Chapter 34 Problem 36 †

Given

$m_e = 9.11 \times 10^{-31}\ kg$
$v = 5.0 \times 10^{7}\ m/s$
$\Delta v = \pm 10\ \%$
$h = 6.63 \times 10^{-34}\ J \cdot s$

Solution

Find the minimum uncertainty of the position.

The uncertainty of the velocity is from -10% to +10% or

$$\Delta v = 0.20(5.0 \times 10^{7}\ m/s) = 1.0 \times 10^{7}\ m/s$$

From Heisenberg's uncertainty principle

$$\Delta x \Delta p \geq \hbar$$

Rewriting momentum as velocity times mass and solving for uncertainty in position we get

$$m \Delta x \Delta v \geq \frac{h}{2\pi}$$

$$\Delta x \geq \frac{h}{2\pi m \Delta v}$$

Substituting in the provided values gives

$$\Delta x \geq \frac{6.63 \times 10^{-34}\ J \cdot s}{2\pi(9.11 \times 10^{-31}\ kg)(1.0 \times 10^{7}\ m/s)}$$

$$\Delta x \geq 1.16 \times 10^{-11}\ m$$

†Problem from Essential University Physics, Wolfson