

Electrolysis of Acidulated Water

When a small amount of acid like lemon, vinegar, etc is added to water, the new mixture is called acidulated water. We know that electrolysis of dilute sulphuric acid gives hydrogen and oxygen gas. Similarly, all acidulated water will give same products as the anion part do not readily lose electrons

Importance of Electrolysis

Electrolysis directly or indirectly plays an important role in our daily life. Some of them are as follows:

Electroplating helps in prevention of rusting of metals. This makes all the metal components we use durable.

Purification of metals is done by purification.

This helps in recycling the metal for future use.

Many of the metals, as well as non-metals, are extracted by the method of electrolysis.

Characteristics of Electrolysis

Following are the characteristics of electrolysis:

Electrolyte is required to convert its ions to pure element

Electrode is required to provide contact to non-metallic part (electrolyte)

Electrical energy is required for reaction to occur

Only redox reaction occurs in electrolysis

Application of Electrolysis

Electrolysis is applied in the various field. It is required for extraction and purification of metals. It is used as one of the commercial processes to produce hydrogen gas. It is also used to prevent the rusting of metals.

Selective Discharge of Ions

Among several ions, only one ion is discharged at each electrode. This is because each ion differs in its tendency to gain or lose electron(s). Since there is a selection of ions among several others, it is called as selective discharge of ions.

Define Electrolyte

Electrolytes are substances that dissociate into ions in solution to conduct electricity. Dissociation can happen in a molten state or an aqueous solution of an electrolyte. Examples: Sodium chloride is an electrolyte. It dissociates into Na^+ and Cl^- to conduct electricity in aqueous and molten state

Define Non-Electrolyte

Electrolytes are substances that do not dissociate into ions in aqueous solution to conduct electricity. They are covalent compounds and mainly organic in nature.

Example: Urea, benzene and other organic compounds are non-electrolyte. They do not dissociate into ions in aqueous solution.

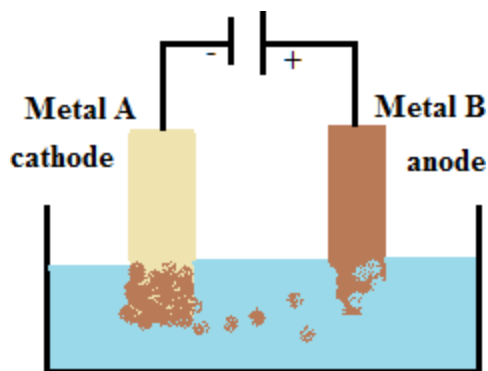
Define Non-volatile Solute

Non-volatile refers to a substance that does not readily evaporate into a gas under existing conditions. Thus, non-volatile solute refers to the solute in mixture which does not evaporate. Example: Sugar in water is a solution. Sugar is a non-volatile solute as it doesn't evaporate into its gaseous in normal room condition.

Define Electroplating

Electroplating is a process of coating one metal on the another. This process is done for decorative purpose or for preventing it from rusting. Example: Coating iron with copper

Process of Electroplating



Let A be metal on which B metal has to be coated. B is generally a least reactive metal while A is most reactive metal. Take electrolyte as a solution of metal B salt. Use metal A as cathode while B as anode. That is connect metal A to the negative terminal and B to the positive terminal of battery. After few minutes, you will observe that anode (metal B) starts dissolving in water and also starts depositing on cathode (metal B). This is how metal B is electroplated on metal A .

Reasons for Electroplating

Electroplating is done to enhance the appearance and prevent the metal from rusting. It changes the surface properties of an object like corrosion protection, abrasion, etc. It can also be used to build up the thickness of undersized parts.

Conditions of Electroplating

Following are the condition electroplate one metal on another.

The article which is to be electroplated should be taken as a cathode. The metal used during electrolysis should be placed as an anode.

Periodic replacement of anode metal should be done.

Lower current for a longer time should be used.

The current used in the process of electroplating should be direct current (DC).

Electrolytic Dissociation in Molten State

When an electric current is passed through ionic compounds in molten form, it dissociates into cations and anions. Cations migrate towards negatively cathode and anions migrate towards the positively charged anode.

Electrolytic Dissociation in Aqueous State

When an electric current is passed through an aqueous solution of ionic compounds, cations from the ionic compound as well as H^+ ions from water, migrate towards the cathode. And, anion from the ionic compound and OH^- ions from water, migrate towards the anode.

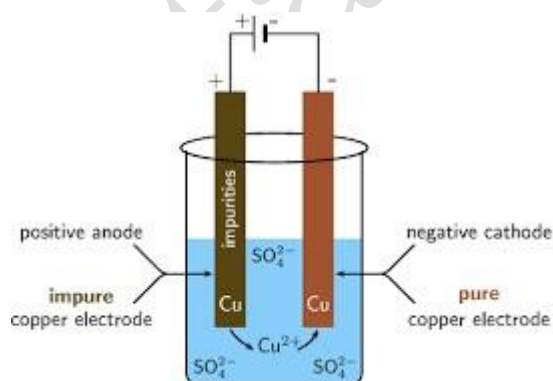
Compare Electrolytic Dissociation and Ionization

Ionization happens in polar covalent compounds where compounds dissolve into ions. Dissociation happens in ionic compounds, where the pre-existing ions are separated.

