Section 7.4: Potential Difference and Electric Potential

Tutorial 1 Practice, page 349

1. (a) Given: $\vec{\varepsilon}$ = 145 N/C [right]; $q = -1.6 \times 10^{-19}$ C; d_i = 1.5 m; d_f = 4.6 m

Required: ΔE_E

Analysis: $\Delta E_E = -q\varepsilon\Delta d$

Solution:

$$\begin{aligned}\Delta E_E &= -q\varepsilon\Delta d \\ &= -q\varepsilon(d_f - d_i) \\ &= -(-1.6\times10^{-19}\text{ C})\left(145\ \frac{\text{N}}{\text{C}}\right)(4.6\text{ m} - 1.5\text{ m}) \\ &= (1.6\times10^{-19}\ \cancel{\text{C}})\left(145\ \frac{\text{N}}{\cancel{\text{C}}}\right)(3.1\text{ m}) \\ &= 7.192\times10^{-17}\text{ N}\cdot\text{m (two extra digits carried)} \\ \Delta E_E &= 7.2\times10^{-17}\text{ J}\end{aligned}$$

Statement: The change in the electric potential energy of the electron is 7.2×10^{-17} J.

(b) Given: $v_i = 1.7 \times 10^7$ m/s; $\Delta E_E = 7.192 \times 10^{-17}$ J; $m = -9.11 \times 10^{-31}$ kg

Required: v_f

Analysis: $\Delta E_E + \Delta E_k = 0$; $\Delta E_k = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

Solution:

$$\begin{aligned}\Delta E_E + \Delta E_k &= 0 \\ \Delta E_E + \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right) &= 0 \\ \frac{1}{2}mv_f^2 &= \frac{1}{2}mv_i^2 - \Delta E_E \\ v_f &= \sqrt{\frac{2}{m}\left(\frac{1}{2}mv_i^2 - \Delta E_E\right)} \\ &= \sqrt{v_i^2 - \frac{2\Delta E_E}{m}} \\ &= \sqrt{(1.7\times10^7\text{ m/s})^2 - \frac{2(7.192\times10^{-17}\text{ J})}{(9.11\times10^{-31}\text{ kg})}} \\ &= \sqrt{(1.7\times10^7\text{ m/s})^2 - \frac{1.4384\times10^{-16}\ \cancel{\text{kg}}\cdot\frac{\text{m}}{\text{s}^2}\cdot\text{m}}{9.11\times10^{-31}\ \cancel{\text{kg}}}} \\ v_f &= 1.1\times10^7\text{ m/s}\end{aligned}$$

Statement: The final speed of the electron is 1.1×10^7 m/s.

2. Given: $q = 1.6 \times 10^{-19}$ C; $\Delta d = 0.75$ m; $\varepsilon = 23$ N/C
Required: W
Analysis: $W = q\varepsilon\Delta d$
Solution: $W = q\varepsilon\Delta d$

$$= \left(1.6\times10^{-19}\ \cancel{\text{C}}\right)\left(23\ \frac{\text{N}}{\cancel{\text{C}}}\right)\left(0.75\ \text{m}\right)$$
$$= 2.76\times10^{-18}\ \text{N}\cdot\text{m}$$
$$W = 2.8\times10^{-18}\ \text{J}$$

Statement: The work done in moving the proton 0.75 m is 2.8×10^{-18} J.

3. Given: $q = -1.6 \times 10^{-19}$ C; $\Delta E_k = +4.2 \times 10^{-16}$ J; $\Delta\vec{d} = 0.18$ m [right]
Required: $\vec{\varepsilon}$
Analysis: $\Delta E_E + \Delta E_k = 0$; $\Delta E_E = -q\varepsilon\Delta d$
Solution:

$$\Delta E_E + \Delta E_k = 0$$
$$-q\varepsilon\Delta d + \Delta E_k = 0$$
$$\Delta E_k = q\varepsilon\Delta d$$
$$\varepsilon = \frac{\Delta E_k}{q\Delta d}$$
$$= \frac{4.2\times10^{-16}\ \text{N}\cdot\cancel{\text{m}}}{\left(-1.6\times10^{-19}\ \text{C}\right)\left(0.18\ \cancel{\text{m}}\right)}$$
$$\varepsilon = -1.5\times10^{4}\ \text{N/C}$$

Since the magnitude of the electric field is negative, the direction of the electric field is in the opposite direction of the displacement.
Statement: The magnitude and direction of the electric field are as follows:
1.5×10^4 N/C [toward the left].

