

→ Answer

Electric Potential

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$k = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$$

1. The potential energy, U , of a proton is $5 \times 10^{-18} \text{ J}$ at a certain point in an electric field. What is the electric potential, V , at this point?

$$V = \frac{U}{q} = \frac{5 \times 10^{-18} \text{ J}}{1.6 \times 10^{-19} \text{ C}} = 31.25 \text{ volts}$$

2. An object with charge $q = +2 \times 10^{-16} \text{ C}$ is located 1.0 cm from another ^{pt charge} object with charge $Q = +2 \times 10^{-10} \text{ C}$.

- a. What is the electric potential, V , at the point occupied by q ?

$$\left(\bigcirc Q \right) \xrightarrow{1 \times 10^{-2} \text{ m}} V = \frac{kQ}{r} = \frac{(8.99 \times 10^9)(2 \times 10^{-10})}{1 \times 10^{-2}} = 179.8 \text{ V}$$

- b. What is the potential energy, U , of q ?

$$V = \frac{U}{q} \quad U = qV = 3.6 \times 10^{-14} \text{ J}$$

3. What is the final velocity of an electron that started from rest and was accelerated through a potential difference of 1000 V? (electron mass = $9.11 \times 10^{-31} \text{ kg}$)

$$\begin{aligned} K_f + U_f &= K_i + U_i \\ 0 + U_f &= K_f + 0 \\ -\Delta U &= K_f \\ W = -\Delta U \\ W = qV \\ \Delta U &= q\Delta V = (1.6 \times 10^{-19})(1000) = 1.6 \times 10^{-16} \text{ J} \\ K_f &= \frac{1}{2}mv^2 \\ 1.6 \times 10^{-16} &= \frac{1}{2}(9.11 \times 10^{-31})v^2 \\ v &= 1.87 \times 10^6 \text{ m/s} \end{aligned}$$

4. A proton is located 0.80 meters from a source charge, $Q = +3 \text{ C}$. How much work is required to move the proton to a point 0.50 meters from Q ?

$\{V(r) - V(r_i)\}$
Field would do work
Proton would go
away from +ve
charge

$$\begin{aligned} V &= \frac{kQ}{r} = \frac{(8.99 \times 10^9)(3)}{0.8} = 3.37 \times 10^{10} \text{ V} \\ V &= \frac{kQ}{r} = \frac{(8.99 \times 10^9)(3)}{0.5} = 5.39 \times 10^{10} \text{ V} \end{aligned}$$

$$\begin{aligned} W &= \Delta U = q(V_f - V_i) \\ &= (1.6 \times 10^{-19})(5.39 \times 10^{10} - 3.37 \times 10^{10}) \\ \Delta U &= 3.15 \times 10^{-9} \text{ J} \\ W &= -\Delta U = -3.15 \times 10^{-9} \text{ J} \end{aligned}$$

5. An electron starts from rest and is accelerated through a potential difference of 12V.

- a. How much work was done on the electron? (express answer in J and eV) $(1.6 \times 10^{-19} \text{ J} = 1 \text{ eV})$

$$\begin{aligned} W &= q\Delta V \\ &= (1.6 \times 10^{-19})(12) \\ &= 1.92 \times 10^{-18} \text{ J} \\ &= 12 \text{ eV} \end{aligned}$$

- b. How much energy did the electron gain? (express answer in J and eV)

$$\begin{aligned} &1.92 \times 10^{-18} \text{ J} \\ &12 \text{ eV} \end{aligned}$$

- c. What is the final speed of the electron?

$$\begin{aligned} 1.92 \times 10^{-18} &= \frac{1}{2}(9.11 \times 10^{-31})v^2 \\ v &= 2.05 \times 10^6 \text{ m/s} \end{aligned}$$