Practice 18A, p. 669

Givens

1. $q_1 = 3.0 \times 10^{-9}$ C at (0.0 cm, 0.0 cm)

$q_2 = 6.0 \times 10^{-9}$ C at (0.0 cm, 30.0 cm)

$q_3 = 4.0 \times 10^{-9}$ C at (0.0 cm, 60.0 cm)

Solutions

a. $PE_{1,2} = \dfrac{k_C q_1 q_2}{r_{1,2}} = \dfrac{(8.99 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)(3.0 \times 10^{-9}\ \text{C})(6.0 \times 10^{-9}\ \text{C})}{30.0 \times 10^{-2}\ \text{m}}$

$PE_{1,2} = 5.4 \times 10^{-7}$ J

$PE_{1,3} = \dfrac{k_C q_1 q_3}{r_{1,3}} = \dfrac{(8.99 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)(3.0 \times 10^{-9}\ \text{C})(4.0 \times 10^{-9}\ \text{C})}{60.0 \times 10^{-2}\ \text{m}}$

$PE_{1,3} = 1.8 \times 10^{-7}$ J

$PE_{2,3} = \dfrac{k_C q_2 q_3}{r_{2,3}} = \dfrac{(8.99 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)(6.0 \times 10^{-9}\ \text{C})(4.0 \times 10^{-9}\ \text{C})}{30.0 \times 10^{-2}\ \text{m}}$

$PE_{2,3} = 7.2 \times 10^{-7}$ J

$PE_{tot} = PE_{1,2} + PE_{1,3} + PE_{2,3} = (5.4 \times 10^{-7}\ \text{J}) + (1.8 \times 10^{-7}\ \text{J}) + (7.2 \times 10^{-7}\ \text{J})$

$PE_{tot} = \boxed{14.4 \times 10^{-7}\ \text{J}}$

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$\Delta V_2 = 2.5\ \text{V}$

b. $Q = C\Delta V_2 = (2.00 \times 10^{-12}\ \text{F})(2.5\ \text{V}) = \boxed{5.0 \times 10^{-12}\ \text{C}}$

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2. $A = 2.0\ \text{cm}^2$

$d = 2.0\ \text{mm}$

a. $C = \dfrac{\varepsilon_0 A}{d} = \dfrac{(8.85 \times 10^{-12}\ \text{C}^2/\text{N}\bullet\text{m}^2)(2.0 \times 10^{-4}\ \text{m}^2)}{2.0 \times 10^{-3}\ \text{m}} = \boxed{8.8 \times 10^{-13}\ \text{F}}$

$\Delta V = 6.0\ \text{V}$

b. $Q = C\Delta V = (8.8 \times 10^{-13}\ \text{F})(6.0\ \text{V}) = \boxed{5.3 \times 10^{-12}\ \text{C}}$

3. $C = 1.35\ \text{pF}$

$\Delta V = 12.0\ \text{V}$

$PE = \frac{1}{2}C(\Delta V)^2 = (0.5)(1.35 \times 10^{-12}\ \text{F})(12.0\ \text{V})^2$

$PE = \boxed{9.72 \times 10^{-11}\ \text{J}}$

4. $d = 800.0\ \text{m}$

$A = 1.00 \times 10^6\ \text{m}^2$

$E = 2.0 \times 10^6\ \text{N/C}$

a. $C = \dfrac{\varepsilon_0 A}{d} = \dfrac{(8.85 \times 10^{-12}\ \text{C}^2/\text{N}\bullet\text{m}^2)(1.00 \times 10^6\ \text{m}^2)}{800.0\ \text{m}} = \boxed{1.11 \times 10^{-8}\ \text{F}}$

b. $\Delta V = -E\Delta d$

$Q = C\Delta V = C(-E\Delta d) = (1.11 \times 10^{-8}\ \text{F})(-2.0 \times 10^6\ \text{N/C})(800.0\ \text{m}) = -18\ \text{C}$