Tutorial 2 Practice, page 353

1. (a) Given: $\Delta V = 1.6 \times 10^4$ V; $\Delta d = 12$ cm $= 0.12$ m; $q = -1.6 \times 10^{-19}$ C; $m = 9.11 \times 10^{-31}$ kg
Required: v_f
Analysis: $\Delta E_E + \Delta E_k = 0$; $\Delta E_E = q\Delta V$; $\Delta E_k = \frac{1}{2}mv_f^{\ 2}$

$$\Delta E_E + \Delta E_k = 0$$
$$\left(q\Delta V\right) + \left(\frac{1}{2}mv_f^2\right) = 0$$
$$\frac{1}{2}mv_f^2 = -q\Delta V$$
$$v_f = \sqrt{\frac{-2q\Delta V}{m}}$$

Solution:

$$v_f = \sqrt{\frac{-2q\Delta V}{m}}$$

$$= \sqrt{\frac{-2(-1.6\times10^{-19}\text{ C})(1.6\times10^{4}\text{ V})}{9.11\times10^{-31}\text{ kg}}}$$

$$= \sqrt{\frac{(3.2\times10^{-19}\text{ }\cancel{\text{C}})\left(1.6\times10^{4}\text{ }\cancel{\text{kg}}\cdot\frac{\text{m}}{\text{s}^2}\cdot\frac{\text{m}}{\cancel{\text{C}}}\right)}{9.11\times10^{-31}\text{ }\cancel{\text{kg}}}}$$

$$v_f = 7.5\times10^{7}\text{ m/s}$$

Statement: The electrons strike the screen at a speed of 7.5×10^7 m/s.

(b) Given: $\Delta V = 1.6 \times 10^4$ V; $\Delta d = 0.12$ m

Required: ε

Analysis: $\varepsilon = \frac{\Delta V}{\Delta d}$

Solution:

$$\varepsilon = \frac{\Delta V}{\Delta d}$$

$$= \frac{1.6\times10^{4}\text{ N}\cdot\frac{\cancel{\text{m}}}{\text{C}}}{0.12\text{ }\cancel{\text{m}}}$$

$$\varepsilon = 1.3\times10^{5}\text{ N/C}$$

Statement: The magnitude of the electric field is 1.3×10^5 N/C.

2. (a) Given: $\Delta d_{XW} = 6.0$ cm = 0.060 m; $v_i = 0$ m/s; $\Delta V = 4.0 \times 10^2$ V; $q = -1.6 \times 10^{-19}$ C; $m = 9.11 \times 10^{-31}$ kg

Required: v_f

Analysis: Determine the final speed of the electron using the equation $v_f^2 = v_i^2 + 2a\Delta d$. But first calculate the acceleration of the electron using the equations $a = \frac{F_E}{m} = \frac{q\varepsilon}{m}$ and $\varepsilon = \frac{\Delta V}{\Delta d}$:

$$a = \frac{q\varepsilon}{m}$$

$$a = \frac{q}{m}\left(\frac{\Delta V}{\Delta d}\right)$$

Solution:

$$a = \frac{q}{m}\left(\frac{\Delta V}{\Delta d}\right)$$

$$= \frac{\left(1.6\times10^{-19}\ \cancel{\text{C}}\right)\left(4.0\times10^{2}\ \cancel{\text{kg}}\cdot\frac{\text{m}}{\text{s}^2}\cdot\frac{\cancel{\text{m}}}{\cancel{\text{C}}}\right)}{\left(9.11\times10^{-31}\ \cancel{\text{kg}}\right)\left(0.060\ \cancel{\text{m}}\right)}$$

$a = 1.171\times10^{15}\ \text{m/s}^2$ (two extra digits carried)

Determine the final speed of the electron as it reaches hole W:

$$v_\text{f} = \sqrt{v_\text{i}^2 + 2a\Delta d}$$

$$= \sqrt{0^2 + 2\left(1.171\times10^{15}\ \frac{\text{m}}{\text{s}^2}\right)(0.060\ \text{m})}$$

$= 1.185\times10^{7}$ m/s (two extra digits carried)

$v_\text{f} = 1.2\times10^{7}$ m/s

Solution: The speed of the electron at hole W is 1.2×10^7 m/s.

