Chapter 24

P24.4 (a)

$$A' = (10.0\text{ cm})(30.0\text{ cm})$$
$$A' = 300\text{ cm}^2 = 0.030\,0\text{ m}^2$$
$$\Phi_{E,\,A'} = EA'\cos\theta$$
$$\Phi_{E,\,A'} = (7.80\times 10^4)(0.030\,0)\cos 180°$$
$$\Phi_{E,\,A'} = \boxed{-2.34\text{ kN}\cdot\text{m}^2/\text{C}}$$

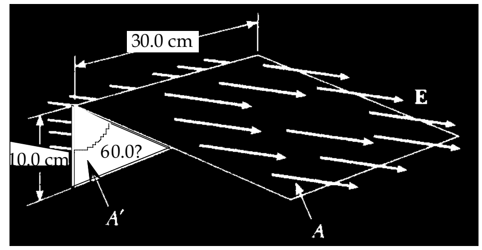

FIG. P24.4

(b)

$$\Phi_{E,\,A} = EA\cos\theta = (7.80\times 10^4)(A)\cos 60.0°$$
$$A = (30.0\text{ cm})(w) = (30.0\text{ cm})\left(\frac{10.0\text{ cm}}{\cos 60.0°}\right) = 600\text{ cm}^2 = 0.060\,0\text{ m}^2$$
$$\Phi_{E,\,A} = (7.80\times 10^4)(0.060\,0)\cos 60.0° = \boxed{+2.34\text{ kN}\cdot\text{m}^2/\text{C}}$$

(c) The bottom and the two triangular sides all lie *parallel* to **E**, so $\Phi_E = 0$ for each of these. Thus,

$$\Phi_{E,\,\text{total}} = -2.34\text{ kN}\cdot\text{m}^2/\text{C} + 2.34\text{ kN}\cdot\text{m}^2/\text{C} + 0 + 0 + 0 = \boxed{0}.$$

P24.8 The flux entering the closed surface equals the flux exiting the surface. The flux entering the left side of the cone is $\Phi_E = \int \mathbf{E}\cdot d\mathbf{A} = \boxed{ERh}$. This is the same as the flux that exits the right side of the cone. Note that for a uniform field only the cross sectional area matters, not shape.

P24.12 (a) One-half of the total flux created by the charge q goes through the plane. Thus,

$$\Phi_{E,\,\text{plane}} = \frac{1}{2}\Phi_{E,\,\text{total}} = \frac{1}{2}\left(\frac{q}{\epsilon_0}\right) = \boxed{\frac{q}{2\epsilon_0}}.$$

(b) The square looks like an infinite plane to a charge *very close* to the surface. Hence,

$$\Phi_{E,\,\text{square}} \approx \Phi_{E,\,\text{plane}} = \boxed{\frac{q}{2\epsilon_0}}.$$

(c) $\boxed{\text{The plane and the square look the same to the charge.}}$

P24.24 (a)

$$E = \frac{k_e Q r}{a^3} = \boxed{0}$$

(b)

$$E = \frac{k_e Q r}{a^3} = \frac{(8.99\times 10^9)(26.0\times 10^{-6})(0.100)}{(0.400)^3} = \boxed{365\text{ kN/C}}$$

(c)

$$E = \frac{k_e Q}{r^2} = \frac{(8.99\times 10^9)(26.0\times 10^{-6})}{(0.400)^2} = \boxed{1.46\text{ MN/C}}$$

(d)

$$E = \frac{k_e Q}{r^2} = \frac{(8.99\times 10^9)(26.0\times 10^{-6})}{(0.600)^2} = \boxed{649\text{ kN/C}}$$

The direction for each electric field is $\boxed{\text{radially outward}}$.