Compare Metallic Conduction and Electrolytic Conduction

Metallic conductance involves the movement of electrons throughout a metal. Electrolytic conduction involves the movement of ions throughout a pure liquid or solution. The major difference between them is that one involves the movement of electrons and the other involves the movement of ions.

Explain Electro-refining of Copper



In electrorefining of copper, impure copper is refined by electrolysis. In apparatus, aqueous copper sulphate solution is used as an electrolyte. Anode is made of impure copper and cathode

is made of pure copper. At anode, copper is oxidized to copper ions. Copper ions in electrolyte migrate towards the cathode (pure copper) and get reduced. Thus, copper is deposited on the surface of a pure copper electrode.

Electrical Units of Charge

Following are the units of charge.

Coulomb (C): Coulomb is the smaller unit of charge or electricity . The amount of charge that passes a given point when 1A current flows for 1 s.

Faraday (F): The amount of electric charge on one mole of electron is called as Faraday.

Electronic conductors example

The conduction which is due to flow of electrons and in which matter and chemical changes does not occur is called as electronic conductors.

Electrolytic conductor

The conduction in which there is flow of ions, transfer of matter and chemical changes occur is called as electrolytic conductor. Example : copper, silver etc.

Arrhenius theory of electrolytic conductance

Theory says an electrolyte, when dissolved in water, breaks up into two types of charged particles, one carrying a positive charge and the other a negative charge. These charged particles are called ions. Positively charged ions are termed cations and negatively charged as anions.

Discuss the evidence of Arrhenius theory of electrolytic dissociation

A large number of experimental observations are available which support Arrhenius theory. Some of them are given below:

X-ray diffraction studies have shown that electrolytes are composed of ions.

The electrolytic solutions like metallic conductors obey Ohm's law

Evidence for the existence of ions in aqueous solutions of electrolytes is furnished by well known reactions in inorganic chemistry.

The abnormal behavior towards colligative properties as observed in the case of electrolytes can be explained on the basis of ionic theory.

Electric conduction

Electric conduction is the movement of electrically charged particles through a transmission medium.

Electrolyte

An electrolyte is a substance that produces an electrically conducting solution when dissolved in water. Eg., NaCl , KOH , HCl .

Strong electrolytes

Strong electrolytes completely ionize in water. This means 100% of the dissolved chemical breaks into cations and anions. Eg., NaCl , KOH , HCl .

Weak electrolyte

A weak electrolyte is an electrolyte that does not completely dissociate in solution. The solution will contain both ions and molecules of the electrolyte. Eg., CH_3COOH

Acids, bases and salts as electrolytes

Acid, base and salt act as electrolytes in the molten state or in their aqueous solution. There can be both strong and weak electrolytes in acids and bases. However, salts are strong electrolytes.

Factors affecting electrolytic conduction

1. Temperature
2. Nature of electrolyte.
3. Concentration of solution.

Factors affecting mettalic conduction

1. Type of material
2. area of cross section of material
3. Ttemperature

Difference between metallic and electrolytic conductors

Metallic conductors : These are the metals which contain free electron for conduction of electricity hence metallic conductor is a good conductor of heat and electricity.

Electrolytic conductors : These are the conductors which contain ions for conduction. Hence conductance increases with increase of temperature.

Electronic conduction	Electrolytic conduction
It is due to flow of electrons	It is due to flow of ions
It involves no chemical change	It involves chemical change
There is no transfer of matter	There is transfer of matter
Conduction decreases with an increase in temperature	Conduction increases with an increase in temperature

Ohm's law

Ohm's Law

$$I = \frac{V}{R}$$

Electric current = Voltage / Resistance

According to Ohm's law the electrical resistance of a conductor to the passage of current is equal to the potential difference , V divided by the electric current I.

Resistance and its units

The electrical resistance of a conductor is linearly proportional to its length and inversely proportional to its area of cross section. Ohm is the unit of resistance.

Conductance and its unit

1. The ability of an electrolyte to conduct electricity is called as conductance .

The SI unit of conductivity is Siemens per meter (S/m)

Conductance and its unit

The degree to which an object conducts electricity, calculated as the ratio of the current which flows to the potential difference present. This is the reciprocal of the resistance, and is measured in Siemens or Mhos.

Specific resistance

A measure of the potential electrical resistance of a conductive material. It is determined experimentally using the equation $R = \frac{l}{A}$, where R is the measured resistance of some length of the material, A is its cross-sectional area (which must be uniform), and l is its length.

numericals on resistance

$$R = \frac{V}{I}$$

Where R is electrical resistance, V the potential difference, I is the electric current.

Specific conductance

The ability of an electrolyte to conduct electricity is called as conductance .

The SI unit of conductivity is Siemens per meter (S/m)

Numericals on conductance

$$\text{Conductance (G)} = \frac{1}{R}$$

Conductivity at constant volume at constant volume

Conductivity of a solution is defined as the conductance of a solution of 1 cm length and having 1 sq. cm as the area of cross section.

