DUAL NATURE OF RADIATION

WAVE NATURE OF MATTER

DE-BROGLIE WAVELENGTH OF MATTER WAVE

The energy of a photon with frequency v and wavelength λ is given by the expression:

$$E = hv = \frac{hc}{\lambda}$$

According to Einstein's energy-mass relation, the equivalent mass E = mc ^{2} of a photon is determined by the equation:

$$m = \frac{E}{c^2} = \frac{hv}{c^2} = \frac{h}{\lambda c} \qquad \text{... (i)}$$

Or $\lambda = \frac{h}{mc}$ $\lambda = \frac{h}{p}$ ... (ii)

In analogy with the concept proposed by de Broglie, a particle of mass m traveling at speed v exhibits wave-like characteristics, specifically manifesting as waves with a wavelength denoted as λ (termed the de Broglie wavelength). Mathematically, this can be expressed as:

$$\lambda = \frac{h}{mv} = \frac{h}{p} \qquad \text{... (iii)}$$

The momentum p of a particle is connected to its kinetic energy through the equation:

$$P = \sqrt{2km}$$

And a charge q when accelerated by a potential difference V gains a kinetic energy K = qV
Combining all these relations Eq. (iii), can be written as,

$$\lambda = \frac{h}{mv} = \frac{h}{p} = \frac{h}{\sqrt{2km}} = \frac{h}{\sqrt{2qvm}} \qquad \text{... (iv)}$$

The de-Broglie wavelength for an electron, which possesses a charge e and is subjected to acceleration through a potential V, resulting in the acquisition of kinetic energy, can be expressed as follows:

K = eV

By substituting the values of Planck's constant (h), mass (m), and charge (q) into Equation (iv), we obtain a straightforward formula for determining the de-Broglie wavelength of an electron:

$$\lambda\left(in\ \mathring{A}\right)=\sqrt{\frac{150}{V\left(in\ volts\right)}}$$

DE-BROGLIE WAVELENGTH OF A GAS MOLECULE:

Let's examine a gas molecule at an absolute temperature T. The kinetic energy of the gas molecule is expressed as:

$$K.E.=\frac{3}{2}KT\ ;\ K = Boltzman\ cons\tan t$$

$$\lambda_{gas\ molecules}=\frac{h}{\sqrt{2mkT}}$$