Solutions

Each answer shows the steps, then the **result**.

2.1

- the **work done per unit positive charge** in bringing a small test charge from **infinity** to that point

2.2

- $V = Q/(4\pi\varepsilon_0 r)$

2.3

- $E_\mathrm{P} = Qq/(4\pi\varepsilon_0 r)$

2.4

- the field is the **negative of the potential gradient**: $E = -\Delta V/\Delta r$

3.1 B

- electric potential is defined as **zero** at infinity

3.2

- $V = Q/(4\pi\varepsilon_0 r)$

$$V = \frac{(9.0 \times 10^9\ \mathrm{N\ m^2\ C^{-2}})(3.0 \times 10^{-9}\ \mathrm{C})}{0.050\ \mathrm{m}} = \mathbf{540}\ \mathrm{V}$$

3.3

- $E_\mathrm{P} = Qq/(4\pi\varepsilon_0 r)$

$$E_\mathrm{P} = \frac{(9.0 \times 10^9\ \mathrm{N\ m^2\ C^{-2}})(2.0 \times 10^{-9}\ \mathrm{C})(3.0 \times 10^{-9}\ \mathrm{C})}{0.040\ \mathrm{m}} = \mathbf{1.35 \times 10^{-6}}\ \mathrm{J}$$

3.4

- near a **positive** charge the potential is **positive**; near a **negative** charge it is **negative**

3.5

(a) potential is a **scalar**, so the contributions simply add (algebraically, keeping their signs) — there are no directions to resolve

(b) $V = 0$ where the magnitudes cancel

$$\frac{5.0}{x} = \frac{2.0}{0.21\ \mathrm{m} - x}$$

$$5.0(0.21\ \mathrm{m} - x) = 2.0x \Rightarrow 1.05\ \mathrm{m} = 7.0x$$

- $x = \mathbf{0.15}$ m from A

3.6

(a) the **work done per unit positive charge** in bringing a small test charge from **infinity** to that point

(b) $V = Q/(4\pi\varepsilon_0 r)$

$$V = \frac{(8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2})(4.0 \times 10^{-12} \text{ C})}{10 \times 10^{-12} \text{ m}} \approx \mathbf{3.6} \text{ V}$$

(c) B is 30 pm away

$$V_\text{B} = \frac{(8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2})(-1.0 \times 10^{-12} \text{ C})}{30 \times 10^{-12} \text{ m}} = -0.30 \text{ V}$$

- potential is a **scalar**, so the two simply add: $V = 3.6 \text{ V} - 0.30 \text{ V} = \mathbf{3.3}$ V

(d) let the point be x from A, so it is $(40 - x)$ from B

$$\frac{4.0}{x} = \frac{1.0}{40 \text{ pm} - x}$$

$$4.0(40 \text{ pm} - x) = x \Rightarrow 160 \text{ pm} = 5.0x$$

- $x = \mathbf{32}$ pm from A

(e) **no**

- potential is a scalar and cancels there, but the fields of the two charges at that point both point in the **same direction** (away from the positive charge and towards the negative one), so they add rather than cancel