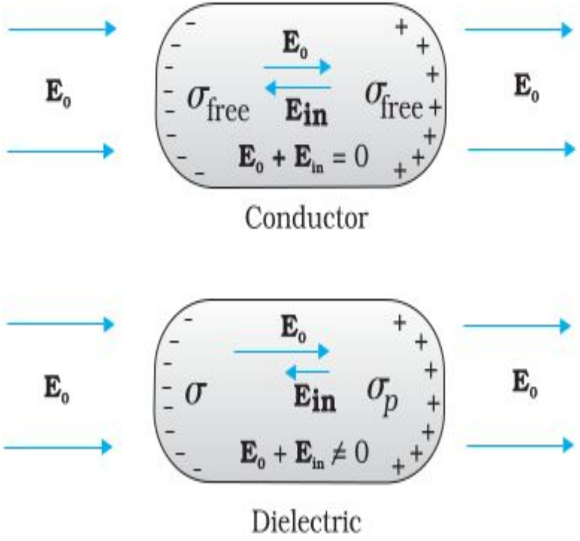
DIELECTRICS AND POLARISATION

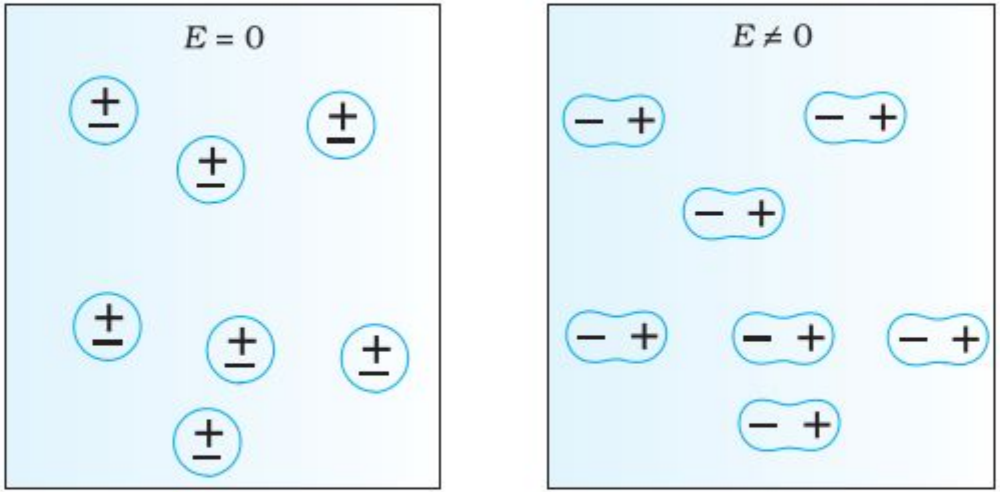
Dielectrics are non-conducting substances. In contrast to conductors, they have no (or negligible number of) charge carriers



The free charge carriers move and charge distribution in the conductor adjusts itself in such a way that the electric field due to induced charges opposes the external field within the conductor. This happens until, in the static situation, the two fields cancel each other and the net electrostatic field in the conductor is zero.

In a dielectric, this free movement of charges is not possible. It turns out that the external field induces dipole moment by stretching or re-orienting molecules of the dielectric.

Unlike in a conductor, in an external electric field. however, the opposing field so induced does not exactly cancel the external field. It only reduces it.

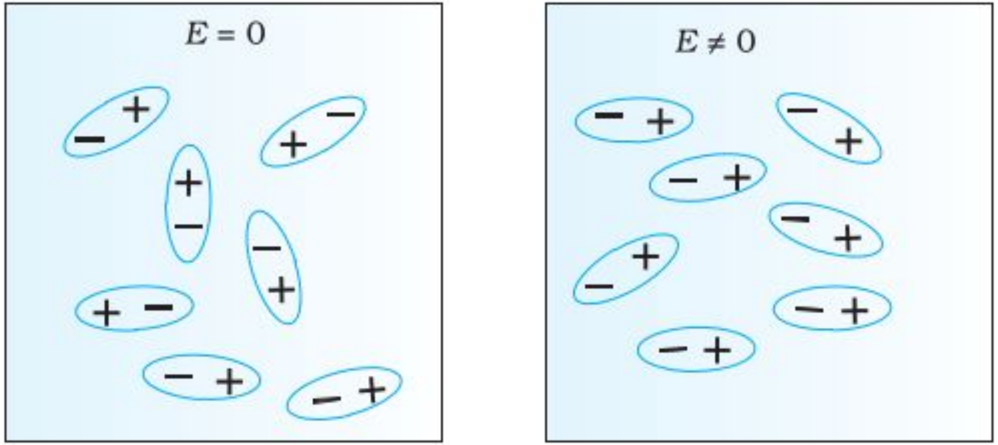


(a) Non-polar molecules

In an external electric field, the positive and negative charges of a non-polar molecule are displaced in opposite directions.

The non-polar molecule thus develops an induced dipole moment. The dielectric is said to be polarised by the external field.

The induced dipole moments of different molecules add up giving a net dipole moment of the dielectric in the presence of the external field



(b) Polar molecules

A dielectric with polar molecules also develops a net dipole moment in an external field, but for a different reason.

In the absence of any external field, different permanent dipoles are oriented randomly due to thermal agitation; so the total dipole moment is zero.

When an external field is applied, the individual dipole moments tend to align with the field.

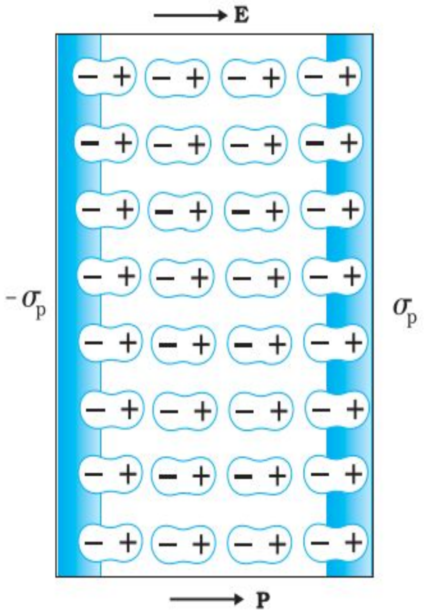
When summed over all the molecules, there is then a net dipole moment in the direction of the external field, i.e., the dielectric is polarised.

Thus in either case, whether polar or non-polar, a dielectric develops a net dipole moment in the presence of an external field.

The dipole moment per unit volume is called polarisation and is denoted by P. For linear isotropic dielectrics

$$P = \chi_e E$$

where χ_e is a constant characteristic of the dielectric and is known as the electric **susceptibility** of the dielectric medium



The polarised dielectric is equivalent to two charged surfaces with induced surface charge densities, say $\boldsymbol{\sigma_p}$ and $-\boldsymbol{\sigma_p}$.

Clearly, the field produced by these surface charges opposes the external field. The total field in the dielectric is, thereby, reduced from the case when no dielectric is present.