Define equivalent conductivity

The conductivity produced by dissolving one gram equivalent of an electrolyte in solution placed between two large electrodes one centimeter apart.

Units of equivalent conductance

Units for equivalent conductivity is $\text{ohm}^{-1} \text{cm}^2$

Definition of molar conductivity

The conductivity produced by dissolving 1 gram-mole of an electrolyte placed between two large electrodes at one centimeter apart is called as molar conductivity.

Units of molar conductivity

Units of molar conductivity is Siemens meter per molarity or Siemens meter per-square per mole.

Question on equivalent conductivity

$$\Lambda_{eq} = \kappa \times V$$
$$= \kappa \times \frac{1000}{C_{eq}} = \frac{\kappa \times 1000}{\text{normally}}$$

Where, V = Volume of solution containing 1 g equivalent of the electrolyte, C_{eq} = Gram equivalent concentration or normality.

Question on molar conductivity

$$\Lambda_m = \frac{\kappa}{c}$$

The problems on molar conductivity is solved by above formula. In which κ is the measured conductivity and c is the electrolyte solution .

Mesurement of electrolytic conductance by wheatstone bridge

A Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component.

Difficulties in wheatstone meter bridge experiment

During measurements by wheatstone meter bridge some time the solution is not of good concentration, the plates used are not completely coated, some time the detector is not properly working.

Wheatstone meter bridge

The glass tube which we used with two platinum plates coated with a thin layer of finely divided platinum black must be removed from the solution after use.

cell constant

This cell constant (K) is a function of the electrode areas, the distance between the electrodes and the electrical field pattern between the electrodes. The theoretical cell just described has a cell constant of $K = 1.0$.

Variation of conductance with dilution

The conductance of solution is due to presence of ions in the solution. The greater the number of ions, greater is the conductance.

Variation of specific conductivity with dilution

The specific conductivity of an electrolytic solution decreases with dilution.

variation of eq. conductivity with dilution

Equivalent conductivity is defined as the conductance of a volume of solution containing one equivalent weight of dissolved substance when placed between two parallel electrode 1 cm apart, and large enough to contain between them all of the solution. It increase with dilution.

Variation of molar conductivity with dilution

For weak as well as strong electrolyte , molar conductivity increase with dilution.

Molar conductivity is the conductivity of the electrolyte solution divided by the molar concentration of the solution.

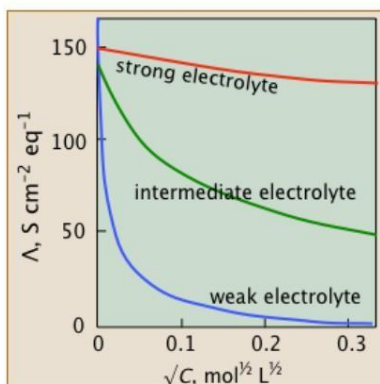
Concepts of ionic mobility

The ionic mobility is defined as the velocity attained by an ion moving through a gas under unit electric field.

Understand the variation of conductance with temperature

Conductance of solution increases with increase of temperature. As the temperature increases conductance also increases.

Variation of molar conductivity with concentration



Molar conductivity of both strong and weak electrolytes increase with dilution that is with decrease in concentration.

Limiting molar conductivity

The molar conductivity at infinite dilution is considered as limiting molar conductivity. For example : limiting molar conductivity of acetic acid .

Molar ionic conductivity

The individual contribution of an ion, irrespective of the nature of the ion of the electrolyte in infinite dilution is called as molar conductivity.

Kohlrausch law

Equivalent conductivity of an electrolyte at infinite dilution is the sum of equivalent conductivities of cations and anions.

Limiting molar conductivity by Kohlrausch law

The limiting molar conductivity of an electrolyte is the sum of the limiting ionic conductivities of the cation and the anion each multiplied with the number of ions present in one formula unit of electrolyte.

Limiting equivalent conductivity by Kohlrausch's law

The equivalent conductivity of an electrolyte at infinite dilution is the sum of two values one depending upon the cation and other upon anion.

Application of Kohlrausch's law

- 1) For determination of Λ^∞ or α of weak electrolytes.
- 2) For calculation of dissociation constant of a weak electrolyte at concentration c of solution. For determining degree of dissociation (α) of an electrolyte at a given dilution.

Electrochemical cell

An electrochemical cell is a device capable of either generating electrical energy from chemical reactions or facilitating chemical reactions through the introduction of electrical energy.

Galvanic or voltaic cells

A Voltaic Cell (also known as a Galvanic Cell) is an electrochemical cell that uses spontaneous redox reactions to generate electricity.

Explain primary and secondary voltaic cell

A primary battery is a portable voltaic cell that is not rechargeable. A secondary battery is a portable voltaic cell that is rechargeable.

Working of electrochemical cell

An electrochemical cell consists of two half-cells. Each half-cell consists of an electrode and an electrolyte. The two half-cells may use the same electrolyte, or they may use different electrolytes. The chemical reactions in the cell may involve the electrolyte, the electrodes, or an external substance.

