Problem-solving Example 21

a) In a diffraction experiment, a electron was accelerated with a kinetic energy of 10,000 eV. Calculate the wavelength of the electron.

b) If a ball which has a mass of 200g and has the same wavelength as in (a), calculate the velocity of the ball.

Given: $1eV = 1.602 \times 10^{-19} J$; $m_e = 9.110 \times 10^{-31} kg$

$h = 6.626 \times 10^{-34} Js$

Solution

Solution :

(a) Based on De Broglie's Theory: $\lambda = \frac{h}{mv}$

Given: $E_k = \frac{1}{2}mv^2 = (10,000 \times 1.602 \times 10^{-19})\ J$

$\frac{1}{2}(9.11 \times 10^{-31}\ kg)\ V^2 = 1.602 \times 10^{-15}\ J$

$\therefore V^2 = \frac{2(1.602 \times 10^{-15})}{(9.11 \times 10^{-31})}$

$V = (3.517 \times 10^{15})^{\frac{1}{2}}$

$V = 5.930 \times 10^{7}\ ms^{-1}$

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

$= \frac{6.626 \times 10^{-34}\ Js}{(9.110 \times 10^{-31} kg)(5.930 \times 10^{7} ms^{-1})}$

$= 1.227 \times 10^{-11}\ m$

$= 1.227 \times 10^{-11} \times 10^{10}\ Å$

$\lambda = 0.1227\ Å$ (Ans)

(b) For the ball: $m = 200g = 0.2kg$

Wavelength for the ball, $\lambda = 1.227 \times 10^{-11} m$

From De Broglie's Concept:

$\lambda = \frac{h}{mv}$ OR $v = \frac{h}{m\lambda}$

$= \frac{(6.626 \times 10^{-34}\ Js)}{(0.2kg)(1.227 \times 10^{-11} m)}$

$V = 2.700 \times 10^{-22}\ ms^{-1}$

or $8.51 \times 10^{-15}\ m\ tahun^{-1}$

Or it takes 1.174 x 1012 years to travel / move a distance of 1 cm. So for the ball to move a distance of 1 cm, it takes a few billions years – not practical in our experience. Thus it is NOT possible by us to assume the ball has wave property.

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