



DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J-Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module 3

Solving Problems





A neutron of mass 1.675×10^{-27} Kg is moving with a kinetic energy 10 keV. Calculate the De-Broglie wavelength associated with it.

Given data Mass of the neutron = 1.675×10^{-27} kg Kinetic energy = $10 \text{ keV} = 10 \times 10^3 \text{ eV}$ = $10 \times 10^3 \times 1.6 \times 10^{-19}$ J Planck's constant h = 6.625×10^{-34} Js





Solution: We know that $\lambda = \frac{h}{\sqrt{2mE}}$ Substituting the given values, we have $= \frac{6.625 \times 10^{-34}}{\sqrt{2 \times 1.675 \times 10^{-27} \times 10 \times 10^3 \times 1.6 \times 10^{-19}}}$

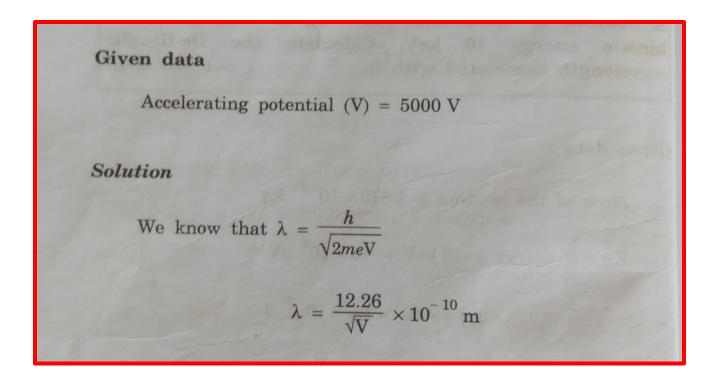
$$= \frac{6.625 \times 10^{-34}}{\sqrt{5.36 \times 10^{-42}}}$$

$$\lambda = 2.862 \times 10^{-13} \,\mathrm{m}$$





An electron at rest is accelerated through a potential of 5000 V. Calculate de-Broglie wavelength of matter wave associated with it.







Substituting the given values, we have
$$\lambda = \frac{12.26 \times 10^{-10}}{\sqrt{5000}}$$

$$\lambda = \frac{12.26 \times 10^{-10}}{70.71}$$

$$\lambda = 0.173 \times 10^{-10} \text{ m}$$

$$\lambda = 0.173 \text{ Å}$$



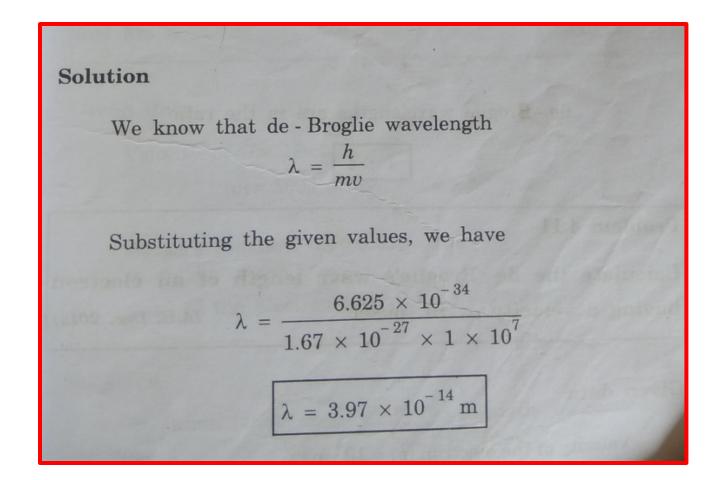


Calculate de- Broglie's wavelength associated with a proton moving with a velocity equal to one-thirtieth of velocity of light.