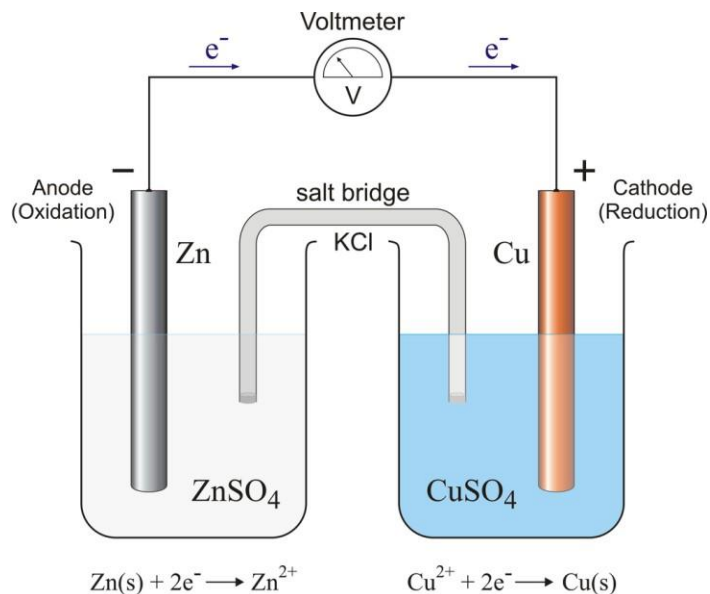
Half-cells or redox cells

A half-cell is a structure that contains a conductive electrode and a surrounding conductive electrolyte separated by a naturally occurring Helmholtz double layer.

Salt bridge

1. It provides an electrical contact between the two solutions and thereby completes the electrical circuit.
2. It prevents the mixing of electrode solutions. Maintains electrical neutrality in both the solution by a flow of ions.

Features of electrochemical cell



Electrochemical cell is a device that used to study chemical reaction electrically.

It is of two type:

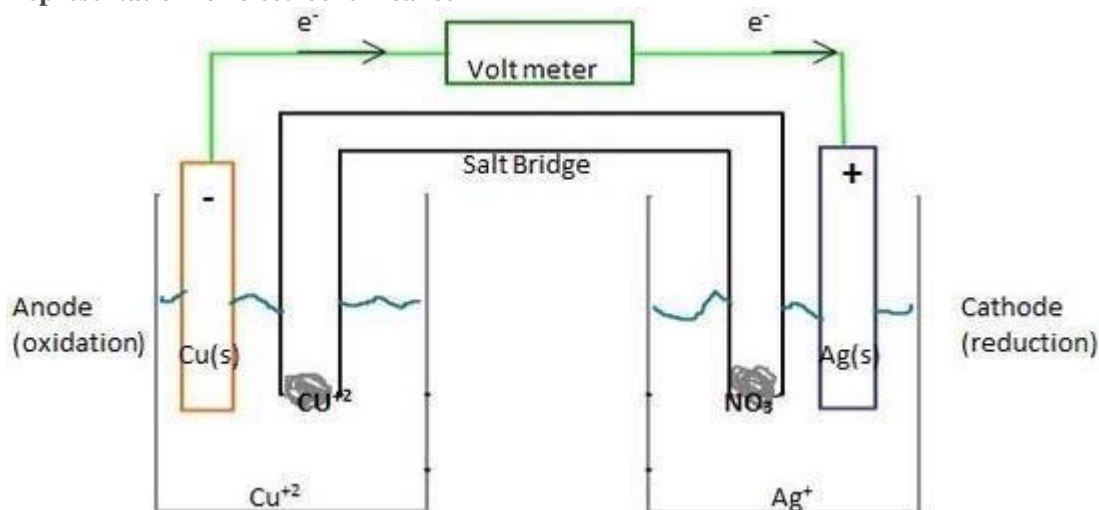
1. Electrolytic cell
2. Galvanic cell

Differentiate between electrochemical cell and electrolytic cell

A Galvanic cell converts chemical energy into electrical. Here, the redox reaction is spontaneous and is responsible for the production of electrical energy.

An electrolytic cell converts electrical energy into chemical energy. The redox reaction is not spontaneous and electrical energy has to be supplied to initiate the reaction. Both the electrodes are placed in the same container in the solution of molten electrolyte.

Representation for electrochemical cell



This is the representation for electrochemical cell of copper sulphate and zinc sulphate solution.

Daniel cell

It consists of two separate half-cells. One half-cell is a beaker containing a strip of metallic zinc that is immersed in 1 M aqueous solution of zinc sulphate. The second half-cell is a beaker containing a strip of metallic copper that is immersed in 1 M aqueous solution of copper sulphate. The solutions are connected with a salt bridge.

Metal-metal ion electrode

It is the electrode which contains a metal strip immersed into the solution of its own ions.

Non-metal ion electrode

Non-metal ion electrode consists of an inert metal electrode immersed in a solution containing ions of the gas.

Metal sparingly soluble salt electrode

It consists of a metal coated with one of its sparingly soluble salts immersed in a solution of a soluble salt that contains the same anion as that of the sparingly soluble salt.

Redox electrode

It consists of metal wire serving as an inert electrode immersed in a solution containing the ions of the same substance in two valency states.

