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Matter waves-wave nature of particles, de-Broglie relation

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 11
CHAPTER NAME : Dual Nature of Radiation and Matter

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LEARNING OUTCOME

- Understand the concept matter wave.
- Understand the de Broglie wave relation.

Matter Wave

The waves associated with material particles in motion are called matter or de Broglie waves and their wavelength is called de Broglie wavelength.

de Broglie's wave equation

$$\lambda = \frac{h}{mc} = \frac{h}{p}$$

From de-Broglie's equation, we find that

1. $\lambda \propto 1/p$
2. If v =0, then $\lambda = \infty$. This implies that waves are associated with material particles only when they are in motion.
3. To be associated with a de Broglie wave, a particle need not have a charge. That is why, de-Broglie waves are also known as matter waves.
4. de-Broglie waves cannot be electromagnetic in nature because electromagnetic waves are only associated with accelerated charged particles.

Numerical

- What is the de Broglie wavelength associated with (i) an electron moving with a speed of 5.4 $\times 10^6$m/s and (ii) a ball of mass 1.50 g travelling at 30.0 m/s ?

De-broglie Wavelength of an electron

de-Broglie wavelength,

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mK}}.$$

de-Broglie wavelength of an electron beam accelerated through a potential difference of V volts is

$$\lambda = \frac{h}{\sqrt{2meK}} = \frac{1.23}{\sqrt{V}} \text{ nm}$$

Numerical

- An electron and a proton are accelerated through the same potential. Which one of the two has (i) greater value of de-Broglie wavelength associated with it and (ii) less momentum ? Justify your answer.
- An electron, α-particle and a proton have the same kinetic energy. Which of these particles has the shortest de-Broglie wavelength ?
- A photon and a proton have the same de Broglie wavelength. Show, by actual calculations, which has more kinetic energy.

THANKING YOU

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