



Battery Technology Overview

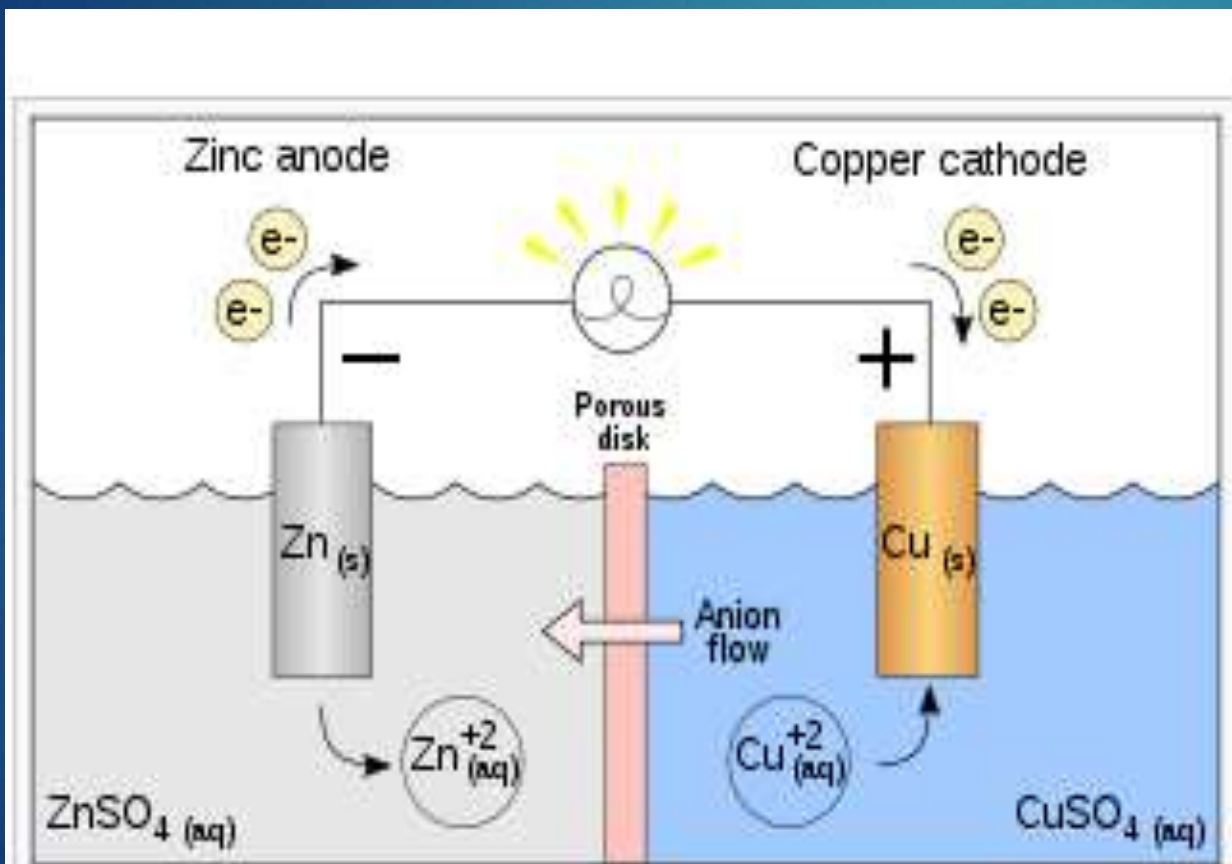
BATTERY DEFINITIONS, TERMS AND TERMINOLOGY

Electrochemical cell


- ▶ An electrochemical cell is a device capable of either generating electrical energy from chemical reactions or using electrical energy to cause chemical reactions.
- ▶ The electrochemical cells which generate an electric current are called voltaic cells or galvanic cells and those that generate chemical reactions, via electrolysis for example, are called electrolytic cells.
- ▶ A common example of a galvanic cell is a standard 1.5 volt cell meant for consumer use.
- ▶ A battery consists of one or more cells, connected in parallel, series or series-and-parallel pattern.


Galvanic cell


- ▶ A galvanic cell or voltaic cell, named after the scientists Luigi Galvani and Alessandro Volta, respectively, is an electrochemical cell in which an electric current is generated from spontaneous redox reactions.
- ▶ A common apparatus generally consists of two different metals, each immersed in separate beakers containing their respective metal ions in solution that are connected by a salt bridge (or separated by a porous membrane).




Galvanic cell

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- ▶ Batteries convert chemical energy directly to electrical energy. In many cases, the electrical energy released is the difference in the cohesive or bond energies of the metals, oxides, or molecules undergoing the electrochemical reaction.
 - ▶ Batteries are designed such that the energetically favorable redox reaction can occur only if electrons move through the external part of the circuit.
 - ▶ A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing metal cations.