(b) Given: Δd_YZ = 6.0 cm = 0.060 m; v_i = 0 m/s; $v_\text{f} = 1.185 \times 10^7$ m/s; $\Delta V = 7.0 \times 10^3$ V; $q = -1.6 \times 10^{-19}$ C; $m = 9.11 \times 10^{-31}$ kg

Required: Δd_Z0, the distance from Z at which the speed of the electron is 0 m/s

Analysis: $a = \frac{q}{m}\left(\frac{\Delta V}{\Delta d}\right)$;

$$v_\text{f}^2 = v_\text{i}^2 + 2a\Delta d$$

$$\Delta d = \frac{v_\text{f}^2 - v_\text{i}^2}{2a}$$

Solution:

$$a = \frac{q}{m}\left(\frac{\Delta V}{\Delta d}\right)$$

$$= \frac{\left(1.6\times10^{-19}\ \cancel{\text{C}}\right)\left(7.0\times10^{3}\ \cancel{\text{kg}}\cdot\frac{\text{m}}{\text{s}^2}\cdot\frac{\cancel{\text{m}}}{\cancel{\text{C}}}\right)}{\left(9.11\times10^{-31}\ \cancel{\text{kg}}\right)\left(0.060\ \cancel{\text{m}}\right)}$$

$a = 2.049\times10^{16}\ \text{m/s}^2$ (two extra digits carried)

Determine the distance the electron travels from Y before its speed becomes 0:

$$\Delta d = \frac{v_f^2 - v_i^2}{2a}$$

$$= \frac{\left(1.185 \times 10^7 \text{ m/}\cancel{\text{s}}\right)^{\cancel{2}} - 0^2}{2\left(2.049 \times 10^{16} \text{ }\cancel{\text{m}}/\cancel{\text{s}^2}\right)}$$

$\Delta d = 0.0034$ m

Determine the distance the from Z:

$\Delta d_{Z0} = 0.060 \text{ m} - 0.0034 \text{ m}$

$\Delta d_{Z0} = 0.057$ m, or 5.7 cm

Statement: The electron changes direction 5.7 cm to the left of Z.

3. Given: $L = 8.0 \text{ cm} = 0.080 \text{ m}$; $\Delta d = 4.0 \text{ cm} = 0.040 \text{ m}$; $\vec{v}_i = 6.0 \times 10^7$ m/s [E]; $\Delta V = 6.0 \times 10^2$ V; $q = -1.6 \times 10^{-19}$ C; $m = 9.11 \times 10^{-31}$ kg

Required: $\vec{v}_f$

Analysis: There is an upward force on the electron because the negative plate is below the negatively charged electron. First, determine the magnitude of the electric field, $\varepsilon = \frac{\Delta V}{\Delta d}$. Then calculate the amount of time it takes the electron to pass through the plates, $v = \frac{\Delta d}{\Delta t}$; $v_i = \frac{L}{\Delta t}$; $\Delta t = \frac{L}{v_i}$. Then calculate the resultant velocity using the equation $v_f = \sqrt{{v_{xf}}^2 + {v_{yf}}^2}$, where the components of the final velocity are the initial velocity for v_{xf} and $v_{yf} = a_y \Delta t$, where $a_y = \frac{F_E}{m} = \frac{q\varepsilon}{m}$. Finally, calculate the angle using the inverse tangent function.

Solution:

$$\varepsilon = \frac{\Delta V}{\Delta d}$$

$$= \frac{6.0 \times 10^2 \text{ N} \cdot \frac{\cancel{\text{m}}}{\text{C}}}{0.040 \text{ }\cancel{\text{m}}}$$

$\varepsilon = 1.500 \times 10^4$ N/C (two extra digits carried)

Determine the amount of time it takes the electron to pass through the plates:

$$\Delta t = \frac{L}{v_i}$$

$$= \frac{(0.080 \text{ }\cancel{\text{m}})}{\left(6.0 \times 10^7 \text{ }\frac{\cancel{\text{m}}}{\text{s}}\right)}$$

$\Delta t = 1.333 \times 10^{-9}$ s (two extra digits carried)

Determine the upward velocity of the electron:

$$v_{yf} = \frac{q\varepsilon}{m}\Delta t$$

$$= \frac{(1.6\times10^{-19}\ \not{C})\left(1.500\times10^{4}\ \frac{\text{N}}{\not{C}}\right)}{9.11\times10^{-31}\ \text{kg}}(1.333\times10^{-9}\ \text{s})$$

$$= \frac{2.400\times10^{-15}\ \not{\text{kg}}\cdot\frac{\text{m}}{\text{s}^{\not{2}}}}{9.11\times10^{-31}\ \not{\text{kg}}}(1.333\times10^{-9}\ \not{\text{s}})$$

