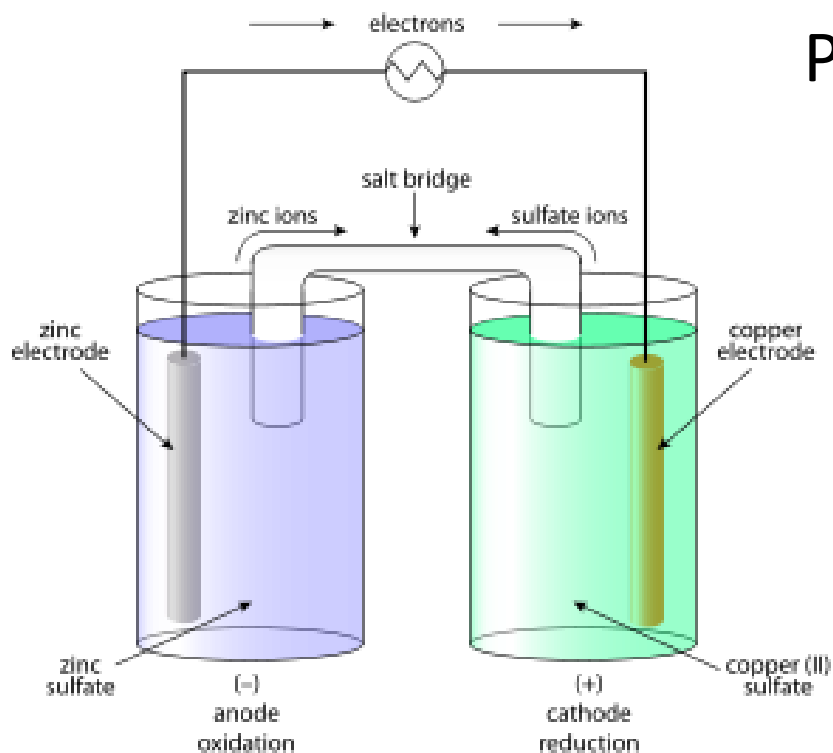


Electrochemical Cell

Chemical redox reaction is utilized to produce electrical current

Chemical energy is converted into electrical energy

Electrochemical cell

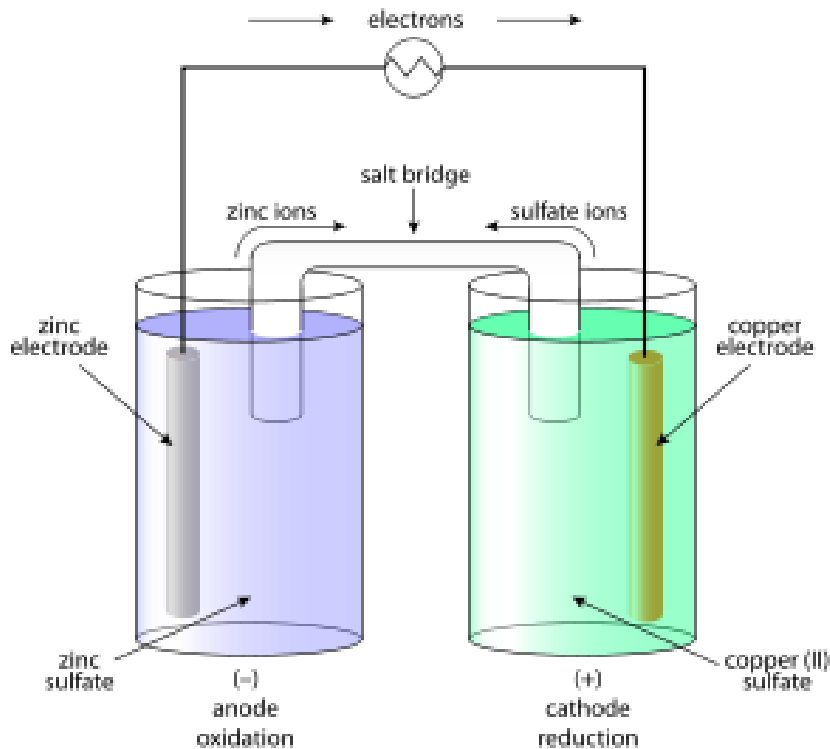


Parts of electrochemical cell

- Electrodes
 - i. Anode
 - ii. Cathode
- Electrolyte
- Separator

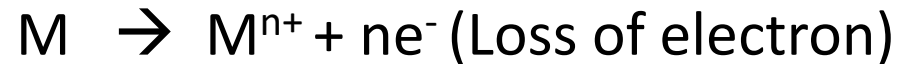
Oxidation occurs in Anode
Reduction occurs in Cathode

