Name: Key

Practice - 19.1 Electric Potential Energy: Potential Difference

1. A. What is the speed of an electron starting from rest accelerated through a potential difference of 100 V? $m_e = 9.11 \times 10^{-31}$ kg

$$\Delta U = \Delta K \qquad \Delta U = q\Delta V \qquad \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2 \quad (v_0 = 0)$$

$$\Rightarrow \frac{1}{2}mv_f^2 = q\Delta V \Rightarrow v_f = \sqrt{\frac{2q\Delta V}{m}}$$

$$v_f = \sqrt{\frac{2(1.60\times10^{-19}\,C)(100\,V)}{9.11\times10^{-31}\,kg}} = \boxed{5.93\times10^{6}\,\frac{m}{s}}$$

B. What is the speed of a proton starting from rest accelerated through a potential difference of 100 V? $m_p = 1.67 \times 10^{-27}$ kg

$$v_f = \sqrt{\frac{2q\Delta V}{m}} = \sqrt{\frac{2(1.60\times10^{-19}\,C)(100\,V)}{1.67\times10^{-27}\,kg}} = \boxed{1.38\times10^{5}\,\frac{m}{s}}$$

2. An evacuated tube uses an accelerating voltage of 40.0 kV to accelerate electrons to hit a copper plate and produce x rays. What is the speed of these electrons?

$$v_f = \sqrt{\frac{2q\Delta V}{m}} = \sqrt{\frac{2(1.60\times10^{-19}\,C)(40.0\times10^{3}\,V)}{9.11\times10^{-31}\,kg}}$$

$$= \boxed{1.19\times10^{8}\,\frac{m}{s}}$$

3. A bare helium nucleus has two positive charges and a mass of 6.64×10^{-27} kg.

A. Calculate its kinetic energy in joules at 2.00% of the speed of light. $c = 3.00 \times 10^8$ m/s.

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(6.64\times10^{-27}\,\text{kg})\left(0.0200 \times 3.00\times10^{8}\,\frac{\text{m}}{\text{s}}\right)^2$$

$$= \boxed{1.20\times10^{-13}\,\text{J}} \quad 1.195\times10^{-13}\,\text{J}$$

B. What is this in electron volts? $1.00\text{ eV} = 1.60 \times 10^{-19}$ J.

$$1.20\times10^{-13}\,\text{J}\left(\frac{1.00\,\text{eV}}{1.60\times10^{-19}\,\text{J}}\right) = \boxed{7.47\times10^{5}\,\text{eV}} \quad 7.470\times10^{5}$$

$$= 747\text{ keV}$$

C. What voltage would be needed to obtain this energy?

$$K_f = U_i = qV \Rightarrow V = \frac{K}{q} = \frac{1.195\times10^{-13}\,\text{J}}{2(1.60\times10^{-19}\,\text{C})}$$

$$= \boxed{3.74\times10^{5}\,\text{V}}$$

or $U = qV$

$$\Rightarrow V = \frac{U}{q} = \frac{7.470\times10^{5}\,\text{eV}}{2e} = \boxed{3.74\times10^{5}\,\text{V}}$$