Electrode potential

The potential difference of two half cells or electrodes is called as electrode potential.

Oxidation and reduction potential

The potential associated with an oxidation reaction is called as oxidation potential and the potential associated with a reduction reaction is called as reduction potential.

Standard electrode potential

The electrode and cell potentials depend on the concentration of solutions, partial pressure of gases and the temperature. Therefore, these potentials are measured under standard conditions defined as standard electrode potential.

Applications and difficulties of standard electrode potential

It is used in calculation of strength of oxidizing and reducing agents is done by its standard electrode potential.

Difficulties of standard electrode potential : although the overall potential of a cell can be measured, there is no simple way to accurately measure the electrode potential in isolation. The electric potential also varies with temperature, concentration and pressure.

Reference Electrode

A reference electrode is an electrode which has a stable electrode potential and its value is known. Such stable potential is achieved by maintaining the concentrations of constituent species at a fixed value.

Reference electrodes are used at various places, but the most important of all is in the electrochemical cell. This is where it's used as a half cell in the electrochemical cell to allow for

the determination of the other half's cell potential.

Common examples include Standard hydrogen electrode, Saturated calomel electrode, Silver chloride electrode etc.

Standard Hydrogen Electrode

A Standard Hydrogen Electrode (SHE) is an electrode that scientists use as a reference on all half-cell potential reactions. SHE is the most commonly used reference electrode since its potential is exactly equal to Zero at all temperatures. Since the potential of SHE is zero, it forms the perfect basis to calculate cell potentials using different electrodes or different concentrations.

Advantages and Disadvantages of S.H.E.

Advantages of Standard Hydrogen Electrode (S.H.E.):

1. During electrolysis, only small potential is developed on the hydrogen electrode. Hence assumption of Zero potential of S.H.E. holds true for almost all the cases.
2. In determining the single electrode potential, using S.H.E. as a reference, the potential of the unknown potential will be equal to the e.m.f. of the cell as electrode potential of S.H.E. is Zero. Hence it becomes very handy to use S.H.E. as a reference electrode for determining the potential of unknown electrode. This way, we can determine the absolute value of the electrode potential.

Disadvantages of Standard Hydrogen Electrode (S.H.E.):

1. It is not convenient to assemble the apparatus.
2. It is difficult to maintain the pressure of hydrogen gas at 1atm and concentration of HCl at 1M all the time.
3. It is difficult to get pure, dry hydrogen gas and prepare ideal platinised platinum plate.
4. Its very costly and is difficult to transport due to its bigger size.

Applications and Advantages of S.C.E.

Applications of Standard Calomel Electrode (S.C.E.):

1. The S.C.E is used in pH measurement, cyclic voltammetry and general aqueous electrochemistry.
2. It serves the same purpose as the S.H.E. It helps in determining the absolute value of the electrode potential of an unknown electrode.

Advantages of S.C.E.:

1. It is very handy, compact and easy to transport.
2. Its potential can remain constant and it can easily be reproduced.

3. It is easy to construct and maintain.

It is for these reasons, it is more convenient to go for S.C.E. instead of S.H.E.

EMF and Potential Difference of a cell

The difference between electrode potentials of two electrodes of electrochemical cell when no current is drawn from the cell is known as 'Electromotive Force (EMF)' of a cell, while the difference between the electrode potential of two electrodes when the cell is sending current through the circuit is called 'Cell Potential or Potential Difference' of the cell. Hence EMF is the maximum voltage that can be obtained from a cell, while Potential Difference of a cell is always less than EMF of cell.

EMF and Potential Difference of a cell

EMF	Potential difference
It is the potential difference between two electrodes when no current is flowing in the circuit.	It is the difference of the electrode potentials of the two electrodes when the cell is under operation.
It is the maximum voltage that the cell can deliver.	It is always less than the maximum value of voltage which the cell can deliver.
EMF is responsible for the steady flow of the current in cell.	Potential Difference is not responsible for the flow of steady current in the cell.

Factors affecting the EMF of a cell

Following are the two factors which influence EMF of the cell:



1. Material of the electrodes
2. The electrode used in the cell

The energy supplied by a cell to a charge is used to overcome the electrical resistance in the external circuit and the resistance offered by the cell itself. The resistance offered by the cell when a charge is brought from lower potential to higher potential within itself is called its 'Internal resistance'. Hence EMF is dependent on internal resistance of a cell. and the internal resistance of a cell depends on the area of the electrodes, the distance between them, and the nature, concentration and temperature of the electrolyte.

For an ideal cell, internal resistance is zero. If an ideal cell is not connected to an external circuit, then the potential difference across its terminals is equal to its EMF. If the ideal cell is connected

to an external circuit, then the potential difference across the terminals of the cell is equal to that across the resistance in the external circuit.

