

Problem-solving Example 24

An electron moving at a speed of $5.4 \times 10^5 \text{ ms}^{-1} \pm 1.3\%$ at the second Bohr orbit ($n = 2$).
What is the uncertainty in its position, Δx ?

Solution



Solution :

Uncertainty in the speed, $\Delta u = 1.3\%$

$$\begin{aligned}\therefore \Delta u &= \frac{1.3}{100} \times 5.4 \times 10^5 \text{ m s}^{-1} \\ &= 7.0 \times 10^3 \text{ m s}^{-1}\end{aligned}$$

According to Uncertainty Principle :

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

$$\Delta x \cdot m \Delta u = \frac{h}{4\pi}$$

$$\therefore \Delta x = \frac{h}{4\pi m \Delta u} = \frac{6.626 \times 10^{-34} \text{ Js}}{4\pi (9.11 \times 10^{-31} \text{ kg}) (7.0 \times 10^3 \text{ m s}^{-1})}$$

$$= 8.3 \times 10^{-9} \text{ m}$$

$$= 82.7 \text{ \AA}$$

compare with 4.232 \AA
diameter, $d_2 = 2r_2$

$$(\because r_2 = a_0 n^2)$$

$$= (0.529)(2^2)$$

$$= 2.116 \text{ \AA}$$

$$\begin{aligned}\text{diameter} &= (2.116 \times 2) \text{ \AA} \\ (\text{till } n=2) &= 4.232 \text{ \AA}\end{aligned}$$

\therefore The uncertainty in the electron's position is about 20 times ($= 82.7/4.232$) greater than the diameter of the atom (till $n=2$). Therefore, we have no precise idea where in the atom, the electron is located.

Prepared by
V. Manoharan
ymano@usm.my
manovv1955@yahoo.com
04-6533888 ext 3566