# ELECTROCHEMISTRY

## Module – 13.1: Electrolytes, Non - electrolytes and Electrolysis

### Introduction:

Electrochemistry is the field of chemistry which deals with the results in the generation of an electric current (electricity) or be caused by passing an electric current. Electron transfer reactions are oxidation-reduction or redox reactions. In other words ***"the study of interchange of chemical and electrical energy is Electrochemistry".***

Electrochemistry can be divided in to two categories:

a. Use of electrical energy to produce chemical changes which is known as Electrolysis,
b. Conversion of chemical energy into electrical energy (by spontaneous redox reactions).

A substance which allows the passage of current to flow through it is called a conductor. For example copper wire, a solution of copper sulphate, Aluminium wire, Fused NaOH, etc., This substance may be a solid like a metal, a fused salt or an aqueous solution of a substance. Accordingly the electrical conductors are divided into two types. They are

1. Metallic conductors or electronic conductors (These are solids.)
2. Electrolytic conductors ( These are solutions or fused substances )

### Metallic conductors:

Metals are the best conductors. In them the passage of current is not accompanied by any movement of matter. Besides metals, alloys and some solids like graphite, some oxides also conduct electricity. In these substances the electrons move from a higher negative potential region to a lower positive potential region. No chemical reactions occur in such substances.

**Ex:** metallic wires like those of Cu., Al or Ag.,

### Electrolytic Conductors:

In these conductors electricity is conducted due to the migration of ions or transport of ions to oppositely charged electrodes.

**Ex:** Fused salts like KCl, NaCl, Aqueous solutions like NaOH, KOH**;**

These substances are known as electrolytes**". A solution that contains ions and conducts electricity in the fused state or in the aqueous solution or as a solution in any other solvent is known as an electrolyte".** Chemical substances that do not permit the passage of current through them either in the fused state or in aqueous solution or in any other solution form is known as non-electrolytes.

Conduction of current through a metallic conductor and an electrolytic conductor may be distinguished briefly as follows:

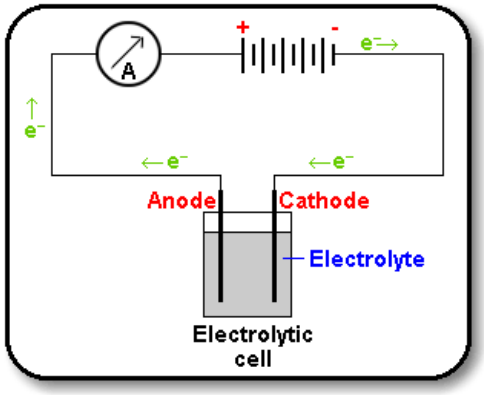
| Metallic conduction | Electrolytic conduction |
|---|---|
| 1. It occurs due to the flow of electrons | 1. In the solution or in the fused state the current is conducted due to the movement of the ions. |
| 2. This is only a physical change in the conductor | 2. It involves a chemical change. This change occurs at the electrode. |
| 3. No transfer of matter takes place | 3. This involves transfer of matter in the form of ions. |
| 4. Resistance increase with a raise in temperature. | 4. It shows a decrease in resistance with a raise in temperature. |

### Electrolysis:

Electrolysis takes place in an electrolytic cell, the simplest form of which is shown below:

The components which make contact with the electrolyte are called **electrodes.** The electrode which is attached to the negative pole of the battery, and which supplies electrons to the electrolyte, is called the **Cathode**. Reduction takes place at the cathode.

The electrode which is attached to the positive pole of the battery, and which accepts electrons from the electrolyte, is called the **anode**. Oxidation takes place at the anode.




When a direct electric current is passed through an **electrolyte** (such as a molten salt or an aqueous solution of a salt, acid or base), chemical reactions take place at the contacts between the circuit and the solution. This process is called **electrolysis.**

Various reactions take place at the electrodes during electrolysis. In general, **reduction takes place at the cathode,** and **oxidation takes place at the anode.**

Some examples of electrolysis: Its products

## Electrolysis of water:

Water may be electrolyses in the apparatus shown below. Pure water is however a very poor conductor of electricity and one has to add dilute sulphuric acid in order to have a significant current flow.