Electrochemical Series

	Half Reaction	Standard Potential (V)
 stronger oxidizing agent	$\text{F}_2 + 2\text{e}^- \rightleftharpoons 2\text{F}^-$	+2.87
	$\text{Pb}^{4+} + 2\text{e}^- \rightleftharpoons \text{Pb}^{2+}$	+1.67
	$\text{Cl}_2 + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-$	+1.36
	$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1.23
	$\text{Ag}^+ + 1\text{e}^- \rightleftharpoons \text{Ag}$	+0.80
	$\text{Fe}^{3+} + 1\text{e}^- \rightleftharpoons \text{Fe}^{2+}$	+0.77
	$\text{Cu}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cu}$	+0.34
	$2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$	0.00
	$\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}$	-0.13
	$\text{Fe}^{2+} + 2\text{e}^- \rightleftharpoons \text{Fe}$	-0.44
	$\text{Zn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn}$	-0.76
 stronger reducing agent	$\text{Al}^{3+} + 3\text{e}^- \rightleftharpoons \text{Al}$	-1.66
	$\text{Mg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mg}$	-2.36
	$\text{Li}^+ + 1\text{e}^- \rightleftharpoons \text{Li}$	-3.05

The standard reduction potentials of a large number of electrodes have been measured using standard hydrogen electrode as the reference electrode. These various electrodes can be arranged in increasing or decreasing order of their reduction potentials. The arrangement of elements in order of increasing reduction potential values is called '**Electrochemical series**'. It is also called '**Activity series**', of some typical electrodes.

Applications of Electrochemical Series

Applications of Electrochemical Series are as follows:

1. **Reactivity of metals:** The activity of the metal depends on its tendency to lose electron or electrons, i.e., tendency to form cation. This tendency depends on the magnitude of standard reduction potential. The metal which has high negative value (or smaller positive value) of standard reduction potential readily loses the electron or electrons and is converted into cation. Such a metal is said to be chemically active. The chemical reactivity of metals decreases from top to bottom in the series. The metal higher in the series is more active than the metal lower in the series. For example,

(a) Alkali metals and alkaline earth metals having high negative values of standard reduction

potentials are chemically active. These react with cold water and evolve hydrogen. These readily dissolve in acids forming corresponding salts and combine with those substances which accept electrons.

(b) Metals like Fe, Pb, Sn, Ni, Co, etc., which lie a little down in the series do not react with cold water but react with steam to evolve hydrogen.

(c) Metals like Cu, Ag and Au which lie below hydrogen are less reactive and do not evolve hydrogen from water.

2. Electropositive character of metals: The electropositive character also depends on the tendency to lose electron or electrons. Like reactivity, the electropositive character of metals decreases from top to bottom in the electrochemical series. On the basis of standard reduction potential values, metals are divided into three groups

(a) Strongly electropositive metals : Metals having standard reduction potential near about 2.0 volt or more negative like alkali metals, alkaline earth metals are strongly electropositive in nature.

(b) Moderately electropositive metals : Metals having values of reduction potentials between 0.0 and about 2.0 volt are moderately electropositive Al, Zn, Fe, Ni, Co, etc., belong to this group.

(c) Weakly electropositive : The metals which are below hydrogen and possess positive values of reduction potentials are weakly electropositive metals. Cu, Hg, Ag, etc., belong to this group.

3. Reducing power of metals: Reducing nature depends on the tendency of losing electron or electrons. More the negative reduction potential, more is the tendency to lose electron or electrons. Thus reducing nature decreases from top to bottom in the electrochemical series. The power of the reducing agent increases (ability to reduce), as the standard reduction potential becomes more and more negative.

4. Oxidising nature of non-metals: Oxidising nature depends on the tendency to accept electron or electrons. More the value of reduction potential, higher is the tendency to accept electron or electrons. Thus, oxidising nature increases from top to bottom in the electrochemical series. The strength of an oxidising agent increases as the value of reduction potential becomes more and more positive.

5. Thermal stability of metallic oxides: The thermal stability of the metal oxide depends on its electropositive nature. As the electropositivity decreases from top to bottom, the thermal stability of the oxide also decreases from top to bottom. The oxides of metals having high positive reduction potentials are not stable towards heat. The metals which come below copper form unstable oxides, i.e., these are decomposed on heating.

Latest sign convention for electrode potential

According to latest convention, all standard electrode potentials are taken as reduction potentials. Thus, the electrode at which reduction occurs with respect to S.H.E has positive electrode

potential and while the electrode at which oxidation occurs with respect to S.H.E has negative electrode potential.

Activity of metals from Electrochemical Series

The electrochemical series (also known as the activity series) is a list of metals listed in order of decreasing reactivity or in the order of decreasing ease of oxidation.

The activity of the metal depends on its tendency to lose electron or electrons, i.e., tendency to form cation. This tendency depends on the magnitude of standard reduction potential. The metal which has high negative value (or smaller positive value) of standard reduction potential readily loses the electron or electrons and is converted into cation. Such a metal is said to be chemically active. The chemical reactivity of metals decreases from top to bottom in the series. The metal higher in the series is more active than the metal lower in the series. For example,

(a) Alkali metals and alkaline earth metals having high negative values of standard reduction potentials are chemically active. These react with cold water and evolve hydrogen. These readily dissolve in acids forming corresponding salts and combine with those substances which accept electrons.

(b) Metals like Fe, Pb, Sn, Ni, Co, etc., which lie a little down in the series do not react with cold water but react with steam to evolve hydrogen.

