Answer on Question #45779, Physics, Electromagnetism

The electron beam in a television tube consists of electrons accelerated from rest through a potential difference of about 20 000V. What is the speed of the electrons? (Ignore relativistic effects). Electron rest mass is 9.11×10^{-31} kg and electronic charge is 1.6×10^{-19}C.

a. 8.4×10^{7} m/s
b. 3.8×10^{6} m/s
c. 6×10^{6} m/s
d. 4.7×10^{7} m/s

Solution:

Mechanical energy is the sum of the kinetic energy and potential energy of a system; that is, KE+PE = constant. A loss of PE of a charged particle becomes an increase in its KE. Here PE is the electric potential energy. Conservation of energy is stated in equation form as

$$KE_i + PE_i = KE_f + PE_f,$$

where i and f stand for initial and final conditions. As we have found many times before, considering energy can give us insights and facilitate problem solving.

We have a system with only conservative forces. Assuming the electron is accelerated in a vacuum, and neglecting the gravitational force, all of the electrical potential energy is converted into kinetic energy.

We can identify the initial and final forms of energy to be $KE_i = 0$, $KE_f = ½mv^2$, $PE_i = qV$, and $PE_f = 0$.

Entering the forms identified above, we obtain

$$qV = ½mv^2$$

We solve this for v:

$$v = \sqrt{\frac{2qV}{m}}$$

Entering values for q, V, and m gives

$$v = \sqrt{\frac{2(1.6\times10^{-19}\text{C})(20000\ V)}{9.11\times10^{-31}}} = 8.38\ \times\ 10^{7}\ \text{m/s}$$

Answer: a. 8.4×10^{7} m/s.