Hydrogen gas is evolved at the cathode, and oxygen at the anode.

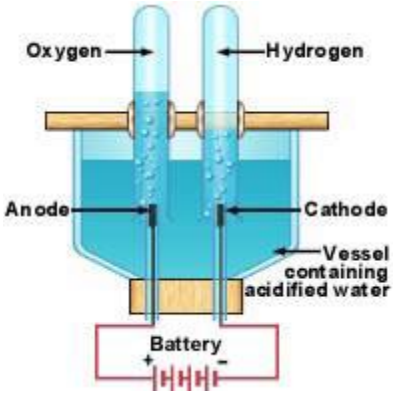
The ratio, by **volume** of hydrogen to oxygen, is exactly 2:1.

The overall reactions are

**Over all reaction:** $2H_2O_{(l)} \rightarrow 2H_{2\,(g)} + O_{2\,(g)}$

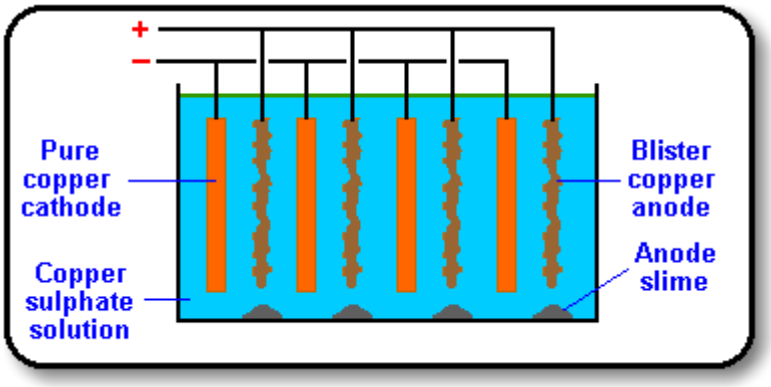
**At anode:** $4OH^- \rightarrow 2H_2O + O_{2\,(g)} + 4e^-$

**At cathode:** $2H^+ + 2e^- \rightarrow 2H_{2\,(g)}$




## Electrorefining of copper:

Impure Copper obtained by reduction of its ores is cast as slabs or ingots, called **blister copper**. In the **electrorefining** process, the blister ingots are used as anodes in an electrolytic cell. An acid solution of copper (II) sulphate is used as electrolyte. Initially, the cathode consists of thin sheets of pure copper




During electrolysis, copper passes into solution from the anodes, (leaving the impurities, normally containing silver, gold and platinum) as **an anode slime or anode mud.** The anode mud which sinks to the bottom of the cell. The anode reaction is

$$Cu_{(S)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$$

At the cathode, copper (II) ions are discharged. The pure copper sheet, cathode, becomes coated with a thick layer of very pure copper:

$$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(S)}$$

## Assignment Questions:

1. Explain electrolysis with an example
2. Write a short note on metallic conductor

**Example Set:**

**1.** Metallic conduction is due to the movement of _____
   a. Ions
   b. Atoms
   c. Electrons
   d. All

**Solution:** c)

**2.** Electrolytic conduction is due to migration of _____
   a. Protons
   b. Electrons
   c. Ions
   d. All

**Solution:** c)

**3.** In electrolytic conduction the resistance of the electrolyte _____ with increase in temperature.
   a. increases
   b. decreases
   c. remains unchanged
   d. becomes zero (at low temperature)

