Common Batteries

There are a wide variety of batteries available in stores today. They come in different sizes, shapes, and brands. Different batteries are also based on different redox reactions.

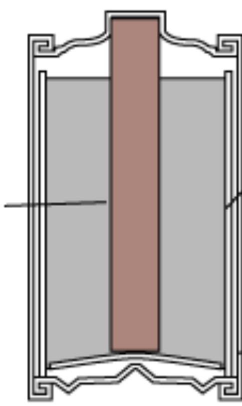
Some batteries can be recharged while others cannot. Batteries that can't be recharged are called **primary cells**, while those that can be recharged are called **secondary cells**.

Secondary cells are recharged by using an outside power source to reverse the redox reactions of the original cell. This results in the regeneration of the original reactants, extending the life of the battery.

When the reactants are used up in a primary cell, the cell must be discarded.

The Common Dry Cell

A voltaic cell in which the electrolyte is a paste is called a dry cell. The common dry cell consists of a zinc container filled with a thick paste of zinc chloride, manganese(IV) oxide, ammonium chloride, and water.



The zinc is separated from the other chemicals by a liner of porous paper that acts as the salt bridge. A graphite rod in the center acts as an inexpensive electrode.

The half-reactions for a common dry cell are shown below:

oxidation: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

reduction: $2MnO_2(s) + 2NH_4^+(aq) + 2e^- \rightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$

The primary advantage of the common dry cell is its low cost. It has a number of disadvantages, however. First, it is not rechargeable. Second, if the current is drawn from the battery too quickly, its voltage drops significantly from its normal value of about $1.5\ V$. Third, the zinc reacts directly with the ammonium ions, causing the cell to run down even when it is not being used.

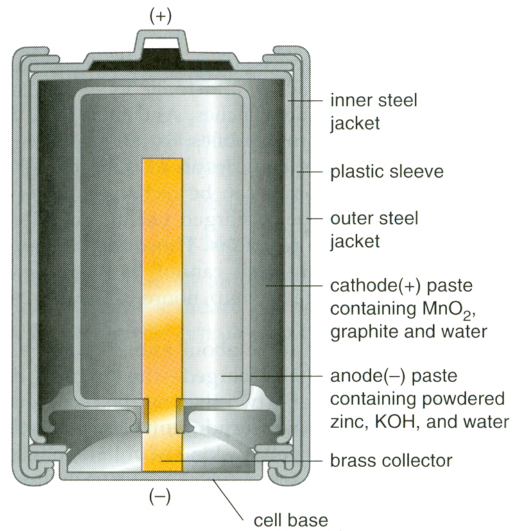
The Alkaline Dry Cell

The alkaline dry cell is a modification of the common dry cell. In an alkaline cell, potassium hydroxide replaces ammonium chloride in the paste, giving rise to slightly different reactions at the electrodes.

oxidation: $Zn(s)+2OH^{-}(aq)\rightarrow ZnO(s)+H_2O(l)+2e^{-}$

reduction: $2MnO_2(s)+H_2O(l)+2e^{-}\rightarrow Mn_2O_3(s)+2OH^{-}(aq)$

The design of the alkaline dry cell is also different, as you can see in the diagram to the right.



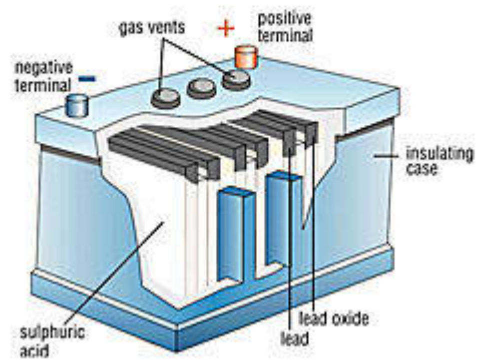
The alkaline dry cell has several advantages over the common dry cell. It has a longer shelf life because zinc does not react as readily with the potassium hydroxide as it does with the ammonium chloride. It also maintains a steady voltage of about $1.5\ V$ under high current loads, and generates about 50 percent more energy than a common dry cell of the same size.

The main disadvantage of the alkaline dry cell is its higher cost.

Lead-Acid Battery

The car battery is the best known example of a rechargeable battery. It is also known as a lead-acid battery because its electrodes are composed of alternating sheets of lead and lead dioxide separated by porous spacers. The electrolyte in the battery is sulfuric acid, commonly called battery acid.

During discharge, lead is oxidized and therefore serves as the anode. In the presence of sulfate ions from the electrolyte, this creates lead(II) sulfate.



oxidation: $Pb(s)+SO_4^{2-}(aq)\rightarrow PbSO_4(s)+2e^{-}$

The cathode consists of lead dioxide, also immersed in sulfuric acid. During discharge, the lead dioxide is reduced in the presence of sulfuric acid and also produces lead(II) sulfate.

reduction: $PbO_2(s)+4H^{+}(aq)+SO_4^{2-}(aq)+2e^{-}\rightarrow PbSO_4(s)+2H_2O(l)$

Each cell in a lead-acid battery generates a voltage of $2\ V$. Thus, a $12\ V$ car battery consists of six voltaic cells.

The lead(II) sulfate formed at the anode and cathode during discharge is insoluble and sticks to the electrode surfaces. This makes it possible to reverse the reactions when the battery is recharged.

To recharge a lead-acid battery, a source of direct electrical current is used to reverse the electrode reaction and regenerate the original reactants.

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \Leftrightarrow 2PbSO_4(s) + 2H_2O(l)$$

The forward reaction is spontaneous, and represents the discharge of the battery. The reverse reaction is not spontaneous, and represents charging the battery.

Lead-acid batteries are simple, inexpensive, and reliable. Their major drawback is their mass. A typical battery contains 15 to 20 kg of lead.

Nickel-Cadmium Battery

Nickel-cadmium (NiCad) batteries are popular rechargeable voltaic cells, used in a lot of consumer electronic devices. The anode is composed of cadmium. During discharge, cadmium is oxidized, forming Cd^{2+}, which reacts with OH^- ions to form $Cd(OH)_2$. The cathode reaction involves the reduction of NiO_2, which is present in the paste.

oxidation: $Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$

reduction: $NiO_2(s) + 2H_2O(l) + 2e^- \rightarrow Ni(OH)_2(s) + 2OH^-(aq)$

Like the lead-acid battery, the products formed in the electrode reactions are insoluble and stick to the electrode surfaces, thus permitting recharging.

The NiCad battery is lightweight and produces a constant voltage during discharge. However, it suffers somewhat from discharge "memory." If it is discharged only partially and then recharged, it develops the tendency to need recharging more often.