P24.26 (a) $E = \frac{2k_e\lambda}{r}$ $\qquad 3.60\times 10^4 = \frac{2(8.99\times 10^9)(Q/2.40)}{0.190}$

$Q = +9.13\times 10^{-7}\text{ C} = \boxed{+913\text{ nC}}$

(b) $\mathbf{E} = \boxed{0}$

P24.41 The fields are equal. The Equation 24.9 $E = \frac{\sigma_{\text{conductor}}}{\epsilon_0}$ for the field outside the aluminum looks different from Equation 24.8 $E = \frac{\sigma_{\text{insulator}}}{2\epsilon_0}$ for the field around glass. But its charge will spread out to cover both sides of the aluminum plate, so the density is $\sigma_{\text{conductor}} = \frac{Q}{2A}$. The glass carries charge only on area A, with $\sigma_{\text{insulator}} = \frac{Q}{A}$. The two fields are $\frac{Q}{2A\epsilon_0}$ the same in magnitude, and both are perpendicular to the plates, vertically upward if Q is positive.

P24.58 $\oint \mathbf{E}\cdot d\mathbf{A} = E\left(4\pi r^2\right) = \frac{q_{\text{in}}}{\epsilon_0}$

(a) $\left(-3.60\times 10^3\text{ N/C}\right)4\pi(0.100\text{ m})^2 = \frac{Q}{8.85\times 10^{-12}\text{ C}^2/\text{N}\cdot\text{m}^2}$ $\qquad (a < r < b)$

$Q = -4.00\times 10^{-9}\text{ C} = \boxed{-4.00\text{ nC}}$

(b) We take Q' to be the net charge on the hollow sphere. Outside c,

$\left(+2.00\times 10^2\text{ N/C}\right)4\pi(0.500\text{ m})^2 = \frac{Q+Q'}{8.85\times 10^{-12}\text{ C}^2/\text{N}\cdot\text{m}^2}$ $\qquad (r > c)$

$Q + Q' = +5.56\times 10^{-9}\text{ C}$, so $Q' = +9.56\times 10^{-9}\text{ C} = \boxed{+9.56\text{ nC}}$

(c) For $b < r < c$: $E = 0$ and $q_{\text{in}} = Q + Q_1 = 0$ where Q_1 is the total charge on the inner surface of the hollow sphere. Thus, $Q_1 = -Q = \boxed{+4.00\text{ nC}}$.

Then, if Q_2 is the total charge on the outer surface of the hollow sphere,

$Q_2 = Q' - Q_1 = 9.56\text{ nC} - 4.0\text{ nC} = \boxed{+5.56\text{ nC}}$.

P24.62 Consider the field due to a single sheet and let E_+ and E_- represent the fields due to the positive and negative sheets. The field at any distance from each sheet has a magnitude given by Equation 24.8:

$$|E_+| = |E_-| = \frac{\sigma}{2\epsilon_0}.$$

(a) To the left of the positive sheet, E_+ is directed toward the left and E_- toward the right and the net field over this region is $\mathbf{E} = \boxed{0}$.

(b) In the region between the sheets, E_+ and E_- are both directed toward the right and the net field is

$$\mathbf{E} = \boxed{\frac{\sigma}{\epsilon_0}\text{ to the right}}.$$

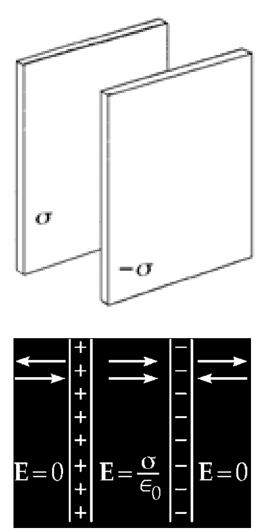

FIG. P24.62

(c) To the right of the negative sheet, E_+ and E_- are again oppositely directed and $\mathbf{E} = \boxed{0}$.

P25.4 $W = \Delta K = -q\Delta V$

$$0 - \frac{1}{2}\left(9.11\times 10^{-31}\text{ kg}\right)\left(4.20\times 10^{5}\text{ m/s}\right)^2 = -\left(-1.60\times 10^{-19}\text{ C}\right)\Delta V$$

From which, $\Delta V = \boxed{-0.502\text{ V}}$.

P25.6 $E = \dfrac{|\Delta V|}{d} = \dfrac{25.0\times 10^{3}\text{ J/C}}{1.50\times 10^{-2}\text{ m}} = 1.67\times 10^{6}\text{ N/C} = \boxed{1.67\text{ MN/C}}$