(c) Metals like Cu, Ag and Au which lie below hydrogen are less reactive and do not evolve hydrogen from water.

Types of Concentration Cells

Concentration cells are of two types:

1. **Electrode concentration cells:** In these cells, the potential difference is developed between two electrodes at different concentrations dipped in the same solution of the electrolyte. For example, two hydrogen electrodes at different gaseous pressures in the same solution of hydrogen ions constitute a cell of this type.
2. **Electrolyte concentration cells:** In these cells, electrodes are identical but these are immersed in solutions of the same electrolyte of different concentrations. The source of electrical energy in the cell is the tendency of the electrolyte to diffuse from a solution of higher concentration to that of lower concentration. With the expiry of time, the two concentrations tend to become equal. Thus, at the start the emf of the cell is maximum and it gradually falls to zero.

Factors affecting Electrolysis

Factors Affecting Products of Electrolysis are as follows:

1. Products of electrolysis depend on the material being electrolyzed. In other words, the nature of electrolyte governs the process of electrolysis. The process is fast for a strong electrolyte whereas for weak electrolyte an extra potential better known as overpotential is required. Products of electrolysis depend on upon the value of this overpotential too.
2. Products of electrolysis depend on the nature of electrodes too. That is, in the case of the inert electrode (say gold, platinum), it doesn't participate in the reaction whereas if the electrode used is reactive in nature it takes part in the reaction.
3. Various oxidising and reducing species present in the electrolytic cell do affect the products of electrolysis.
4. The products of electrolysis depend on standard electrode potentials of the different oxidizing and reducing species present in the electrolytic cell.
5. In case of multiple reactions, product of electrolysis depends on the standard electrode potential of various reactions taking place. Out of the multiple reduction reactions taking place, the reduction reaction which has highest value of standard electrode potential takes place at cathode. Similarly, out of the multiple oxidation reactions, the oxidation reaction which has the lowest value of standard electrode potential takes place at anode.

Battery

A battery (storage cell) is a galvanic cell (or a series of galvanic cells) that contains all the reactants needed to produce electricity. It is a container consisting of one or more cells, in which chemical energy is converted into electricity and used as a source of power.

Common examples include Lead Storage Battery, Dry Cell, Nickel-Cadmium Cell etc.

Difference between Primary, Secondary and Fuel cells

Primary cell: A primary cell or battery is the one that cannot easily be recharged after one use, and are discarded following discharge. These cell are not chargeable because the electrode reaction occurs only once and after the use over a period of time the batteries become dead and cannot be reused.

Secondary cell: A secondary cell or battery is one that can be electrically recharged after its complete discharge. It is recharged by passing current through the circuit in the opposite direction to the current during discharge.

Fuel cell: Fuel cells are another means by which chemical energy can be converted into

electrical energy. Main disadvantage of a primary cell is that it can deliver current for short period of time only because, the quantity of oxidizing and reducing agent is limited. But energy can indefinitely be obtained from fuel cell as long as outside supply of fuel is maintained.

Corrosion

Corrosion is a process through which a metal is destroyed by the reaction with the environment. This process is a reduction-oxidation reaction in which the metal is being oxidized by its surroundings, often the *Oxygen* in air. This reaction is both spontaneous and electrochemically favored. Corrosion is essentially the creation of voltaic, or galvanic, cells where the metal in question acts as an anode and generally deteriorates or loses functional stability.

Corrosion is a commonplace occurrence, like the rusting and flaking of an old iron yard piece. There are three main components necessary for corrosion to occur:

1. Metal (example: iron)
2. Oxygen (usually from the atmosphere)
3. An electrolyte (usually water)

Factors affecting the rate of Corrosion

Main factors which promote the rate of corrosion are:

1. **Oxygen:** Like water, oxygen increases the rate of corrosion. Corrosion can take place in an oxygen-deficient environment, but the rate of the corrosion reaction (and destruction of the metal) is generally much slower. In immersed conditions, if an electrolyte is in contact with one area of metal containing more oxygen than the electrolyte in contact with another area of the metal, the higher oxygen-concentration area is cathodic relative to the remaining surface. An oxygen concentration cell then forms, which results in rapid corrosion.
2. **Temperature:** Corrosion reactions are electrochemical in nature and usually accelerated with increasing temperature; therefore, corrosion proceeds faster in warmer environments than in cooler ones.
3. **Chemical Salts:** Chemical salts increase the rate of corrosion by increasing the efficiency (conductivity) of the electrolyte. The most common chemical salt is sodium chloride, a major element of seawater. Sodium chloride deposited on atmospherically exposed surfaces also acts as a hygroscopic material (i.e., it extracts moisture from the air), which then increases the corrosion in non-immersed areas.
4. **Humidity:** Humidity and time-of-wetness play a large role in promoting and accelerating corrosion rates. Time-of-wetness refers to the length of time an atmospherically exposed

substrate has sufficient moisture to support the corrosion process. The wetter the environment, the more corrosion is likely to occur.

Importance of Electrochemistry

Electrochemistry deals with the relations between electrical and chemical phenomena. Electrochemical processes are used in various branches of industry. It is the most important process for the production of several chemicals. The production of various metals is based on electrochemical method. Hydrogen is manufactured by the electrolysis of water. It also plays a major role in the development of the electric automobile.

