Chapter 7 Problem 34 [†]

Given
$q_e = -1.60 \times 10^{-19}\ C$
$m_e = 9.11 \times 10^{-31}\ kg$
$\Delta V = 40\ kV = 4.0 \times 10^4\ V$

Solution
Find the velocity of electrons accelerated through this potential difference.

The potential energy change for each electron is

$$\Delta U = q_e \Delta V = (-1.60 \times 10^{-19}\ C)(4.0 \times 10^4\ V) = -6.4 \times 10^{-15}\ J$$

This loss of energy results in a gain of kinetic energy. Therefore,

$$\Delta K = 6.4 \times 10^{-15}\ J$$

If the electron is initially at rest, then

$$\Delta K = \tfrac{1}{2} m v^2$$

And the velocity is

$$v = \sqrt{\frac{2\Delta K}{m}}$$

Substituting in values gives

$$v = \sqrt{\frac{2(6.4 \times 10^{-15}\ J)}{9.11 \times 10^{-31}\ kg}} = 1.19 \times 10^8\ m/s$$

This is about 40% the speed of light. Due to relativistic effects, the actual speed would be slightly less than this.

[†]Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)