

Unit I: Assessment: Q & A CL6

CL6_Q1. What are matter waves? State De-Broglie hypothesis.

Answer

Waves associated with material particles in motion are called matter waves or de-Broglie waves.

De-Broglie in his study, assuming that what is true with energy (X-ray/light) is also true with matter and put forward a hypothesis stating that like light, matter also has a wave-particle dual nature. He proposed that all particles in motion behave as waves. This is known as de-Broglie hypothesis.

The wavelength of a moving particle is given by

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

Where h is the Planck's constant and p is the momentum of moving particles.

CL6_Q2. Why is the wave nature of matter not apparent for macroscopic particles?

Answer

According to de-Broglie hypothesis a moving body is associated with matter waves and the wavelength of the waves is given by

$$\lambda = \frac{h}{mv}$$

Where 'v' is the velocity with which the body moves.

As the mass 'm' of the body increases, the wavelength tends to be insignificant. Therefore, the wavelength associated with macroscopic bodies become insignificant in comparison to the size of the bodies themselves even at very low

Unit I: Assessment: Q & A CL6

velocities. Because of the smaller magnitude of Planck's constant h , the wavelength λ will be significant only in the case of micro-particles.

CL6_Q3. The mass of the oxygen molecule is 5.4×10^{-26} kg. If this molecule moves with a speed of 500 m/s, calculate the de-Broglie wavelength associated with the molecule?

Answer

Given: Mass of the oxygen molecule $m = 5.4 \times 10^{-26}$ kg

$$V = 500 \text{ m/s}$$

We know that the de-Broglie wavelength is given by

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$
$$\lambda = \frac{6.626 \times 10^{-34}}{5.4 \times 10^{-26} \times 500}$$
$$\lambda = 2.45 \times 10^{-11} \text{ m}$$

CL6_Q4. A Proton and an alpha particle are accelerated by the same potential difference. Assume the mass of alpha particle to be four times the mass of protons. What will be the ratio of the de-Broglie wavelengths associated with them?

Answer

The charge of proton is 'e' and that of an alpha- particle is $2e$. Also $m_\alpha \approx 4m_p$

$$\text{For proton, } \lambda_p = \frac{h}{\sqrt{2m_p eV}}$$

$$\text{For alpha particle, } \lambda_\alpha = \frac{h}{\sqrt{2(4m_p)(2e)V}}$$

$$\therefore \frac{\lambda_p}{\lambda_\alpha} = \frac{h}{\sqrt{2m_p eV}} \times \frac{\sqrt{2(4m_p)(2e)V}}{h} = \sqrt{8} = 2\sqrt{2}$$

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