Unit 2

Electric Fields

Part 1 – Electrostatics

Part 1
Electrostatics (Read section 524 - 534)

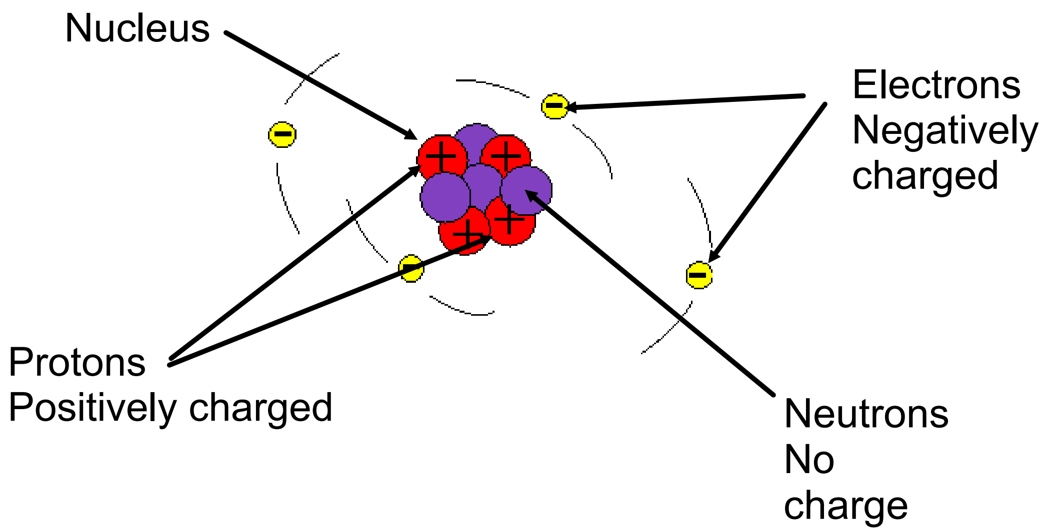
In the first eleven sections you will

- draw, label and describe a simple model of the atom that satisfies electrostatic observations
- state and demonstrate the law of electric charges
- explain what is meant by the phrase "conservation of charge"
- describe how charge may be transferred by friction, contact and induction
- describe how it is that a charged object attracts but never repels a neutral object
- describe the difference between insulators and conductors
- explain the difference between fast electrical discharge and slow electrical discharge and (as an example) the important role that a lightning rod plays in such a difference

Section II : The Electric Structure of Matter

Electrostatics - study of electricity at rest.

The Atom



The nucleus comprises essentially the entire mass of the atom (Mass of Nucleus ≈ Mass of proton + Mass of neutron) and has a fixed position. (Neutrons are heavier than protons).

The electrons occupy a large space surrounding the nucleus and they travel in orbitals.

Normally atoms have the same number of electrons and protons - atoms are normally neutral.

If the atom gains or loses any electrons, the atom will become charged. An atom that has a net charge is called an **ion**.

Negative ion - an atom with an excess of electrons
Positive ion - an atom with a deficit of electrons

Elementary Charge - the charge on one proton

Charge on a proton = 1.60×10^{-19} Coulombs
Charge on an electron = $- 1.60 \times 10^{-19}$ Coulombs

To find the charge on any ion:

Q* = *Ne where

- ***N*** is the number of excess electrons or the deficit of electrons.
- ***e*** is the elementary charge (if an ion has an excess of electrons we will use ***e*** to be negative.
- ***Q*** is the total charge

Fundamental Law of Electric Charges

Opposite electric charges attract.
Like electric charges repel.
Charged objects attract some neutral objects.

Section III: Conductors and Insulators

Conductors

- Primarily metals
- Typically have free space in their valence shell,
- Share electrons among atoms – an electron sea. so electrons are free to move easily from atom to atom.
- Provides a good path for energy transfer
- Cannot be "charged" by friction
- Examples: silver, copper, and aluminum

Insulators

- Primarily complex molecules like plastics and rubber
- Typically have full valence shells
- Do not share electrons between adjoining molecules. Therefore, so electrons are not free to move from atom to atom.
- Do not provide a good path for energy transfer
- Can be "charged" by friction
- Examples: plastic, cork, glass, wood, rubber

Semi-conductors

- Possess properties that mimic those of both insulators and conductors
- Electrons are free to move but not as freely as in conductors.
- Examples: copper oxide, silicon, and germanium.

Section IV: Charging by Friction

3 Ways to Charge an Object

1. Friction: This is used to charge put an electric charge on an insulator. This method cannot be used to place a residual charge.
2. Contact: This method is used to place a residual charge on a conductor. (conductor receives the same charge)
3. Induction: This method is also used to place a charge on a conductor. In this case the charge may be temporary or residual.
   (conductor receives opposite charge).

Adding energy to an atom allows us to remove or add one or more electrons from an atom or substance.

An object will become negatively charged if it gains electrons and it will become positively charged if it loses electrons.

All charge is created by the redistribution of electrons.
Positive charges never move.

The Law of Conservation of Electric Charge

In a closed system, the number of electric charges is constant. They can be rearranged but charge is neither created nor destroyed – the amount is constant.

Different materials have differing **affinities** or **attractions** for electrons. Some materials hold onto electrons very tightly while other materials do not. In other words, some materials give up their electrons easily and some do not.

Electric Static Series Table

Cat's fur	**Weak Attraction for Electrons (Becomes Positive)**
Acetate	
Glass	
Wool	
Lead	
Silk	
Wax	
Ebonite	
Copper	
Rubber	
Amber	
Sulphur	
Gold	**Strong Attraction for Electrons (Becomes Negative)**

Materials with a weak attraction for electrons

Through friction, electrons can be removed from some materials leaving them with a deficit of electrons. We say the material is **positively charged**.

Other Examples: nylon, leather, and hair

Materials with a Strong Attraction for electrons

These materials will accept extra electrons fairly easily. When this happens the material has an excess of electrons and we say the material is **negatively charged**.

Other Examples: cotton, vinyl, polyethylene

The direction in which the electrons move depends upon the affinity or attraction that the particular atoms have for electrons.

For example, when we rub a plastic rod with fur, electrons are removed from the fur and are placed on the plastic rod. So the fur becomes positively charged and the plastic rod becomes negatively charged.

Therefore:

Materials with a greater attraction for electrons obtain a negative charge.
Materials with less attraction for electrons obtain a positive charge

Question: What will be the result of rubbing a piece of vinyl with wool?

Answer: The friction between the vinyl and wool will ‘scrape’ the electrons from the wool. This occurs because the wool has a lesser hold on its electrons than does the vinyl. Therefore, the vinyl now has an excess of electrons and is said to be negatively charged. The wool has a deficit of electrons and is said to be positively charged.