

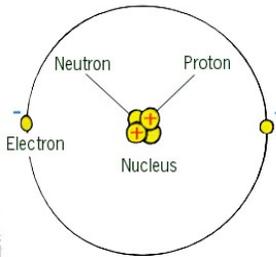
Electricity and Magnetism Unit Notes

STATIC ELECTRICITY

- Charged objects exert forces on other charged objects and the region over which this force can be felt is called the electric field. The term static electricity implies that the electric field is unchanging. Electrostatics involves the build up of charge due to physical contact between, typically, non-conductive surfaces. These charges build up through the flow of electrons from one object to another and they remain in the object until a force is exerted that causes the charges to flow, also known as a static shock. A shock is caused by difference in charge between two objects and the redistribution of the charge in an attempt to achieve balance.

Subatomic Charge

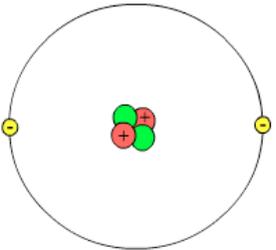
- Electrons and protons have an attribute called *charge*. Electrons have a negative charge. Protons are 1800 times more massive than electrons, but have a positive charge that is equal in magnitude to the charge of an electron. Neutrons have no charge.



- The unit of charge is the Coulomb. There are six million trillion electrons is about 1 Coulomb of charge. An elemental charge of 1.6×10^{-19} Coulombs equals the charge of a proton and the negative charge of an electron.

Atomic Charge

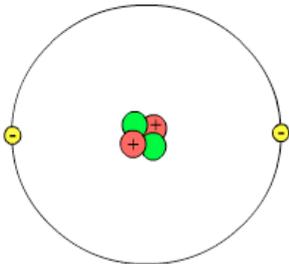
- Lets use a Helium atom as an example...



If we remove an electron the atom becomes charged. Remember:

- A positive ion loses an electron
- A negative ion gain an electron

The atom has now become a positive Helium ion.



- *Charging by induction* - occurs when an uncharged object is brought near but not in contact with a charged object. This polarizes the uncharged object and the unlike charge is then grounded. This produces two charged objects with opposite charges.

Conductors and Insulators

- In conductors electric current flows freely, while in an insulator has a high resistance to the flow of charge. Metals such as copper and gold are great conductors of electricity. "Conductor" implies that the outer electrons of the atoms are loosely bound and free to move through the material. Almost all non-metallic solids are said to be good insulators. Most atoms/materials hold on to their electrons tightly and are insulators.

CURRENT ELECTRICITY

Potential Difference and Current

- A difference in charge causes charge to flow. This difference in charge is also called potential difference and is measured in volts, while the flow of charge is called current and is measured in amperes.
- Current can either be:
 - *Direct current (DC)* - travels in one direction only. It is typically used for small appliances and is produced by batteries
 - *Alternating current (AC)* - the flow of charges switch directions. It is the most practical type of current for transmission and it is what comes out of your wall sockets.

Electrical Energy

- Most of the electrical energy we use in this classroom and you use in your home comes from large electrical power plants. There are different types of power plants, but they all transform some type of energy into electrical energy.
- Electrical energy is measured in **Joules** and power is measured in **Watts**.
- Energy usage in the home is typically measured in **Kilowatt-hours**.

Electrical Devices

- There are various devices involved in electrical energy conversions. Some of these include:
 - *Batteries or Cells* - convert chemical energy into electrical energy
 - *Solar cell* - converts solar energy into electrical energy
 - *Generator* - converts kinetic energy into electrical energy
 - *Motor* - converts electrical energy into kinetic energy

Electrical Circuits

- There are two main types of circuit classifications:
 - *Series Circuits* - all electrical components, like light bulbs, are connected in a single loop to the power source.
 - *Parallel Circuits* - each electrical component, like a light bulb, is connected on separate loops to the power source.

Ohm's Law

- Across a circuit potential difference drives the current. As potential difference increase, current increases. This is a direct relationship. Mathematically this relationship is expressed by Ohm's law: $V = IR$, where V is the potential difference in volts, I is current in amperes, and R is resistance in ohms.

MAGNETISM

- The term magnetism stems from certain rocks called lodestones found more than 2000 years ago in the region of Magnesia in Greece. Magnetic materials attract most types of metals, with a few exceptions like aluminum.

Magnetic Poles

- Magnets exert forces on one another that are similar to electric charges
 - Like poles attract
 - Unlike poles repel
- Electric charges may be isolated, but magnetic poles may not
 - If you break a bar magnet in half, each half will behave as a complete magnet... this suggests atoms themselves are magnets

Magnetic Fields

- The region around a magnet, in which a magnetic force is exerted is called the magnetic field
- The shape of the field is shown by field lines
 - Field lines flow from North to South poles
 - Fields lines can be shown with iron filings or compasses
- Electric charges may be isolated, but magnetic poles may not
 - If you break a bar magnet in half, each half will behave as a complete magnet... this suggests atoms themselves are magnets.

Nature of Magnetic Fields

- Magnetism is very much related to electricity. Moving electric charges are not only surrounded by electric fields, but also magnetic fields.
- Moving electric charge creates all magnets. The motion (spinning) of electrons in the atoms of a bar magnet cause its magnetic field.
 - Spinning same way - strong magnet
 - Spinning opposite ways - work against (not magnetic)

Earth's Magnetic Field

- The Earth's magnetic field is created by the flow of electrical charges deep inside the core. Like all magnets, it has a north and a south pole. The geographic poles do not exactly match up with the magnetic poles, but they are close.

Magnetic Domains

- Certain metals the magnetic fields of the atoms are so strong that they group together in small, magnet-like regions called **domains**. When you hold a magnet close to an un-magnetized object, the domains in the object align to create a temporary magnet. The domains of a permanent are remain aligned and do not change.

Electromagnetism

- Electric current passing through a wire creates a magnetic field. Placing a wire around temporary magnet will magnetize it while wire carries electricity. When the wire doesn't carry current the temporary magnet will no longer be magnetized. As current passes through the wire small magnetic regions within the temporary magnet, domains, align with the wire's magnetic field. The strength of an electromagnet can be increased or decreased by changing the current passing through the wire. Motors, speakers, hard drives, and electric toothbrushes use this principle.