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* **Wave Particle Duality:** It is well known that can exhibit the phenomenon of interference, diffraction, and polarisation which, can only be explained by the wave nature of light or electromagnetic radiation. These phenomenon prove that light is of wave nature

Frank - Hertz experiment show that the energy of electromagnetic wave is absorbed or emitted in disrete quanta or photons which move with velocity of light.

The two specific phenomenon, the photoelectric effect and the compton effect give evidence that the photon be haves like particle

De - Broglie Wavelength: According to De-Broglie a moving particle whatsever its nature, have wave properties associated with it. The wavelength $\lambda$ associated with any moving particle of mass $m$ and velocity $v$ is given by

$$\lambda = \frac{h}{mv} \quad \text{—} \; (1) \quad \Rightarrow \lambda = \frac{h}{p}$$

and kinetic energy of the particle is

$$E = \frac{1}{2}mv^2 = \frac{p^2}{2m} \quad \text{—} \; (2)$$

$(p = mv)$

$$p = \sqrt{2mE}$$

Thus equation (1) becomes:

$$\lambda = \frac{h}{\sqrt{2mE}} \quad \text{—} \; (3)$$

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If a charged particle carrying charge $q$ is accelerated through a potential difference of $V$ volts, then De-Broglie wavelength,

$$\lambda = \frac{h}{\sqrt{2qmV}} \quad \text{— (4)}$$

Kinetic energy at absolute temperature $T$

$$E = \cancel{\frac{1}{m}} \frac{1}{2} m v^2 = \frac{3}{2} KT$$

Thus equation (3) becomes

$$\lambda = \frac{h}{\sqrt{3mKT}}$$

$K$ - Boltzmann constant.

* Properties of Matter waves:

(1) The De-Broglie wavelength of a wave associated with moving light particle is greater than that of heavier particles.

(2) De-Broglie wave length of wave associated with a slow moving particle is greater than the wavelength associated with fast moving particle

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③ For a particle at rest, i.e. $v=0$, the De-Broglie wavelength becomes infinite and if $v=\infty$ then $\lambda=0$. Thus the matter waves are generated only when the material particle is motion.

④: The expression for De-Broglie wavelength $\lambda=\frac{h}{mv}$ is independent of charge of the particle, therefore matter wave are generated by moving charge particles

⑤ The velocity $v$ of the matter wave is greater than the velocity of the electromagnetic wave, i.e the velocity of light. It may be shown as

$$E = h\nu \quad \text{—— ①}$$

Energy of particle mass $m$,

$$E = mc^2 \quad \text{—— ②}$$

$$\therefore \quad h\nu = mc^2 \Rightarrow \nu = \frac{mc^2}{h} \quad \text{—— ③}$$

wave velocity . $\omega = \nu\lambda$ $\qquad \lambda = h/mv$

$\qquad \& \ \nu = \frac{mc^2}{h}$

$$\therefore \quad \omega = \frac{mc^2}{h} \cdot \frac{h}{mv}$$

$$\boxed{\omega = c^2/v}$$

As the particle velocity $v$ is always less than the velocity of light, it follows that velocity of propagation of associated matter wave is greater than the ~~c~~ velocity of light.