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- ▶ One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode, to which cations (positively charged ions) migrate. Cations are reduced (electrons are added) at the cathode, while metal atoms are oxidized (electrons are removed) at the anode.
 - ▶ Some cells use different electrolytes for each half-cell; then a separator is used to prevent mixing of the electrolytes while allowing ions to flow between half-cells to complete the electrical circuit.

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- ▶ Each half-cell has an electromotive force (emf, measured in volts) relative to a standard. The net emf of the cell is the difference between the emfs of its half-cells.
 - ▶ The net emf is the difference between the reduction potentials of the half-reactions.

(Redox potential is a measure of the tendency of a chemical species to acquire electrons from or lose electrons to an electrode and thereby be reduced or oxidised respectively. Redox potential is measured in volts (V), or millivolts (mV).)

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- ▶ The electrical driving force or across the terminals of a cell is known as the terminal voltage (difference) and is measured in volts.
 - ▶ The terminal voltage of a cell that is neither charging nor discharging is called the open-circuit voltage and equals the emf of the cell.

Types of batteries

- ▶ Primary battery or Primary cell

Primary batteries are designed to be used until exhausted of energy then discarded. Their chemical reactions are generally not reversible, so they cannot be recharged. When the supply of reactants in the battery is exhausted, the battery stops producing current and is useless.

Example:- Zn –C batteries and Alkaline batteries

Secondary battery


- ▶ Secondary batteries can be recharged; that is, they can have their chemical reactions reversed by applying electric current to the cell. This regenerates the original chemical reactants, so they can be used, recharged, and used again multiple times.
- ▶ Secondary batteries, also known as secondary cells, or rechargeable batteries, must be charged before first use; they are usually assembled with active materials in the discharged state. Rechargeable batteries are (re)charged by applying electric current, which reverses the chemical reactions that occur during discharge/use. Devices to supply the appropriate current are called chargers.
- ▶ Example:- lead–acid battery, nickel–cadmium (NiCd), nickel–zinc (NiZn), nickel metal hydride (NiMH), and lithium-ion (Li-ion) cells

Terminology

- ▶ Cell performance :- A battery's characteristics may vary over load cycle, over charge cycle, and over lifetime due to many factors including internal chemistry, current drain, and temperature. At low temperatures, a battery cannot deliver as much power.
- ▶ Charge cycle:- A charge cycle is the process of charging a rechargeable battery and discharging it as required into a load. The term is typically used to specify a battery's expected life, as the number of charge cycles affects life more than the mere passage of time. Discharging the battery fully before recharging may be called "deep discharge"; partially discharging then recharging may be called "shallow discharge".

Capacity

- ▶ A battery's capacity is the amount of electric charge it can deliver at the rated voltage. The more electrode material contained in the cell the greater its capacity. A small cell has less capacity than a larger cell with the same chemistry, although they develop the same open-circuit voltage.
- ▶ Capacity is measured in units such as amp-hour (A·h). The rated capacity of a battery is usually expressed as the product of 20 hours multiplied by the current that a new battery can consistently supply for 20 hours at 68 °F (20 °C), while remaining above a specified terminal voltage per cell. For example, a battery rated at 100 A·h can deliver 5 A over a 20-hour period at room temperature

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- ▶ An ampere hour or amp hour (symbol: A·h or A h; often also unofficially denoted as Ah) is a unit of electric charge, having dimensions of electric current multiplied by time, equal to the charge transferred by a steady current of one ampere flowing for one hour, or 3,600 coulombs.
 - ▶ The commonly seen milliampere hour (symbol: mA·h, mA h, or unofficially mAh) is one-thousandth of an ampere hour (3.6 coulombs).
 - ▶ The fraction of the stored charge that a battery can deliver depends on multiple factors, including battery chemistry, the rate at which the charge is delivered (current), the required terminal voltage, the storage period, ambient temperature and other factors

Peukert's law

- ▶ Peukert's law expresses approximately the change in capacity of rechargeable lead–acid batteries at different rates of discharge. As the rate of discharge increases, the battery's available capacity decreases, approximately according to Peukert's law.
- ▶ The higher the discharge rate, the lower the capacity. The relationship between current, discharge time and capacity for a lead acid battery is approximated (over a typical range of current values) by Peukert's law is given as

$$t = \frac{Q_P}{I^k}$$


where

Q_P is the capacity when discharged at a rate of 1 amp.

I is the current drawn from battery (A).

t is the amount of time (in hours) that a battery can sustain.

k is a constant around 1.3.

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- ▶ Batteries that are stored for a long period or that are discharged at a small fraction of the capacity lose capacity due to the presence of generally irreversible side reactions that consume charge carriers without producing current. This phenomenon is known as internal self-discharge.