What is Dipole Moment?

A dipole moment arises in any system in which there is a separation of charge. They can, therefore, arise in ionic bonds as well as in covalent bonds. Dipole moments occur due to the difference in electronegativity between two chemically bonded atoms.

A bond dipole moment is a measure of the polarity of a chemical bond between two atoms in a molecule. It involves the concept of electric dipole moment, which is a measure of the separation of negative and positive charges in a system.

The bond dipole moment is a vector quantity since it has both magnitude and direction. An illustration describing the dipole moment that arises in an HCl (hydrochloric acid) molecule is provided below.

$$\overset{\delta^+}{H}\text{---}\overset{\delta^-}{Cl}$$

It can be noted that the symbols δ^+ and δ^- represent the two electric charges that arise in a molecule which are equal in magnitude but are of opposite signs. They are separated by a set distance, which is commonly denoted by 'd'.

Important Points

- The dipole moment of a single bond in a polyatomic molecule is known as the bond dipole moment and it is different from the dipole moment of the molecule as a whole.

- It is a vector quantity, i.e. it has magnitude as well as definite directions.

- Being a vector quantity, it can also be zero as the two oppositely acting bond dipoles can cancel each other.

- By convention, it is denoted by a small arrow with its tail on the negative center and its head on the positive center.

- In chemistry, the dipole moment is represented by a slight variation of the arrow symbol. It is denoted by a

- In the case of a polyatomic molecule, the dipole moment of the molecule is the vector sum of the all present bond dipoles in the molecule.

Dipole Moment Formula

A dipole moment is the product of the magnitude of the charge and the distance between the centers of the positive and negative charges. It is denoted by the Greek letter 'μ'.

Mathematically,

Dipole Moment (μ) = Charge (Q) * distance of separation (r)

It is measured in Debye units denoted by 'D'. $1 D = 3.33564 \times 10^{-30}$ C.m, where C is Coulomb and m denotes a meter.

The bond dipole moment that arises in a chemical bond between two atoms of different electronegativities can be expressed as follows:

$$\mu = \delta.d$$

Where: μ is the bond dipole moment,

δ is the magnitude of the partial charges δ^+ and δ^-,

And d is the distance between δ^+ and δ^-.

The bond dipole moment (μ) is also a vector quantity, whose direction is parallel to the bond axis. In chemistry, the arrows that are drawn in order to represent dipole moments begin at the positive charge and end at the negative charge.

When two atoms of varying electronegativities interact, the electrons tend to move from their initial positions to come closer to the more electronegative atom. This movement of electrons can be represented via the bond dipole moment.