

71. The position and momentum of a 2 MeV electron are simultaneously determined. If its position is located within 20 nm, what is the percentage of uncertainty in its momentum?

Solution: $E = 2 \text{ MeV}$

$$\Delta x = 20 \text{ nm}$$

$$\Delta p = ?$$

$$\Delta p \Delta x = \hbar$$

$$\Delta p = \frac{\hbar}{2\pi \cdot \Delta x} = \frac{1240 \text{ eV nm/c}}{2\pi \times 20 \text{ nm}}$$

$$= 9.8676 \text{ eV/c}$$

$$\Rightarrow \Delta pc = 9.8676 \text{ eV}$$

$$\text{As } E^2 = p^2 c^2 + m_0^2 c^4$$

$$\therefore p^2 c^2 = (4 - 0.25) \text{ MeV}^2$$
$$= 3.75 \text{ MeV}^2$$

$$pc = 1.93649 \text{ MeV}$$

$$\therefore \% \text{ of uncertainty in momentum} = \frac{\Delta p}{p} \times 100$$
$$= \frac{9.8676 \times 100 \text{ eV}}{1.93649 \text{ MeV}}$$

$$= \frac{986.76 \text{ eV}}{1.93649 \times 10^6 \text{ eV}}$$

$$= 5.0956 \times 10^{-4} \%$$