Intro to Electricity

People have only had electricity for the past hundred years or so. What a difference it makes in how we live. Just about everything in the modern home works off electricity – we make light, wash dishes, clean the deck, drill holes, cook food, freeze pork chops, sew clothes, cut wood, listen to music, cool food, watch moving images, mash potatoes, dry our hair, tape TV shows for later viewing, heat air and water, manipulate bits of information. . . the list goes on and on.

When we studied electric fields, we mainly dealt with charges that weren’t doing much. Well, truth be told, static electricity was not terribly useful, in fact it was mainly used to entertain people during lectures or as toys.

Still, static electricity, while cool and interesting in and of itself, was not terribly useful. For one thing it was a lot of trouble. You had to rub things or rotate things – this entailed a lot of work – and the payoff was rather pitiful – you get a lousy spark or attract a bit of fluff to a charged up rubber stick. Big deal.

Electricity didn’t really take off and become the huge, dynamic engine of change that transformed the planet until a way was found to have a ***continuous*** flow of charge through a conductor. What was needed was a voltage source.

***The first voltage source was what we now call the battery***.

***Battery Business:***  In the 1790’s Luigi Galvani found that he could remove the leg of a frog (from the frog), place it on his lab table, and make it twitch by touching it with a scalpel. This actually happened by accident. Kind of scary don’t you think? A dead leg suddenly twitching?

Well, it quite caught the fancy of Galvani. How could this be? After a series of experiments, he found that the cause of the twitch was a flow of charge generated by two dissimilar metals – the scalpel and the metal lab tabletop.

The word ***galvanized*** remains as a tribute to Mr. Galvani. One is galvanized when the muscles suddenly contract.



Alessandro Volta was inspired by this and learned to manufacture the first wet cells (the thing that led to the modern battery). He used bits of dissimilar metals to generate electricity placed into a sequence of electrolyte bearing bowls. The bowls were placed in a line and he connected them together with strips of metal that were half copper and half zinc. He called this device the “crown of cups”.



The device produced electricity continuously! As fast as you drew the electrons off they were replaced with new ones. ***Amazing***!



Allesandro also developed an even better method – this one involved a stack of discs that alternated between two different metals. Between the metal discs was a cardboard disc that had been soaked in salt water. If the top metal disc was connected to the bottom disc with a conductor, a continuous flow of electrons through the wire and the discs resulted. The device is called ***Volta's pile***.

The unit for potential difference, the volt, was named for Volta.

***Did I mention Volta and Galvani hated each other? More on this later!***

These primitive devices evolved into the batteries that we use today – dry cells (your basic alkaline energy cell type thing) and rechargeable batteries (nickel cadmium and lead acid batteries).

Properly speaking a battery is a collection of cells. A single AA Duracell thingee is, to be correct about the thing, called a cell, ***not*** a battery.

A French physicist named George Leclanche (1839 - 1882) invented the dry cell over a hundred years ago. These cells were made up from a zinc can – the zinc acts as the cathode - and a carbon rod that serves as the anode. The electrolyte is a paste made up of manganese oxide (MnO4), ammonium chloride (NH4Cl), and powdered carbon. Modern dry cells include the alkaline type dry cells. These are constructed much the same as the older (and cheaper) zinc carbon types. The main difference is the electrolyte. Both use carbon rods and zinc cans. The electrolyte in the alkaline battery is basic rather than acidic. It turns out that the zinc can lasts longer in a basic solution. In this type, the NH4Cl is replaced with potassium hydroxide (KOH) or sodium hydroxide (NaOH).

Both of these cells produce approximately 1.5 V.

The amount of charge that can be provided depends upon the size of the cell. A large D cell can produce a greater amount of charge than can a small AAA cell.

All of these types of cells or batteries are called ***primary cells***. They produce electricity as long as the chemical reactions take place. When they cease, the battery is “dead”. At which point you go out and buy a new one. You use them and then throw them away.

A second major type of cell or battery is also in use, these are called ***secondary cells*** or ***storage cells***. These batteries, once they've been drained of current, can be ***recharged***. Examples would be your old automobile lead acid battery and nickel cadmium batteries used in portable electric devices.

Batteries work because of a chemical reaction that takes place within the thing. These are known as ***oxidation/reduction reactions***. You will learn all about them in Mr. Branco’s Chemistry course! The name is often shortened to ***redox*** reactions.

In a redox reaction, electrons are transferred from one reactant to the other. The reactant that gains electrons is "reduced", and the reactant that loses electrons is "oxidized". This causes electrons to move from one chemical substance to another. Any movement of electrons is called an electric current.

***Electric Current:*** Electric current is simply the flow of electrons through a conductor. Two things are needed for current to flow:

1. A voltage source (a dry cell will do nicely).
2. A complete path through witch the electrons may move.

The carrier of charge in a solid conductor is the electron. Positive charge cannot move as it is tied up in the protons of the atoms, which are essentially fixed in position.

There are two different kinds of electric current; ***dc*** and ***ac***. dc stands for direct current. This is where the electrons all flow in the same direction. ac stands for alternating current. In an ac circuit the direction of the current changes. We will deal mainly with dc current.

To maintain the flow of electrons - the electric current - a constant potential difference must be maintained. Such potential differences are produced by ***voltage sources***. Common voltage sources are: dry cells, batteries, generators, magnetos, solar cells, fuel cells, and alternators – just to name a few.

The symbol for electric current is ***I***. (This doesn’t make a whole bunch of sense. You have to understand, however, that this convention comes from France, so what did you expect?)

The unit for current is the ampere, which is abbreviated as A or amps.

 

Electric current is defined as the rate at which the charge flows through the conductor. The equation for current is:

  Equation for current.

***I*** is the current in amperes, ***Q*** is the charge in Coulombs, and ***t*** is the time in seconds.

The equation given on the AP Physics Test is: 

But we’ll use  because it’s easier to write.

The ampere is a fairly large quantity, so it is very common to use the mA.

 1 mA = 10-3 A

1. 3.25 x 1017 e- flow past a point in 0.235 s. What is the current?

***Direction of Current Flow:*** This is an area of controversy. Doesn’t seem logical that people would argue about this, but they do. The convention that we will use is this one. The direction of current flow is the direction that a positive charge carrier would travel in the circuit.

Now this makes no sense at all, and wise people don’t use it. The U.S. Navy does not use this convention; that’s how bad it is.

Anyway for us: ***electricity flows in the same direction as positive charge***. WHAT!?

The reason this is so stupid is that there is no positive charge carrier. Only a negative charge carrier, the ubiquitous electron.

So set your mind to using this stupid convention, it’s here to stay.

***But if you really want to get someone charged up about it go ask Mr. Branco what he thinks of the direction of conventional currently flow!***