Problem-solving Example 22

a) Calculate the velocity of the electron for the first Bohr orbit of hidrogen atom. What is the wavelength of this electron ?

b) For comparison, calculate the wavelength of a ball, weighed 200g which travelled at a velocity of $30 ms^{-1}$.

Given: $a_0 = 0.529 \text{ Å}$, $m_e = 9.110 \times 10^{-31} kg$

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

Solution

Solution :

a) Bohr's postulate :

$$mvr_n = n\frac{h}{2\pi} \quad \text{or} \quad V = \frac{nh}{2\pi m r_n}$$

At first Bohr orbit : $n = 1$; $r_n = r_1 = a_o = (0.529 \times 10^{-10})m$

Thus :

$$V = \frac{(1)(6.626 \times 10^{-34} Js)}{2\pi (9.110 \times 10^{-31} kg)(0.529 \times 10^{-10} m)}$$

$$= 2.188 \times 10^{6} ms^{-1} \text{ (Ans)}$$

From De Broglie's Theory :

$$\lambda = \frac{h}{mv} = \frac{(6.626 \times 10^{-34} Js)}{(9.110 \times 10^{-31} kg)(2.188 \times 10^{6} ms^{-1})}$$

$$= 3.324 \times 10^{-10} m$$

$$= 3.324 \text{ Å} \text{ (Ans)}$$

b) For the ball ; $m = 200g = 0.2kg$; $V = 30ms^{-1}$

$$\lambda = \frac{h}{mv} = \frac{(6.626 \times 10^{-34} Js)}{(0.2kg)(30ms^{-1})}$$

$$\lambda = 1.1 \times 10^{-34} m$$

$$= 1.1 \times 10^{-24} \text{ Å}$$ ← no instrument to detect such a very small λ.

* Wavelength properties is important only if the mass is small and travelling at very speed, v.

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