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Module Concept Repository

- A battery can be defined in a broad sense as any device capable of storing energy from an electric source when available and releasing it. This is a broad definition that even includes thermal batteries which are a container of material connected to a stream of fluid that can go in and out of the container in order to store and release heat as a method to release energy and produce electricity. An electrochemical battery is any device capable storing energy chemically and releasing it when needed in the form of electricity. An example of an electrochemical battery is a lithium-air battery, lithium-ion battery, or alkaline battery.
- The role of the redox reactions as the principal mechanism behind electrochemical batteries is the transfer of electrons through chemicals in oxidation and reduction, therefore providing the current and voltage necessary in the battery. In the first electrode, oxidation occurs which results in positive ions and electron loss which travel to the second electrode. In the second electrode, reduction occurs which results in electron gain and electrode active material interaction to produce negative ions.
- A redox reaction and combustion-like oxidation reaction are similar in the underlying chemical change. For example, a lithium and oxygen reaction will produce both lithium oxide on both occasions. However, the difference is how the energy from the chemical change is released. In a redox reaction, electrical power is released, while in a combustion like reaction, heat is released. Redox reactions and electrochemical energy allow for work to be done directly while combustion reactions allow for work to be done indirectly such as using a thermodynamic cycle leading to limitations on efficiency by the Carnot limit.
- A primary battery is a single-use battery that operates based on a non-reversible redox reaction, where a secondary battery is a rechargeable battery that operates based on a reversible redox reaction.
- The main components of a battery are the electrodes, the electrolyte, the separator, current collectors, tabs, etc. The electrodes are where the oxidation and reduction reactions take place. A positive electrode (reduction) is sometimes considered the cathode and negative electrode (oxidation) is sometimes considered the anode depending on whether the battery is being charged or discharged. Inside the electrodes are the active materials and possibly additional materials such as conductive additives. The electrolyte is what ions dissolve into in order to travel from the anode and cathode and back. The separator prevents electrons from traveling between the anode and cathode and is usually porous that allows ions to flow through. Current collectors are conductive material to transfer electricity to outside. Tabs are connections between current collectors for unification.

- Examples of primary batteries are Alkaline batteries and Lithium iodine batteries. The main reaction in Alkaline battery is a redox reaction with Zinc and Manganese oxide to produce Zinc oxide and a Manganese oxide derivative. Within the electrodes of the battery the half reaction occurs allowing for a production of electrons and a Hydroxide ion to travel between to two while the other chemicals are static. Examples of secondary batteries are Lead-acid batteries, Lithium-air batteries, Lithium-ion batteries, Lithium-sulfur batteries, Nickel metal hydride batteries, Molten salt batteries, and Vanadium redox flow batteries. The main reaction in lead-acid battery is a redox reaction with Lead and Sulfuric Acid to produce electrons and a Hydrogen ion to travel between to two electrodes which also produce precipitates and water.
- Both batteries and fuels cell are electrochemical devices however, the fuel is internal to a battery but external to a fuel cell. In a battery, the fuel or chemical are internal to the battery and the only product that exits is the flow of electrons. In a fuel cell, hydrogen and oxygen are being inputted to the fuel cell from the outside and water and electricity is outputted.
- The primary markets for battery energy storage are consumer electronics and biomedical devices, defense and aerospace, power grid energy storage, and vehicle electrification. In consumer electronics an example is the iPhone batteries, in defense and aerospace is satellite batteries, in grid energy storage is frequency regulation batteries, and in vehicle electrification is Tesla car batteries. The largest markets are the power grid energy storage and vehicle electrification.
- A solid electrolyte is a solid material that allows for ion transfer and are present in solid state batteries. This is where the anode and cathode are a solid, the separator and the electrolyte are also a solid which makes the battery have larger cycle life and better safety but tend to have lower energy density.
- Road vehicle hybridization can improve fuel economy through elimination idling during starting and stopping, regenerative braking, engine downsizing, and optimal energy management. A non-apparent improvement in hybridization is using a reduced combustion engine at max power, therefore increasing efficiency.