Conduction of Liquids

Conduction of liquids depends on the ability of liquids to form ions. Some liquids such as oil or alcohol do not form ions and do not conduct electricity. Vinegar is mostly water with a small amount of acetic acid in it. The acetic acid separates into ions in water. So its solution conducts electricity. Conduction of tap water depends on its hardness.

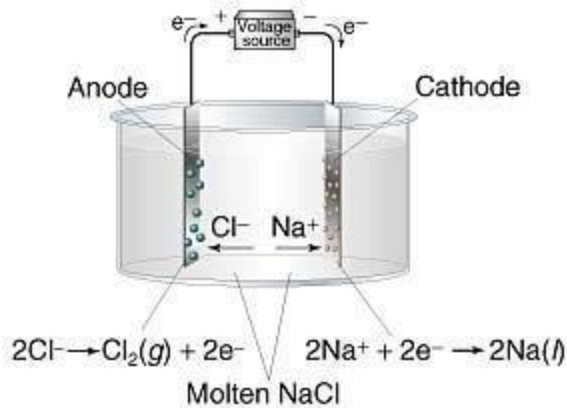
Conduction of Compounds

After understanding concept of electrolyte and non-electrolyte we can say:

Ionic compounds conduct electricity in molten or in their aqueous solution

Covalent compounds do not conduct electricity

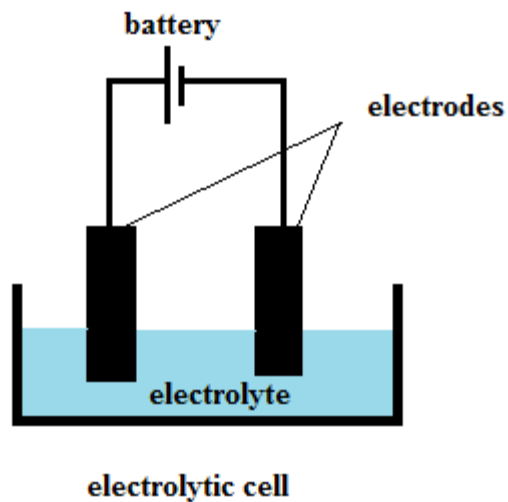
Define Electrolysis



Electrolysis refers to the decomposition of a substance by an electric current.

Example: When the current is passed through the molten sodium chloride, sodium and chlorine are deposited at different electrodes. Thus, sodium chloride is decomposed into sodium and chlorine

Apparatus for Electrolytic Cell



Apparatus for Electrolytic Cell is as follows:

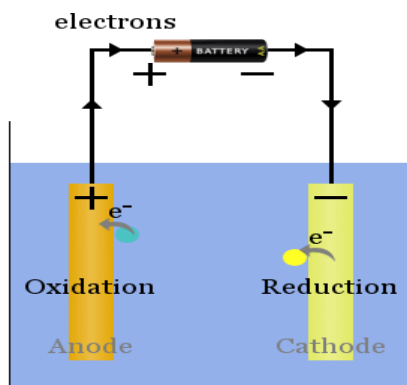
Container to hold electrolyte

Electrolyte

Electrodes

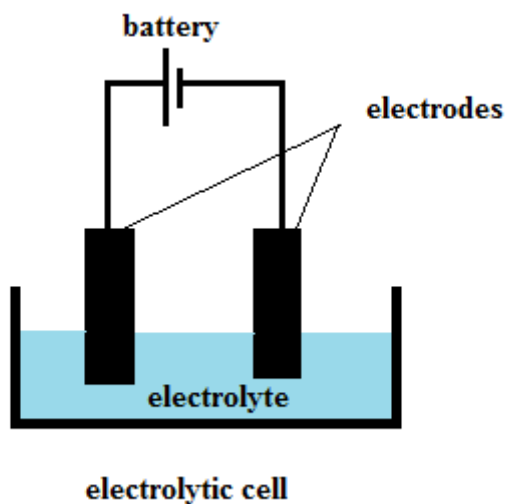
Battery (D.C current)

Conduction in Electrolytic Cell



In electrolytic cell, positive terminal of battery is connected to anode and negative terminal is connected to cathode. Flow of electron is opposite to flow current. Hence flow of electrons is from anode to cathode (ref. figure). Electrons lost at anode flows through the circuit and reaches cathode. The cation moves towards cathode to gain these electrons and formed product. On the other end, anion moves towards anode to lose electrons. This makes a circuit complete, as there is continuous flow of electrons. This is how conduction happens in electrolytic cell.

Define Electrodes



An electrode is a solid electric conductor through which a current enters or leaves the electrolytic cell.

Example: Carbon electrodes, platinum electrodes.

Types of Electrodes

There are two types of electrodes depending on the flow of current through it. These two types of electrodes are:

Cathode

An electrode at which reduction takes place is called cathode.

Note: Reaction in which there is a gain of electrons, it is called reduction *reaction*.

Anode

An electrode at which oxidation takes place is called anode.

Note: Reaction in which there is a loss of electrons, it is called oxidation *reaction*.