13a: Volta

History

Until the year 1800 most people were only generating static electricity for their experiments.

- They were almost exclusively using devices that would build up charges by friction.
- To really make electricity useful (and not just something to show off at parties), they needed a way to produce a steady flow of electrons over a long time, not just a quick burst.

In the 1780's the Italian scientist Luigi Galvani was testing the effect of static electricity on organic material.

- His favorite was to cause a frog leg to contract when it was zapped.
- He discovered that he could get a similar result without any apparent source of electricity.
  - He passed a brass hook through the frog's spinal cord and hung it from an iron railing.
  - If the frog's leg muscle also touched the iron rail the leg would contract!

Galvani concluded that the source of the electricity must be in the frog's muscle itself.

- He referred to this as "animal electric fluid" or the "spark of life."
- Galvani (along with many other important scientists) believed that electricity could unlock all the secrets of life… maybe even souls!

Did you know?

The work of Galvani (and other scientists after him) in "animal electric fluid" was partially the inspiration for Mary Shelley's book "The Modern Prometheus", better known simply as "Frankenstein." You can read the book by clicking here or here.

Illustration 1: Alessandro Volta

Alessandro Volta disagreed, saying that he believed that the electricity was from the two metals, not the frog.

- Volta's problem was that he needed to prove that the electricity had nothing to do with animals or any other living (or once living) tissue.
- If there was anything organic in his experiment, Galvani would say that it was the "animal electricity"
- Electroscopes at the time weren't delicate enough to detect the small currents he would be measuring.
  - A frog's leg muscle would easily detect the small currents, but Volta couldn't use any organic material.

After a few years of experimenting Volta showed how a current could be created without organic material. The materials needed are:

1. Two **dissimilar** (*different*) metals.
2. A liquid or paste between the two (this is what the fluid of the frog's legs had done for Galvani)

After even more experiments Volta found that different combinations of metals produced different voltages.

- He arranged them in order in a list called the "electrochemical series"
  - If you've taken a chemistry class, you'd recognize it.
  - Chemists use it as the table of half reactions, that show how one element will gain this many

electrons, and the other will lose this many, all arranged as a big list.
    - Although chemists and physicists are using it for different reasons, it's based on the same principles.
- Volta also discovered that you could always use **carbon** as one of the metals and get a voltage.

Battery Basics

Volta's next idea was his big one… the one that he is mostly remembered for: the battery.

- Between a disc of **zinc** and a disc of **silver** he placed a piece of **paper** (or cloth) soaked in a salt solution (or dilute acid).
- This is a cell; when you stack several of them you get a battery.
    - The battery in Illustration 2 is made up of three cells.

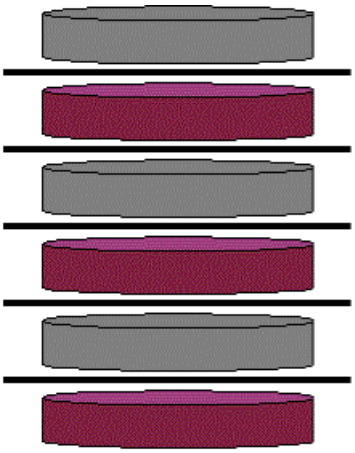

Illustration 2: A simple battery made of three cells. Each cell is made from two dissimilar metals separated by a cloth soaked in acid.

This changes chemical energy into electrical energy.

- Although the voltage created by his first batteries were weak, Volta's invention had two advantages:
    1. It could produce a pretty big charge.
    2. It was self-generating (it kept producing a charge on its own for quite a long time).

The simplest cell made of the parts mentioned above have special names.

1. The two discs made of dissimilar metals called "**electrodes**" (remember one can always be **carbon**).
    - In fact, cheap batteries usually contain carbon as one of the electrodes, which is why they are cheaper to make and usually weigh less!
2. A solution for the rods to be placed into, usually a dilute acid, called the "**electrolyte**"

The part of the electrode that sticks out of the electrolyte is called the **terminal**.

- These are the positive and negative terminals you see on regular batteries where we would make our connections to the battery.
    - The **negative** terminal is referred to as the **anode**.
    - The **positive** terminal is referred to as the **cathode**.

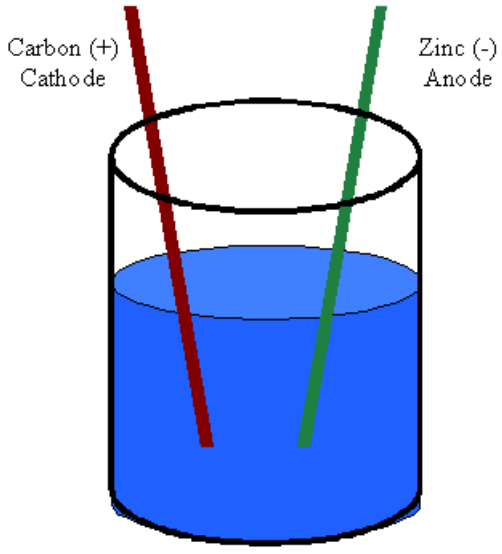

Illustration 3: Two electrodes in an electrolyte.

Let's say we have a battery made with **carbon** and **zinc** rods sitting in an acid solution. The battery will make electricity if it goes through the following steps…

1. Acid attacks the **zinc** and starts to dissolve it.
2. Each **zinc** atom that leaves the electrode and enters the electrolyte leaves 2 electrons behind on the rod. The **zinc anode** is starting to build up a negative charge, while the **zinc** ion in the solution has a positive charge.
3. The positive **zinc** ion in the solution will start to attract electrons off of the **carbon cathode**… the **carbon** rod starts to gain a positive charge.
4. Now the two electrodes have different charges… there is a potential difference between them. If we connect the two terminals now, a charge will flow between them.

After a while, one of the electrodes will be used up as it is eaten away by the acid.

- If the terminals are not connected no current will flow and the reaction in the solution will slow down to almost nothing.
- This is why batteries can be stored for at least a while.

The voltage of the cell depends on what the electrodes are made of and their relative tendency to corrode.

Did you know?

Different types of batteries get their names from the metals used. For example, alkaline batteries use alkaline metals, NiCads use nickel and cadimium, and Lithium ion have lithium. Companies closely guard the exact alloys and way of arranging the metals in their batteries.