Potential Difference and Electric Potential

7.4

Textbook pp. 346–354

Vocabulary

electric potential energy (E_E)   electric potential (V)   electric potential difference (ΔV)

MAIN IDEA: The change in electric potential energy depends on the electric field, the charge being moved, and the charge's displacement: $\Delta E_E = -q\varepsilon\Delta d$. For $\Delta E_E > 0$, work is done against the electric fields ($-W$), resulting in energy stored in the field. For $\Delta E_E < 0$, work is done by the electric field ($+W$) on a particle moving in the field, which typically increases the kinetic energy of the particle.

1. In a particle accelerator, ________________ becomes ________________. K/U
   (a) electric potential energy, kinetic energy
   (b) kinetic energy, electric potential energy
   (c) electric potential energy, gravitational potential energy
   (d) gravitational potential energy, kinetic energy

2. The electron gun in a cathode ray tube television is 10.0 cm long and creates an electric field of 150 N/C. An electron is accelerated through this field. What is the potential energy difference across the electron gun? T/I A

$d = 10.0\text{cm}$
$= 0.100\text{m}$
$\varepsilon = 150\text{N/C}$
$q_e = 1.602\times10^{-19}\text{C}$
$E_e = ?$

$E_e = q\varepsilon d$

$E_e = (1.602\times10^{-19}\text{C})(150\text{N/C})(0.100\text{m})$

$E_e = 2.403\times10^{-18}\text{J}$
$= 2.40\times10^{-18}\text{J}$

3. A linear accelerator accelerates electrons from rest to 10.0 % of the speed of light across a distance of 1.80 m. What is the average electric field in the accelerator? T/I A

$V_1 = 0\text{ m/s}$
$V_2 = 0.100c$
$d = 1.80\text{m}$
$q = 1.602\times10^{-19}\text{C}$
$\varepsilon = ?$

$\Delta E_k = \Delta E_e = q\varepsilon d$

$\therefore \varepsilon = \dfrac{\Delta E_k}{qd}$ but $E_{k1} = 0$, $\therefore \Delta E_k = E_{k2}$

$\varepsilon = \dfrac{E_{k2}}{qd} = \dfrac{\frac{1}{2}mv_2^2}{qd}$

$\varepsilon = \dfrac{\frac{1}{2}(9.11\times10^{-31}\text{kg})(0.100c)^2}{(1.602\times10^{-19}\text{C})(1.80\text{m})}$

$\varepsilon = 1422\text{ N/C}$

$\varepsilon = 1.42\times10^{3}\text{ N/C}$

LEARNING TIP

Electric Potential
Electric potential, or voltage, is sometimes described in elementary science or technical courses as an "electrical pressure". This concept is only useful when modelling electricity using water flow. Voltage is a measure of electrical energy per unit charge, not of force or pressure.

MAIN IDEA: The electric potential is the electric potential energy per unit charge at a given point in the electric field: $V = \frac{E_E}{q}$. The magnitude of an electric field varies with the electric potential difference and the change in position in the field: $\varepsilon = \frac{\Delta V}{\Delta d}$.

4. Which statement is true of the volt? K/U
   (a) It is a measure of force per unit charge.
   (b) It has units of joules per kilogram.
   (c) It was named after Alessandro Volta.
   (d) all of the above

5. What does electrical potential depend on? K/U
   (a) the amount of charge at a particular location in an electric field
   (b) the electric field strength at that location
   (c) the work done in creating the electric field
   (d) all of the above

6. The picture tube for a colour television of the late twentieth-century required a potential difference of about 3.00×10^4 V to operate the picture tube. How fast were electrons moving when they left the electron gun in such a tube? T/I A

$\Delta V = 3.00 \times 10^4 V$
$v_2 = ?$
$v_1 = 0\ m/s$

$\Delta E_e = \Delta E_K = E_{K2}$ $\therefore$ $V = \frac{E_e}{q} \Rightarrow E_e = qV$

$E_{K2} = qV$

$\frac{1}{2} m v_2^2 = qV$

$v_2 = \left(\frac{2qV}{m}\right)^{1/2} = \left[\frac{2(1.602\times10^{-19}C)(3.00\times10^4V)}{9.11\times10^{-31}kg}\right]^{1/2}$

$v_2 = 1.03\times10^8\ m/s$.

7. The potential difference across the terminals of a car battery is 12.0 V. How much work must the alternator do to charge the battery with 2.16×10^5 C of electrons? T/I A

$V = 12.0 V$
$W = ?$
$q = 2.16\times10^5 C$

$V = \frac{E_e}{q} \rightarrow E_e = W = Vq$

$W = (12.0V)(2.16\times10^5C)$
$= 2.59\times10^6 J$