Electric charge and field

Electric Charge

INTRODUCTION TO ELECTRIC CHARGE:

The word ‘electrostatics’ is an amalgamation of two words: electro and statics. Electro Means that it has something to do with electricity derived from electrons, and static means ‘Not in motion’.

We know that the electric current (i) is defined as, $i = \frac{q}{t}$ where q denotes the **electric Charge** and t denotes the time. This means that **the charge flowing per unit time gives the Electric current**.

However, electrostatics deals with static charges and therefore, this formula can be kept A side for some time.

Now, the question is: if moving charges are the cause of electric current, what possibly Could charges at rest do? To understand this in detail, let us have a look at the following Phenomena:

1. If you rub amber (a fossilised resin that is used to make jewellery) with a cloth, the Amber attracts the pieces of dry leaves.
2. If you rub a glass rod with a silk cloth, the glass rod attracts the pieces of dry paper. If You rub a plastic rod with a woolen cloth, the plastic rod also attracts the pieces of dry Paper. Although the different materials of the rod and the cloth are used, they show the Same property.

It is time to look at phenomenon 2 in greater detail. It was mentioned that because of Rubbing the Rod with the cloth, it got charged and the rod became capable of attracting the Pieces of dry paper. Because of this, the scientists called the charge in the first case of Phenomenon 2 (the glass rod and the silk cloth combination) by A and the charge in the Second case of phenomenon 2 (the plastic rod and the woolen cloth combination) by B.

However, the question that arises is if both the rods get charged by the same charge, why are they called by two different names, *A* and B? Is there any chance to prove that both A and B are the same? To answer this question, the following experiment is done.

Suppose that a glass rod and a plastic rod are charged individually by rubbing them with a silk cloth and a woolen cloth, respectively, in such a way that the glass rod is able to attract 10 pieces of dry paper and the plastic rod is also able to attract 10 pieces of dry paper. Hence, it is likely that when these two rods are brought together, they should be able to attract 20 pieces of dry paper. On the contrary, what is actually seen is that they do not attract any pieces of dry paper. This proves that the effectiveness with which the rods were able to attract the dry papers gets nullified when the rods are brought together. Hence, it can be concluded that **charge A and charge B are opposite to each other.**

The following three phenomena are also seen from the experiment.

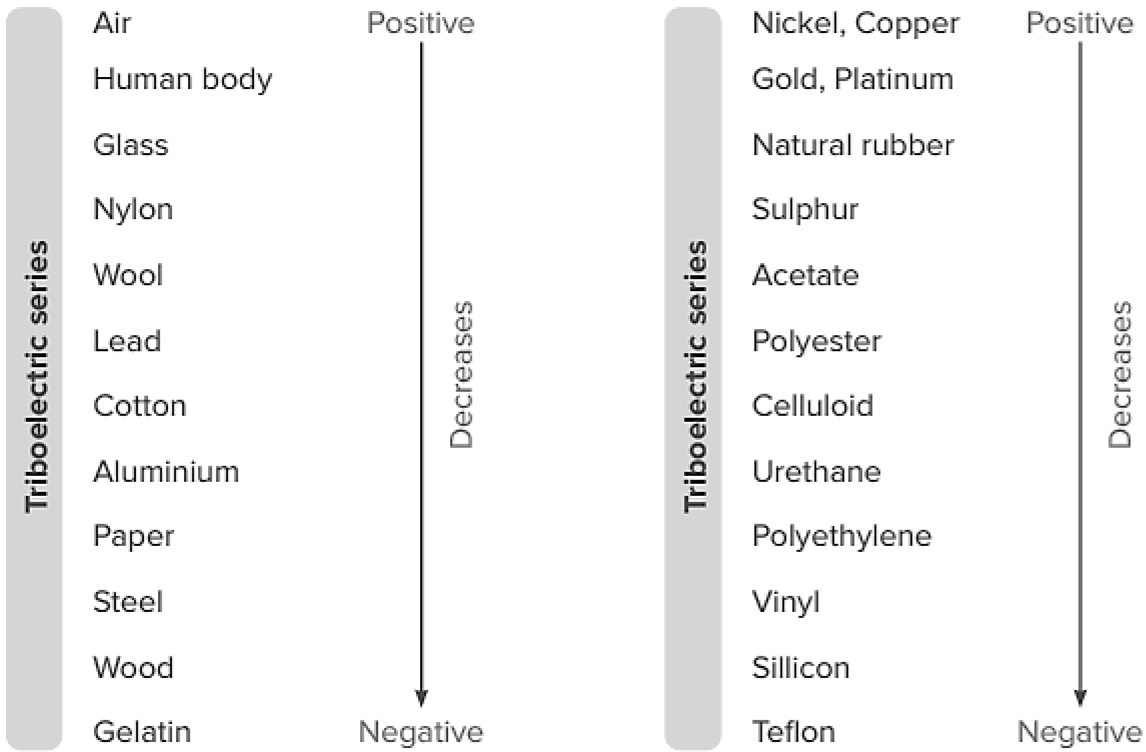
1. When two glass rods are charged by charge *A* and brought close to one another, they Repel each other.
2. When two plastic rods are charged by charge B and brought close to one another, they Repel each other.
3. When one glass rod is charged by charge A and one plastic rod is charged by charge B, And they are brought close to one another, they attract each other.