$\boxed{Q = \pm 18\ \text{C}}$

30. $\Delta V = 12.0\ \text{V}$

$C = 6.0\ \text{pF}$

$$Q = C\Delta V = (6.0 \times 10^{-12}\ \text{F})(12.0\ \text{V}) = 7.2 \times 10^{-11}\ \text{C}$$

$$Q = \boxed{\pm 7.2 \times 10^{-11}\ \text{C}}$$

31. $\Delta V = 100.0\ \text{V}$

$Q = 400.0\ \mu\text{C}$

$$C = \frac{Q}{\Delta V} = \frac{400.0 \times 10^{-6}\ \text{C}}{100.0\ \text{V}} = \boxed{4.000 \times 10^{-6}\ \text{F}}$$

31. $\Delta V = 100.0\ \text{V}$

$Q = 400.0\ \mu\text{C}$

$$C = \frac{Q}{\Delta V} = \frac{400.0 \times 10^{-6}\ \text{C}}{100.0\ \text{V}} = \boxed{4.000 \times 10^{-6}\ \text{F}}$$

32. $C = 0.20\ \mu\text{F}$

$\Delta V = 6500\ \text{V}$

a. $Q = C\Delta V = (0.20 \times 10^{-6}\ \text{F})(6500\ \text{V}) = \boxed{1.3 \times 10^{-3}\ \text{C}}$

b. $PE = \frac{1}{2}C(\Delta V)^2 = (0.5)(0.20 \times 10^{-6}\ \text{F})(6500\ \text{V})^2 = \boxed{4.2\ \text{J}}$

2.50×10^{-3} m

$d = 1.40 \times 10^{-4}$ m

a. $C = \dfrac{\varepsilon_0 A}{d} = \dfrac{\varepsilon_0 \pi r^2}{d} = \dfrac{(8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2})(\pi)(2.50 \times 10^{-3}\ \mathrm{m}/2)^2}{1.40 \times 10^{-4}\ \mathrm{m}}$

$C = \boxed{3.10 \times 10^{-13}\ \mathrm{F}}$

$\Delta V_1 = 0.12$ V

b. $Q = C\Delta V_1 = (3.10 \times 10^{-13}\ \mathrm{F})(0.12\ \mathrm{V}) = \boxed{3.7 \times 10^{-14}\ \mathrm{C}}$

c. $PE_{electric} = \frac{1}{2}Q\Delta V_1 = (0.5)(3.7 \times 10^{-14}\ \mathrm{C})(0.12\ \mathrm{V}) = \boxed{2.2 \times 10^{-15}\ \mathrm{J}}$

$\Delta d_1 = 1.40 \times 10^{-4}$ m

d. $\Delta V_1 = E\Delta d_1$

$E = \dfrac{\Delta V_1}{\Delta d_1} = \dfrac{0.12\ \mathrm{V}}{1.40 \times 10^{-4}\ \mathrm{m}} = 860\ \mathrm{V/m}$

$\Delta d_2 = 1.10 \times 10^{-4}\ \mathrm{m} - \left(\dfrac{1.40 \times 10^{-4}\ \mathrm{m}}{2}\right) = 4.00 \times 10^{-5}\ \mathrm{m}$

$\Delta V_2 = E\Delta d_2 = (860\ \mathrm{V/m})(4.00 \times 10^{-5}\ \mathrm{m}) = \boxed{3.4 \times 10^{-2}\ \mathrm{V}}$

$Q_2 = (0.707)Q$

e. $\Delta V_3 = \dfrac{Q_2}{C}$

Because the capacitance has not changed, $\Delta V_3 = (0.707)(\Delta V_1)$.

$\Delta V_3 = (0.707)(\Delta V_1) = (0.707)(0.12\ \mathrm{V}) = \boxed{8.5 \times 10^{-2}\ \mathrm{V}}$