Given data Velocity of the proton $v = \frac{1}{30} \times \text{velocity of light}$ $=\frac{1}{30}\times 3\times 10^8 \text{ ms}^{-1}$ $= 1 \times 10^7 \text{ ms}^{-1}$ Mass of the proton $m = 1.67 \times 10^{-27} \text{ kg}$ Planck's constant $h = 6.625 \times 10^{-34} \,\mathrm{J s}$











If the momentum of two particles are in the ratio 1: 0.25, compare their de-Broglie wavelengths.

de-Broglie wavelengths associated with two particles of momentum in the ratio 1: 0.25 are
$$\lambda_1$$
 and λ_2
$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

$$\lambda_1 = \frac{h}{p_1}, \qquad \lambda_2 = \frac{h}{p_2}$$

$$\lambda_1 : \lambda_2$$

$$\frac{h}{p_1} : \frac{h}{p_2}$$

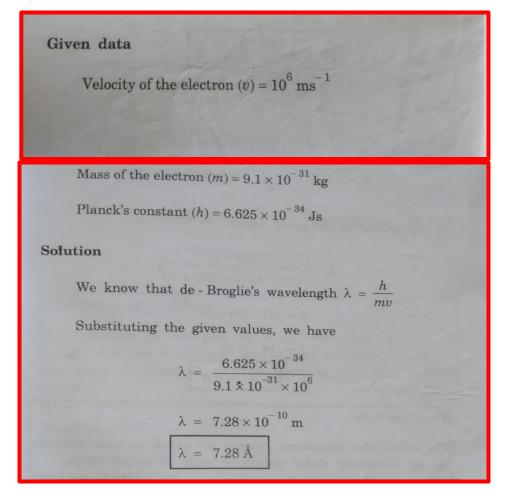
$$\frac{1}{1} : \frac{1}{0.25}$$

$$1: 4$$
 de-Broglie wavelengths are in the ratio





Calculate the de-Broglie's wavelength of an electron having a velocity of 10⁶ m/sec.







Calculate the de- Broglie's wavelength associated with an electron which travels with a velocity 500 Kms⁻¹

Given data

Velocity of the electron

$$(v) = 500 \text{ km} / \text{sec} = 500 \times 10^3 \text{ m s}^{-1}$$

Planck's constant $(h) = 6.625 \times 10^{-34} \text{ Js}$

Mass of the electron $(m) = 9.1 \times 10^{-31} \text{ kg}$





Substituting the given values, we have
$$\lambda = \frac{6.625 \times 10^{-34}}{9.1 \times 10^{-31} \times 500 \times 10^3}$$

$$\lambda = 0.00145 \times 10^{-6}$$

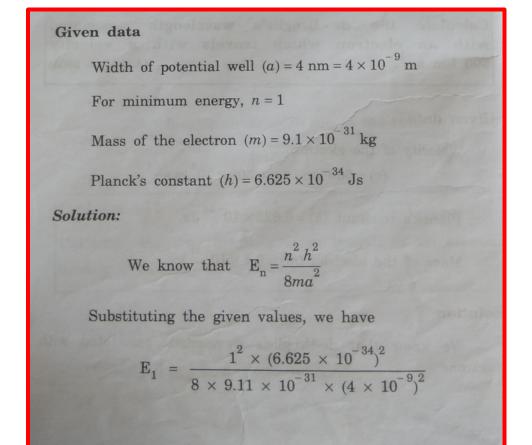
$$\lambda = 14.5 \times 10^{-10} \,\text{m}$$

$$\lambda = 14.5 \,\text{Å}$$





Calculate the minimum energy which an electron can possess in an infinitely deep potential well of width 4 nm.



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$$\mathbf{E}_{1} = 3.764 \times 10^{-21} \,\mathrm{J}$$

$$\mathbf{E}_{1} = \frac{3.764 \times 10^{-21}}{1.6 \times 10^{-19}} \,\mathrm{eV} \quad [1.1 \,\mathrm{eV} = 1.6 \times 10^{-19} \,\mathrm{J}]$$

$$\mathbf{E}_{1} = 0.024 \,\mathrm{eV}$$