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# Theory of Dielectric - Piezo Electric Effect; Van de Graaff Generator

## Polarisation of a dielectric:

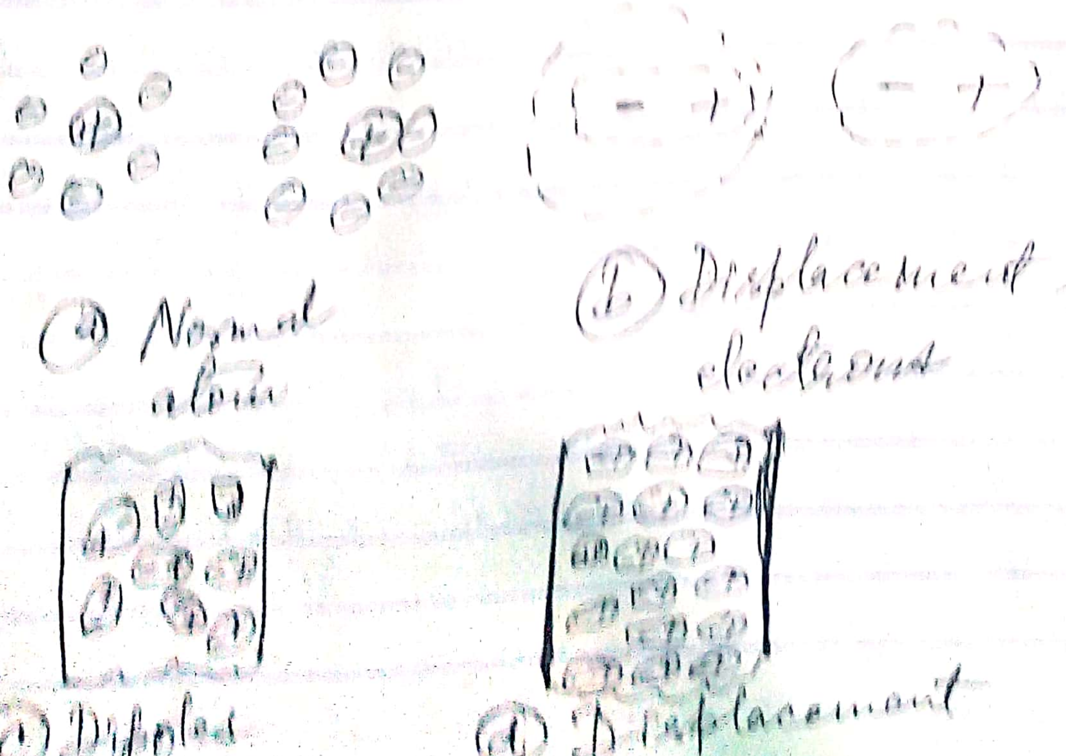


Fig. (1)

The dielectric plays an important part in the subject of electrostatics. Although an elementary idea of the difference between insulators (or dielectrics) and conductors is that dielectrics gets polarized whereas conductors not.

In conductors there is an abundance of conduction or free electrons lying in the inter-atomic and inter-molecular spaces which, under the slightest electric force, begin to move. Even if some electrons may not be quite free from their atom, their bond is so weak that they are easily separated from the atom. The electrons of the atoms of a dielectric, however, are rigidly bound to the atoms and, therefore, they do not move appreciably from their position under electric stresses. In other words, the protons and electrons in a dielectric donot part company unless the electric strain reaches the breaking point. While conduction current is due to the actual drift of electrons, the displacement current is due to displacement of electric charges in the atoms of a dielectric.

Consider an isotropic dielectric placed between two metallic plates, thus forming a condenser, and let these plates be connected to a battery and a key. In a neutral or normal atom the centre of gravity of electrons and that of protons in the atom (or negatively charged and positively charged ends of molecules) of the dielectric coincide. When the key is closed, the electrons and protons get displaced through about $10^{-9}$ cm; their centres of gravity are also displaced and the atoms (and molecules) of the dielectric become oriented, so that the lines joining the separated charges within the atoms (and molecules) lie in the direction of the field, Fig. ①. Each atom of the dielectric becomes an "electric dipole" or an "electric doublet" and the dielectric is said to be "polarised". Similar is the case with the molecules. In molecules in which the centres of gravity of electrons and protons coincide, are called non-polar, e.g.; $H_2$; in others, such as those of water, their charges, and therefore, the centres of gravity are permanently displaced, and are known as "polar molecules," (CChange is a symmetrical). Polar molecules have permanent dipole moment.

Thus under the action of the electric field the electric charges are oriented throughout the dielectric, electrons move towards the +ive plate, and protons move towards the -ive plate. This displacement of the charges producing dipoles, or the reorientation of the polar molecules in an isotropic medium, is proportional to the electric force and takes place in the direction of this force. The phenomenon is called the electric polarisation; the medium is said to be polarised, and the electric charges bound to the molecules are called polarisation charges. The induced surface density of these charges measures the amount of polarisation.

If $\sigma_p$ is the surface density of charge on a block of the dielectric which has been polarised, the block has an electric moment analogous to the moment of a magnet. The average (vector sum of atomic and molecular) induced electric dipole moment per unit volume of the dielectric is called the polarisation of dielectric, and is represented by P. P may be defined as the amount of induced surface charge per unit area, or the surface density of the fictitious charges appearing at right angles to the applied field. If n = number of dipoles per unit volume, then $P = nd\epsilon_0 E$ where E = applied field. d is the distance between the -ve & +ve charges.

Thus $P = q_p/A = \sigma_p$; where $q_p$ is

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the induced charge and

A = area of the surface of the dielectric.

P is a vector quantity, and is directed from -ve to +ve induced charge.