PHYS:1200 LECTURE 24 — ELECTRICITY AND MAGNETISM (2)

In addition to mass which is responsible for the gravitational force, matter has another property-- charge which gives rise to electric and magnetic interactions. The effects of charge may not be as evident as mass, because the charge is bound up in atoms, and matter in the normal state has no net charge – it is electrically neutral. Charge can be wither positive or negative, like charges repel and unlike charged attract. Objects can acquire a net electric charge through frictional charging (rubbing two objects together). **Charge is measured in Coulombs (C).**

24-1. Electric Charge.—There is a fundamental unit of charge denoted by the symbol e which has a value, $e = 1.60217646 \times 10^{-19}\,C \approx 1.6 \times 10^{-19}\,C.$ By fundamental we mean that all charge is a multiple of this basic unit; charge is not found in fractional units of e. A charge of 1 C then represents a huge number of elementary charges on the order of $1/1.6 \times 10^{-19} \approx 6 \times 10^{18}$.

- The proton has a charge of +e
- The electron has a charge of –e

Example 24-1: A charged object has 200 protons and 100 electrons. What is the net charge on this object? Solution-

Total positive charge = $200(+e) = 200\left(1.6 \times 10^{-19}C\right) = +3.2 \times 10^{-17}C$

Total negative charge = $100(-e) = 100\left(1.6 \times 10^{-19}C\right) = -1.6 \times 10^{-17}C$

Net charge = $+3.2 \times 10^{-17}C + \left(-1.6 \times 10^{-17}C\right) = (3.2 - 1.6) \times 10^{-17}C = +1.6 \times 10^{-17}C$

We could also realize that the net charge is $+200e + (-100e) = +100e = +1.6 \times 10^{-17}C.$

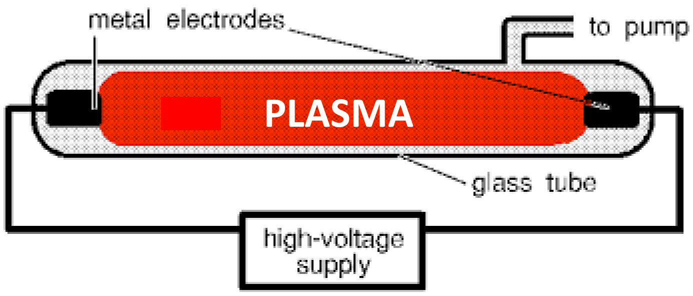
24-2. Conservation of Charge.—In any process involving the transfer of charge, it is conserved. In physics, **charge conservation** is the principle that electric **charge** can neither be created nor destroyed. The net quantity of electric **charge**, the amount of positive **charge** minus the amount of negative **charge** in the universe, is always conserved.

Example 24-2: Object A has a net charge of +7 C and object B has a net charge of +13 C. If –4 C of charge are transferred from A to B, what is the final net charge on A and B?

Solution- Notice that the net charge on both objects before the transfer is +20 C. This values must be the same after the transfer has taken place. If –4 C is removed from A, then A becomes even more positive → + 11 C. When –4 C is added to B, these negative charges will neutralize +4 C, so B will then have →+9 C. The net charge on A and B after the transfer is +20 C, the same as the net charge before the transfer.

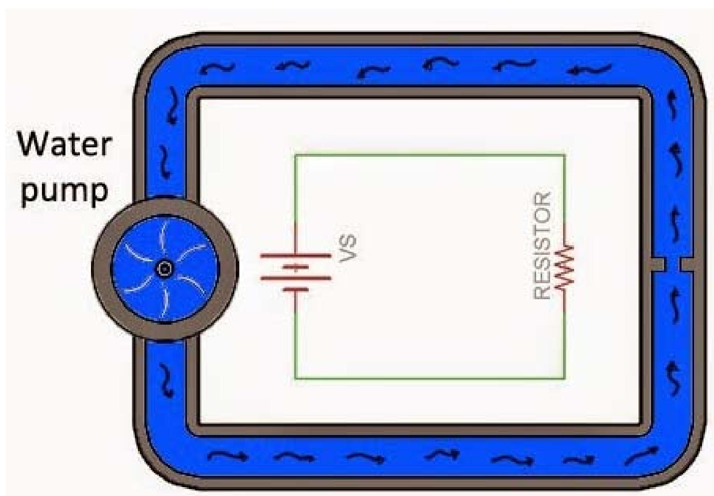
24-3. Liquid and Gaseous Conductors.—The conductors that are used in the wiring of our homes or in typical electrical circuits that we use are solid materials like copper. In critical applications such as cell phones and computers, gold is used as a conductor due to its high electrical conductivity and the fact that it does not corrode as copper and silver due. However, liquids and gases, under certain conditions, can also conduct electricity. (Mercury is a metal that is liquid at room temperature and is also a conductor.) Pure water is a non-conductor, but it becomes a conducting solution when salt (NaCl) is added to it. In solution, NaCl dissociates into a positive sodium ion (Na^+) and a negative chlorine ion (Cl^-), both of which participate in the flow of current (slide 12).

Dry air and other gases are also non-conductors, except they can be converted into a conducting gas when they are ionized. In the **ionization process,** an electron from the outer levels of an atom is removed, leaving a positive ion and a negative electron. If a sufficient number of the atoms are ionized, a large population of electrons exists which conduct an electrical current. A continuous source of ionization is necessary to keep the gas in the conducting state, otherwise the electrons and ions recombine to form neutral atoms**. An ionized gas is also called a plasma** (not to be confused with blood plasma)**.** A gas discharge tube is a device for producing an ionized gas. A high voltage is applied to two metal electrodes contained in a glass tube that is filled with a low-pressure of gas. Stray electrons are accelerated by the high voltage to energies that are sufficient to ionize some of the atoms which then liberates more electrons, until eventually an avalanche of ionized particles is formed.



Another common example of a gas discharge is the **neon light**. Gas discharges produce light because some of the atoms, although not ionized are raised to excited states that relax by emitting light. Gas discharges are the basis for **fluorescent lighting**.

24-4. Sources of Electric Potential: Batteries.—Currents only flow in normal conductors if an external source of electric potential is provided. A battery in an electric circuit plays a role similar to a water pump. Water does not flow freely uphill and a pump is required to produce a pressure difference that pushes the water uphill. The electrons in a wire do move about but in random directions. To produce current, the electrons must be forced to flow in a particular direction. The Battery provided the potential difference (**or voltage source, VS**) to accomplish this.



Batteries are devices which convert chemical energy to electrical energy. A battery is composed of two different metals immersed in an electrically conducting fluid (e.g. acid). Batteries have three parts, an *anode* (-), a *cathode* (+), and the *electrolyte*. The cathode and anode (the positive and negative sides at either end of a traditional battery) are hooked up to an electrical circuit. The chemical reactions in the battery causes a buildup of electrons at the anode. This results in an electrical difference between the anode and the cathode.