$v_{yf} = 3.504\times10^{6}$ m/s (two extra digits carried)

Determine the magnitude of the final velocity:

$$v_{f} = \sqrt{v_{xf}^2 + v_{yf}^2}$$

$$= \sqrt{(6.0\times10^{7}\ \text{m/s})^2 + (3.504\times10^{6}\ \text{m/s})^2}$$

$v_{f} = 6.0\times10^{7}$ m/s

Determine the direction of the final velocity (the angle north of east):

$$\tan\theta = \left(\frac{v_{yf}}{v_{xf}}\right)$$

$$\theta = \tan^{-1}\left(\frac{v_{yf}}{v_{xf}}\right)$$

$$= \tan^{-1}\left(\frac{3.504\times10^{6}\ \not{\text{m/s}}}{6.0\times10^{7}\ \not{\text{m/s}}}\right)$$

$\theta = 3.3°$

Statement: The final velocity of the electron is 6.0×10^7 m/s [E 3.3° N].

Section 7.4 Questions, page 354

1. (a) Given: $q = –1.6 \times 10^{–19}$ C; $V_i = 30$ V; $V_f = 150$ V

Required: ΔE_E

Analysis: $\Delta V = \frac{\Delta E_E}{q}$

$$\Delta E_E = q\Delta V$$

$$\Delta E_E = q(V_f - V_i)$$

Solution: $\Delta E_E = q(V_f - V_i)$

$$= (-1.6\times10^{-19}\ \text{C})(150\ \text{V} - 30\ \text{V})$$

$= -1.92\times10^{-17}$ J (one extra digit carried)

$\Delta E_E = -1.9\times10^{-17}$ J

Statement: The change in the electron's potential energy is a decrease of 1.9×10^{-17} J.
(b) Given: $q = -1.6 \times 10^{-19}$ C; Δd = 10 cm = 0.10 m; $\Delta E_E = -1.92 \times 10^{-17}$ J
Required: $\vec{\varepsilon}$

Analysis: $\Delta E_E = -q\varepsilon\Delta d$; $\varepsilon = -\dfrac{\Delta E_E}{q\Delta d}$. Since electrons travel from regions of low potential to regions of high potential, and electrons move against the direction of an electric field, the direction of the field will be opposite the direction of the electron.

Solution:
$$\varepsilon = -\frac{\Delta E_E}{q\Delta d}$$
$$= -\frac{-1.92\times10^{-17}\ \text{N}\cdot \cancel{\text{m}}}{(1.6\times10^{-19}\ \text{C})(0.10\ \cancel{\text{m}})}$$
$$\varepsilon = 1.2\times10^{3}\ \text{N/C}$$
Statement: The average electric field along the electron's path is -1.2×10^{3} N/C.
2. Given: Δd = 3.0 mm = 3.0×10^{-3} m; ε = 250 V/m
Required: ΔV

Analysis: $\varepsilon = -\dfrac{\Delta V}{\Delta d}$; $\Delta V = -\varepsilon\Delta d$

Solution:
$$\Delta V = -\varepsilon\Delta d$$
$$= -\left(250\ \frac{\text{V}}{\cancel{\text{m}}}\right)(3.0\times10^{-3}\ \cancel{\text{m}})$$
$$\Delta V = -0.75\ \text{V}$$
Statement: The magnitude of the electric potential difference is 0.75 V.
3. (a) Given: $q = 1.6 \times 10^{-19}$ C; V_i = 75.0 V; V_f = –20.0 V
Required: ΔE_k

Analysis:
$$\Delta V = \frac{-\Delta E_k}{q}$$
$$\Delta E_k = -q\Delta V$$
$$\Delta E_k = -q(V_f - V_i)$$
Solution:
$$\Delta E_k = -q(V_f - V_i)$$
$$= -(1.6\times10^{-19}\ \text{C})(-20.0\ \text{V} - 75.0\ \text{V})$$
$$\Delta E_k = 1.52\times10^{-17}\ \text{J}$$
Statement: The change in the proton's kinetic energy is 1.52×10^{-17} J.
(b) Given: $q = -1.6 \times 10^{-19}$ C; V_i = 75.0 V; V_f = –20.0 V
Required: ΔE_k
Analysis: $\Delta E_k = -q(V_f - V_i)$

Solution: $\Delta E_k = -q(V_f - V_i)$

$= -(-1.6 \times 10^{-19}\ \text{C})(-20.0\ \text{V} - 75.0\ \text{V})$

$\Delta E_k = -1.52 \times 10^{-17}\ \text{J}$

Statement: The change in the electron's kinetic energy is -1.52×10^{-17} J.

