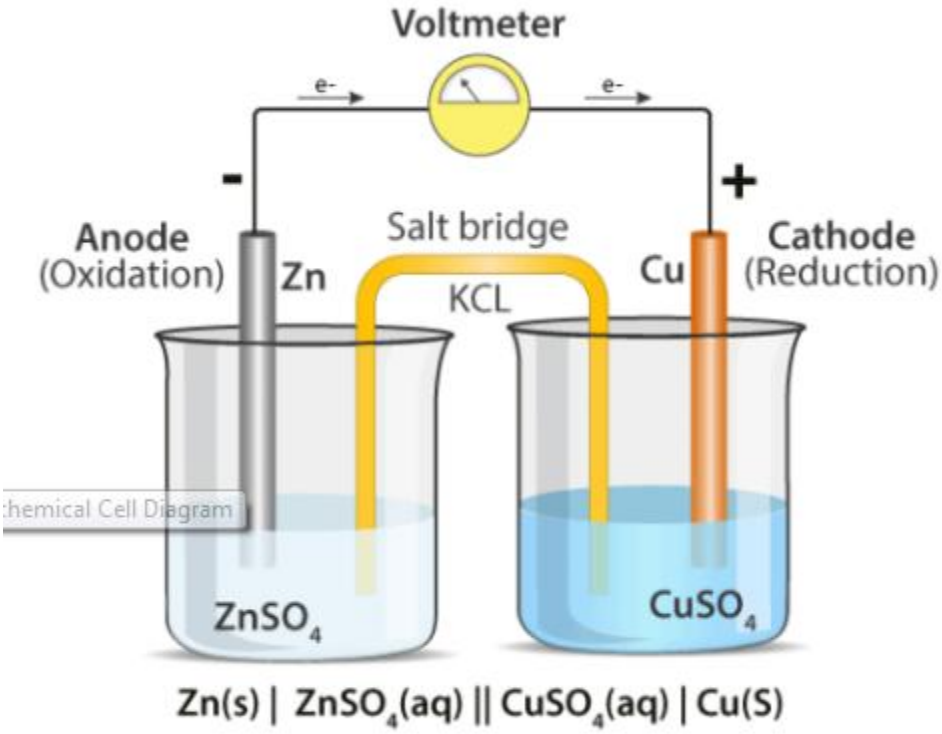
5.1 Electrochemical Cell

An electrochemical cell is a device that can generate electrical energy from the chemical reactions occurring in it, or use the electrical energy supplied to it to facilitate chemical reactions in it. These devices are capable of converting chemical energy into electrical energy, or vice versa. A common example of an electrochemical cell is a standard 1.5-volt cell which is used to power many electrical appliances such as TV remotes and clocks.

Such cells capable of generating an electric current from the chemical reactions occurring in them care called Galvanic cells or Voltaic cells. Alternatively, the cells which cause chemical reactions to occur in them when an electric current is passed through them are called electrolytic cells.

A diagram detailing the different parts of an electrochemical cell is provided below.



Electrochemical Cell

Electrochemical cells generally consist of a cathode and an anode. The key features of the cathode and the anode are tabulated below.

Cathode	Anode
Denoted by a positive sign since electrons are consumed here	Denoted by a negative sign since electrons are liberated here

A reduction reaction occurs in the cathode of an electrochemical cell	An oxidation reaction occurs here
Electrons move into the cathode	Electrons move out of the anode

General convention dictates that the cathode must be represented on the right-hand side whereas the anode is represented on the left-hand side while denoting an electrochemical cell.

Half-Cells and Cell Potential

- Electrochemical Cells are made up of two half-cells, each consisting of an electrode which is dipped in an electrolyte. The same electrolyte can be used for both half cells.
- These half cells are connected by a salt bridge which provides the platform for ionic contact between them without allowing them to mix with each other. An example of a salt bridge is a filter paper which is dipped in a potassium nitrate or sodium chloride solution.
- One of the half cells of the electrochemical cell loses electrons due to oxidation and the other gains electrons in a reduction process. It can be noted that an equilibrium reaction occurs in both the half cells, and once the equilibrium is reached, the net voltage becomes 0 and the cell stops producing electricity.
- The tendency of an electrode which is in contact with an electrolyte to lose or gain electrons is described by its electrode potential. The values of these potentials can be used to predict the overall cell potential. Generally, the electrode potentials are measured with the help of the standard hydrogen electrode as a reference electrode (an electrode of known potential).

Primary and Secondary Cells

- Primary cells are basically use-and-throw galvanic cells. The electrochemical reactions that take place in these cells are irreversible in nature. Hence, the reactants are consumed for the generation of electrical energy and the cell stops producing an electric current once the reactants are completely depleted.
- Secondary cells (also known as rechargeable batteries) are electrochemical cells in which the cell has a reversible reaction, i.e. the cell can function as a Galvanic cell as well as an Electrolytic cell.
- Most of the primary batteries (multiple cells connected in series, parallel, or a combination of the two) are considered wasteful and environmentally harmful devices. This is because they require about 50 times the energy they contain in their manufacturing process. They also contain many toxic metals and are considered to be hazardous waste.

Types of Electrochemical Cells

The two primary types of electrochemical cells are

1. Galvanic cells (also known as Voltaic cells)
2. Electrolytic cells

The key differences between Galvanic cells and electrolytic cells are tabulated below.

Galvanic Cell / Voltaic Cell	**Electrolytic Cell**
Chemical energy is transformed into electrical energy in these electrochemical cells.	Electrical energy is transformed into chemical energy in these cells.
The redox reactions that take place in these cells are spontaneous in nature.	An input of energy is required for the redox reactions to proceed in these cells, i.e. the reactions are non-spontaneous.
In these electrochemical cells, the anode is negatively charged and the cathode is positively charged.	These cells feature a positively charged anode and a negatively charged cathode.
The electrons originate from the species that undergoes oxidation.	Electrons originate from an external source (such as a battery).

Applications of Electrochemical Cells

- Electrolytic cells are used in the electrorefining of many non-ferrous metals. They are also used in the electrowinning of these metals.
- The production of high-purity lead, zinc, aluminium, and copper involves the use of electrolytic cells.
- Metallic sodium can be extracted from molten sodium chloride by placing it in an electrolytic cell and passing an electric current through it.
- Many commercially important batteries (such as the lead-acid battery) are made up of Galvanic cells.
- Fuel cells are an important class of electrochemical cells that serve as a source of clean energy in several remote locations.