Electrochemical cell – Daniell cell



Anode

Oxidation



Cathode

Reduction

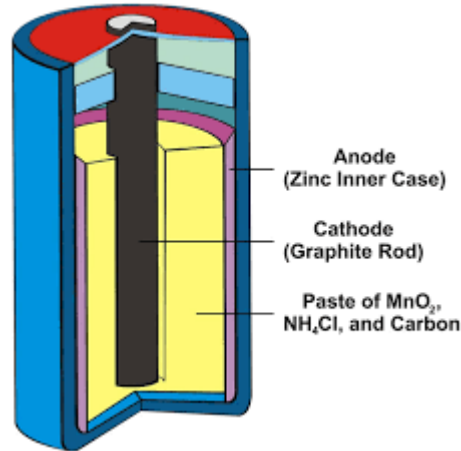


Representation of Electrochemical cell

- **Anode** is written on the **left** hand side, **Cathode** is on the **right** hand side.
- In the anode side, electrode is written on the left.
In the cathode side, electrode is written on the right
$$\text{Anode electrode} \mid \text{Electrolyte} \parallel \text{Electrolyte} \mid \text{Cathode electrode}$$
$$\text{Zn} \mid \text{Zn}^{2+} (1\text{M}) \parallel \text{Cu}^{2+} (1\text{M}) \mid \text{Cu}$$
- Salt bridge is mentioned as “ \parallel ”
- Concentration of the electrolyte solution can be mentioned next to the electrolyte

Battery

- A **battery** is a device consisting of **one or more electrochemical cells** with external connections provided to power electrical devices.



- An **electrochemical cell** is a device capable of generating **electrical energy** from **chemical reactions**.
 - e.g. Daniell Cell

Types of Battery

- **Primary battery (primary cells)**
 - In which the cell reaction is **not reversible**. When all the reactants have been converted to product, no more electricity is produced and the battery is dead.
- **Secondary battery (secondary cells)**
 - In which cell reactions **can be reversed** by passing electric current in the opposite direction. Thus it can be used for a large number of cycles.
- **Flow battery and Fuel Cell**
 - In which materials (reactants, products, electrolytes) pass through the battery, which is simply an electrochemical cell that converts chemical to electrical energy.

Examples

- **Primary batteries**
 - i. Dry or Leclanché cell
 - ii. Alkaline battery
 - iii. Lithium batteries
- **Secondary batteries**
 - i. Lead acid
 - ii. Nickel-Cadmium
 - iii. Nickel Metal hydride
 - iv. Lithium ion
- **Flow battery and Fuel Cell**
 - i. Polymer Membrane Fuel Cell
 - ii. Solid Oxide Fuel Cell

Lithium Primary Cell

- Lithium batteries are different from Lithium ion Batteries (also Known as Li-ion batteries).
- Lithium batteries can not be recharged
- Most of the common lithium batteries contain:
 - Anode: **Metallic Li**
 - Cathode: **MnO₂**
 - Electrolyte: **Li salts dissolved in organic solvents such as Acetonitrile (CH₃CN), propylene carbonate, ethylene carbonate**



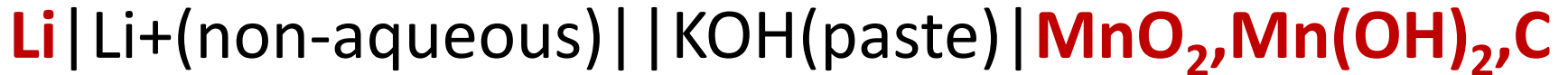
Lithium as a Anode Material

The main attractions of lithium as an anode material is

- It is the most electronegative metal in the electrochemical series
- It has very low density, means, the largest amount of electrical energy per unit weight

Lithium Battery

Cell Representation



Anode



Cathode



Overall Reaction



Different types of Lithium Batteries

S. No.	Anode	Cathode	Characteristics	Applications
1	Li	SOCl_2	3.6 V, Long Shelf life, Low to Moderate rate applications	Memory Devices, Standby Electrical devices
2	Li	SO_2	3.0 V, Best low temperature performance	Military and Special Industrial needs
3	Li	MnO_2	3.0 V, Small in size, good low temperature performance, low drain applications	Medical Devices, Memory Circuits

Advantages of Lithium battery

- High electron density
- Long shelf life
- Low self discharge
- Need less maintenance
- Can provide very high current