4. (a) Given: $q = -1.6 \times 10^{-19}$ C; $\Delta V = 45$ V

Required: W

Analysis:

$$\Delta V = \frac{\Delta E_E}{q}$$

$$\Delta E_E = q\Delta V$$

$$W = -\Delta E_E$$

$$W = -q\Delta V$$

Solution: $W = -q\Delta V$

$= -(-1.6 \times 10^{-19}\ \text{C})(45\ \text{V})$

$W = 7.2 \times 10^{-18}\ \text{J}$

Statement: The work done to push the electron is 7.2×10^{-18} J against the electric field.

(b) The electric field is doing the work.

5. (a) Electrons move from a region of low potential energy to a region of high potential energy.

(b) Given: $q = -1.6 \times 10^{-19}$ C; $\Delta V = 2.5 \times 10^{4}$ V

Required: ΔE_k

Analysis: $\Delta E_k + \Delta E_E = 0$; $\Delta E_E = -\Delta E_k$

$$\Delta V = \frac{\Delta E_E}{q}$$

$$\Delta V = \frac{-\Delta E_k}{q}$$

$$\Delta E_k = -q\Delta V$$

Solution:

$\Delta E_k = -q\Delta V$

$= -(-1.6 \times 10^{-19}\ \text{C})(2.5 \times 10^{4}\ \text{V})$

$\Delta E_k = 4.0 \times 10^{-15}\ \text{J}$

Statement: The change in one of the electron's kinetic energy is 4.0×10^{-15} J.

(c) Given: $v_i = 0$ m/s; $\Delta E_k = 4.0 \times 10^{-15}$ J; $m = 9.11 \times 10^{-31}$ kg
Required: v_f
Analysis:

$$\Delta E_k = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$
$$= \frac{1}{2}mv_f^2 - 0$$
$$v_f = \sqrt{\frac{2\Delta E_k}{m}}$$

Solution:

$$v_f = \sqrt{\frac{2\Delta E_k}{m}}$$
$$= \sqrt{\frac{2\left(4.0\times10^{-15}\ \cancel{\text{kg}}\cdot\frac{\text{m}}{\text{s}^2}\cdot\text{m}\right)}{\left(9.11\times10^{-31}\ \cancel{\text{kg}}\right)}}$$
$$v_f = 9.4\times10^{7}\ \text{m/s}$$

Solution: The final speed of the electron is 9.4×10^7 m/s.
6. Given: $\varepsilon = 2.26 \times 10^5$ N/C; $d_i = 2.55$ m; $d_f = 4.55$ m
Required: ΔV
Analysis:

$$\varepsilon = \frac{\Delta V}{\Delta d}$$
$$\Delta V = \varepsilon\Delta d$$

Solution: $\Delta V = \varepsilon\,\Delta d$

$$= \varepsilon\left(d_f - d_i\right)$$
$$= \left(2.26\times10^5\ \text{N/C}\right)\left(4.55\ \text{m} - 2.55\ \text{m}\right)$$
$$\Delta V = 4.52\times10^5\ \text{V}$$

Statement: The change in the electric potential between the points is 4.52×10^5 V.
7. (a) Given: $\varepsilon = 150$ N/C; $L = 6.0$ cm $= 0.060$ m; $v_i = 4.0 \times 10^6$ m/s; $q = -1.6 \times 10^{-19}$ C; $m = 9.11 \times 10^{-31}$ kg
Required: $\vec{v}_{yf}$
Analysis: There is an upward force on the electron because the negative plate is below the negatively charged electron. First, calculate the amount of time the electron takes to pass through the plates, $v = \frac{\Delta d}{\Delta t}$; $v_i = \frac{L}{\Delta t}$; $\Delta t = \frac{L}{v_i}$. Then determine the vertical component of the final velocity using $v_{yf} = a_y\Delta t$, where $a_y = \frac{F_E}{m} = \frac{q\varepsilon}{m}$.

