

Section 3: Sources of Electric Potential Energy

The Force behind the Current

Charge (or current) does not flow on its own. In order for charges to move in a conductor (or circuit) there must be some sort of **source of charges** (or **Electrical Potential**) and some force to move them!

There are 5 sources of Electric Potential Difference or Voltage. Each one converts one type of energy into electrical energy.

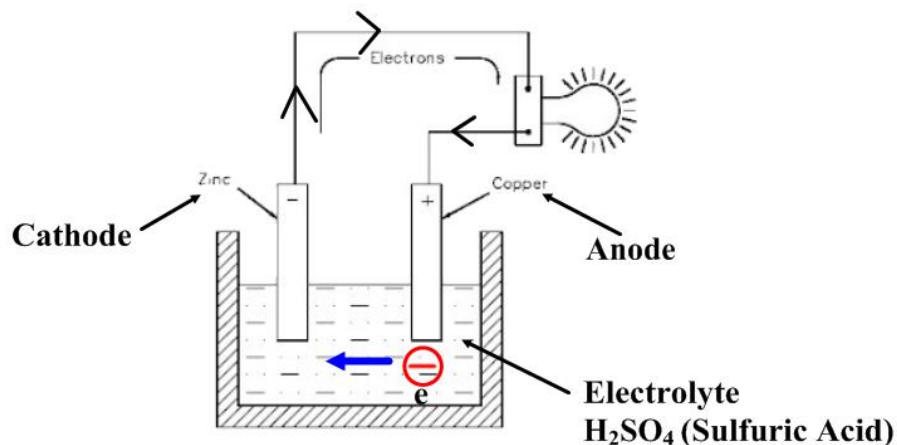
1. Chemical Sources - Electrochemical Cells

- There are two types of electrochemical cells:

- A. the voltaic cell
- B. the dry cell

- Electrochemical cells convert **chemical energy** to **electrical energy**.

A. Voltaic Cell



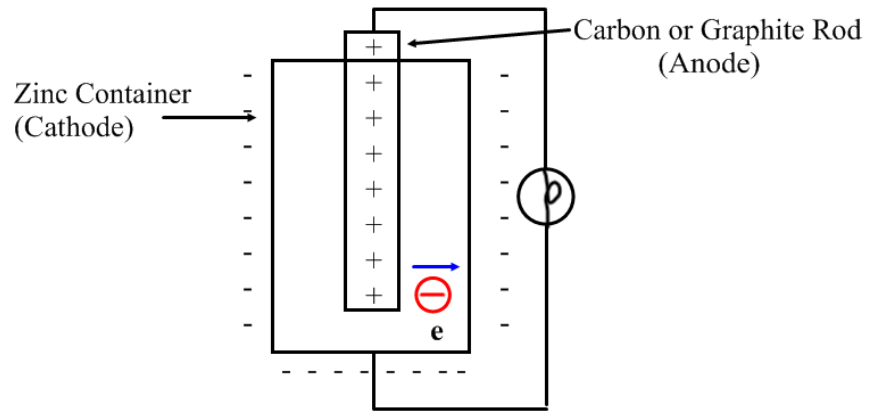
An electrolyte reacts with zinc and chemical energy is produced. This chemical energy removes electrons from the copper rod and puts them on the zinc rod. The copper rod is positively charged and the zinc rod is negatively charged. An electrical potential difference of 1.2 V is set up between the copper rod and the zinc rod.

When the copper rod is connected to the zinc rod through some load (i.e., a small bulb), the electrons start flowing from the zinc rod to the copper rod. This process continues until the zinc is consumed.

Notes:

- Copper and zinc are called **electrodes**.
- The solution, which is an acid or base, is called an **electrolyte**.
- Copper is the positive electrode and is called the **anode**.
- Zinc is the negative electrode and is called the **cathode**

B) Dry Cell



Electrolyte - $\text{NH}_4\text{Cl} + \text{MnO}_2$ (Ammonium Chloride and Manganese Dioxide)

The production of chemical energy removes the electron from the carbon rod and puts them on the zinc container. This process continues until the chemical force is balanced with the coulomb (electrical) force. This happens when the potential difference of 1.5 V is reached.

When the carbon rod is connected to the zinc container through some load, the electrons start flowing from the zinc container to the carbon rod through the load. The load uses the electrical energy of the electrons. This process continues until all of the chemical paste is consumed and the cell is declared DEAD.

The symbol for a **dc** cell (a **direct current cell**) is

- Carbon-zinc dry cells are often used in flashlights, fire alarms and portable radios.

- When a continuous supply of electrical energy is required a mercury-zinc cell is used. These cells are used in devices that require only a small amount of electric charge such as watches, hearing aids and heart pacemakers.

- A dry cell is often called a **primary cell**. In a primary cell the chemical reaction can only proceed one way and the chemicals gradually become used up. Such a cell cannot be recharged. (Voltaic cells are also primary cells.)

C) Secondary Cells

Secondary cells or storage cells are cells in which the chemical reaction producing the electrical potential energy is reversible (i.e., rechargeable). When the cell gets weak, electrical energy may be supplied to it to produce a chemical reaction that renews the cell's ability to separate charge.

Lead-acid cells are used to make car batteries. Other secondary cells are silver-cadmium, nickel-cadmium and nickel-iron cells. These are used in razors, camera flash units, toys, electric toothbrushes, etc.

2. Electromagnetic Induction - Generators

When a conductor is moved through a magnetic field, the electrons in the conductor experiences a force that causes an electric current. Kinetic energy of water or steam forces conductors to rotate in a magnetic field (e.g. Hydro-, nuclear-, fossil-fuel-powered electric generators).

3. Mechanical Sources - Piezoelectricity

Quartz and Rochelle salt crystals create a small electric potential when mechanical force or stress is applied to them. The potential difference depends on the amount of force applied. Piezoelectricity is used in some cigarette lighters, crystal microphones and electroscopes.

4. Thermal sources - Thermoelectricity - Thermocouple

Thermal (heat) energy is converted into electrical energy by means of a device called a thermocouple. It consists of two dissimilar metal conductors joined at the ends, which are kept at different temperatures. This causes a potential difference to be developed in the loop. Thermocouples are used to detect flames and to find the temperature of molten metal. (e.g., gas pilot light safety system: Current keeps gas valve open as long as flame is lit)

5. Light Sources – Photo-electricity - Photo cells

Light energy may be used to do work on electric charge and to produce an electric potential difference. When a short wavelength of light strikes certain metals, the surface electrons are removed from their atoms. This is referred to as the photoelectric effect.

Solar cells, which are thin wafers of semiconductors, can produce a small potential difference when light strikes them. (less than 1 V) It takes a large number of solar cells joined together to produce a large enough potential difference to be of any practical value. These solar cells are used in calculators, satellites, and space probes.