**Solution:** b)

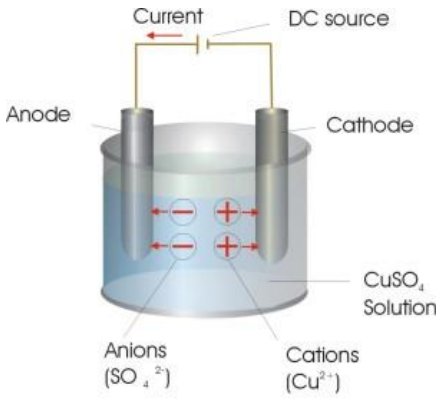
**4.** An Electrolyte is defined as
   a. Solid state
   b. Liquid state
   c. Gaseous state
   d. All states

**Solution:** b)

**5.** What is electrolysis? Illustrate with a suitable example.

**Solution:** Chemical reactions take place at the contacts between the circuit and the solution is called electrolysis.
Let us take an example of electrolysis of aqueous copper sulphate solution using inert electrodes such as platinum electrodes.
In the aqueous solution copper sulphate dissociates into its respective ions, as shown below.

$$CuSO_4 \Rightarrow Cu^{2+} + SO_4^{2-}$$



An Electrolytic Cell

On passing electric current the copper ions (cations) move towards the cathode and get discharged. They are deposited as copper. Simultaneously the sulphate ions (anions) move towards the anode.

**6.** What is an electrolyte? Distinguish between metallic conduction and electrolytic conduction?

**Solution:** A solution that contains ions and conducts electricity in the fused state or in the aqueous solution or as a solution in any other solvent is known as an electrolyte.

| Metallic conduction | Electrolytic conduction |
|---|---|
| 1. It occurs due to the flow of electrons | 1. In the solution or in the fused state the current is conducted due to the movement of the ions. |
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| | |
|---|---|
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**Problem Set:**

**1.** In electrolysis, oxidation takes place at
   a. anode
   b. cathode
   c. in the bulk of electrolyte
   d. with anions and cations

**Solution:** a)

**2.** The reaction taking place at cathode is
   a. Oxidation
   b. Reduction
   c. Neutralization
   d. Hydrolysis

**Solution:** b)

**3.** During electrolysis of acidfied $H_2O$, the ratio of volumes of $H_2$ and $O_2$ formed is
   a. 2:1
   b. 1:2
   c. 1:3
   d. 3:1

**Solution:** a)

**4.** In the electrolysis of $CuSO_4$, the reaction $Cu^{2+} + 2e^- \rightarrow Cu$ takes place at
   a. Anode
   b. Cathode
   c. In solution
   d. Both at the anode & cathode

**Solution:** b)

**5.** Write a note on electrorefining of copper?

**Solution:**

**Electrorefining of copper:**

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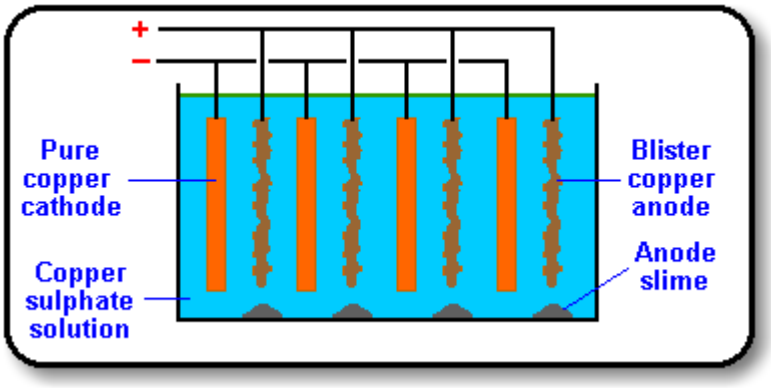


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At the cathode, copper (II) ions are discharged. The pure copper sheet, cathode, becomes coated with a thick layer of very pure copper:

$$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(S)}$$

**6.** What is the reason for the addition of dil.$H_2SO_4$ in electrolysis of pure water?

**Solution:**

Pure water is a very poor conductor of electricity and one has to add dilute sulphuric acid or an alkali in order to have a significant current flow.