Solution: Determine the amount of time it takes the electron to pass through the plates:

$$\Delta t = \frac{L}{v_\text{i}}$$

$$= \frac{(0.060\ \cancel{\text{m}})}{\left(4.0\times10^{6}\ \frac{\cancel{\text{m}}}{\text{s}}\right)}$$

$$\Delta t = 1.5\times10^{-8}\ \text{s}$$

Determine the upward velocity of the electron:

$$v_{y\text{f}} = \frac{q\varepsilon}{m}\Delta t$$

$$= \frac{\left(1.6\times10^{-19}\ \cancel{\text{C}}\right)\left(150\ \frac{\text{N}}{\cancel{\text{C}}}\right)}{9.11\times10^{-31}\ \text{kg}}\left(1.5\times10^{-8}\ \text{s}\right)$$

$$= \frac{2.400\times10^{-17}\ \cancel{\text{kg}}\cdot\frac{\text{m}}{\text{s}^{\cancel{2}}}}{9.11\times10^{-31}\ \cancel{\text{kg}}}\left(1.5\times10^{-8}\ \cancel{\text{s}}\right)$$

$$= 3.952\times10^{5}\ \text{m/s (two extra digits carried)}$$

$$v_{y\text{f}} = 4.0\times10^{5}\ \text{m/s}$$

Statement: The vertical component of the electron's final velocity is 4.0×10^5 m/s [up].

(b) Given: ε = 150 N/C; L = 0.060 m; $v_\text{i} = 4.0 \times 10^6$ m/s; $v_{y\text{f}} = 3.952 \times 10^5$ m/s; $q = -1.6 \times 10^{-19}$ C; $m = 9.11 \times 10^{-31}$ kg

Required: v_f

Analysis: Determine the magnitude of the final velocity using the equation $v_\text{f} = \sqrt{v_{x\text{f}}^2 + v_{y\text{f}}^2}$. Then use the inverse tangent ratio to determine the angle.

Solution: $v_\text{f} = \sqrt{v_{x\text{f}}^2 + v_{y\text{f}}^2}$

$$= \sqrt{\left(4.0\times10^{6}\ \text{m/s}\right)^2 + \left(3.952\times10^{5}\ \text{m/s}\right)^2}$$

$$v_\text{f} = 4.0\times10^{6}\ \text{m/s}$$

$$\tan\theta = \left(\frac{v_{y\text{f}}}{v_{x\text{f}}}\right)$$

$$\theta = \tan^{-1}\left(\frac{v_{y\text{f}}}{v_{x\text{f}}}\right)$$

$$= \tan^{-1}\left(\frac{3.952\times10^{5}\ \cancel{\text{m/s}}}{4.0\times10^{6}\ \cancel{\text{m/s}}}\right)$$

$$\theta = 5.6^\circ$$

Statement: The final velocity of the electron is 4.0×10^6 m/s [5.6° from the *x*-axis].

8. (a) Given: $\varepsilon = 20$ N/C; $d_A = 0$ m; $d_B = 4$ m
Required: ΔV
Analysis: $\varepsilon = -\frac{\Delta V}{\Delta d}$; $\Delta V = -\varepsilon \Delta d$
Solution: $\Delta V = -\varepsilon \Delta d$

$$\Delta V = -\varepsilon(d_B - d_A)$$

$$= -\left(20 \frac{V}{\cancel{m}}\right)(4 \cancel{m} - 0 \cancel{m})$$

$$\Delta V = -80 \text{ V}$$

Statement: The potential difference is –80 V.
(b) Given: $\varepsilon = 20$ N/C; $d_A = 4$ m; $d_B = 6$ m
Required: ΔV
Analysis: $\Delta V = -\varepsilon \Delta d$
Solution: $\Delta V = -\varepsilon \Delta d$

$$\Delta V = -\varepsilon(d_B - d_A)$$

$$= -\left(20 \frac{V}{\cancel{m}}\right)(6 \cancel{m} - 4 \cancel{m})$$

$$\Delta V = -40 \text{ V}$$

Statement: The potential difference is –40 V.
9. The net work done is 0 J because the points are at the same potential.
10. Given: $V = 20$ V; $q = 0.5$ C
Required: W
Analysis:

$$\Delta V = \frac{-W}{q}$$

$$W = -q\Delta V$$

Solution: $W = -q\Delta V$

$$= -(0.5 \text{ C})(20 \text{ V})$$

$$W = -10 \text{ J}$$

Statement: The amount of work done in bringing the charge to the point was 10 J.