From these observations, it can also be concluded that **there are two types of charges and Charges of the same type repel each other, whereas charges of different types attract each Other.** Later, these two kinds of charges were denoted by positive and negative charges.

Do you wonder why glass was rubbed with only silk cloth? Why not any other rod or any Other cloth? How does the rod get charged by rubbing it with a cloth? When two materials are rubbed, it seems that the friction between the objects produces the charge. However, that is not the case. When two objects come in contact, a transfer of charge occurs. Some materials attract negative charges (electrons), while other materials cannot wait to lose the Negative charges, thereby obtaining the positive charges (protons).

Triboelectric series:

Materials that attract charge and materials that want to lose charge are listed in a series Known as the triboelectric series. The series is listed as follows:

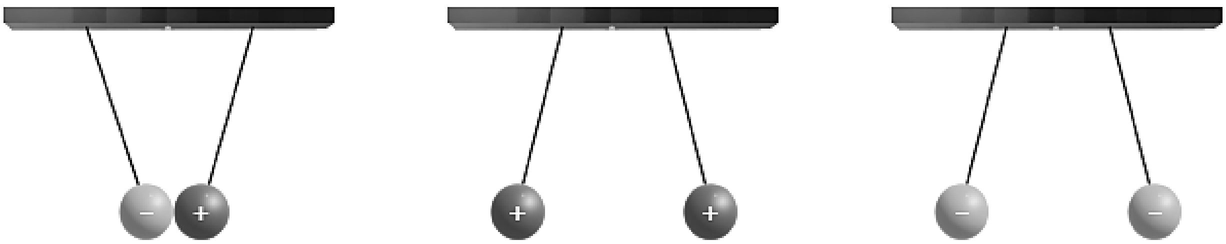


The conclusions that one gets from the triboelectric series are the following:

1. as one goes down the series, the capability of accepting the electron by the material Increases and therefore, it gets negatively charged. As one goes up the series, the Capability of donating the electron by the material increases and therefore, it gets Positively charged.
2. Farther apart are the substances in this series, easier it is for them to transfer the Charges between them.

Properties of Charge:

1. Like mass, charge is an inherent property of matter.
2. There are two types of charges: positive and negative. Like charges repel and unlike Charges attract each other.



3. **Conservation of charge:** Just like energy, the net charge of an isolated system remains Constant throughout any process. In other words, charge can neither be created nor be destroyed.
4. **Relativistic invariance:** Charges obey relativistic invariance. It means the quantity and quality of charge is independent of the frame of reference. No matter how fast or slow the frame of reference is moving, the quantity and quality of the charge remain the same. If there is one electron in a frame of reference moving with the speed of light, the value of the charge (–1.6 ×10–19 *C*) remains unchanged.
5. **Quantisation of charge:** All free charges are integral multiples of a basic unit of charge denoted by *e*. Therefore, the net change on a body is always, Q = ne, where n is any integer. The basic unit of charge 'e' can either be positive or negative. By convention, the Charge on an electron is taken as negative.
6. **Charges obey algebraic addition.** Example: Suppose there are three protons and five electrons in an object. Therefore, we have, $n_p = 3$, and $n_e = 5$ and hence, the net charge in the object is,

$$Q = \text{Charge of protons} + \text{Charge of electrons}$$

$$Q = n_p\,(+e) + n_e\,(-e)$$

$$Q = 3e + (-\,5e)$$

$$Q = -2e$$

Unit of charge:

SI unit of charge: Coulomb

Standard symbol: C

Charge of an electron, $e^- = -1e = -1.6 \times 10^{-19}$ C

Charge of a proton, $p^+ = +1e = 1.6 \times 10^{-19}$C