25.31 Using conservation of energy, we have $K_f + U_f = K_i + U_i$.

But $U_i = \frac{k_e q_\alpha q_{\text{gold}}}{r_i}$, and $r_i \approx \infty$. Thus, $U_i = 0$.

Also $K_f = 0$ ($v_f = 0$ at turning point), so $U_f = K_i$, or $\frac{k_e q_\alpha q_{\text{gold}}}{r_{\min}} = \frac{1}{2} m_\alpha v_\alpha^2$

$$r_{\min} = \frac{2 k_e q_\alpha q_{\text{gold}}}{m_\alpha v_\alpha^2} = \frac{2(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)(2)(79)\left(1.60 \times 10^{-19} \text{ C}\right)^2}{(6.64 \times 10^{-27} \text{ kg})(2.00 \times 10^7 \text{ m/s})^2} = 2.74 \times 10^{-14} \text{ m} = \boxed{27.4 \text{ fm}}$$

***25.26** (a) Each charge separately creates positive potential everywhere. The total potential produced by the three charges together is then the sum of three positive terms. There is **no point** located at a finite distance from the charges, where this total potential is zero.

(b) $V = \frac{k_e q}{a} + \frac{k_e q}{a} = \boxed{\frac{2 k_e q}{a}}$

25.40 Inside the sphere, $E_x = E_y = E_z = 0$.

Outside, $E_x = -\frac{\partial V}{\partial x} = -\frac{\partial}{\partial x}\left(V_0 - E_0 z + E_0 a^3 z (x^2 + y^2 + z^2)^{-3/2}\right)$

So $E_x = -\left[0 + 0 + E_0 a^3 z(-3/2)(x^2 + y^2 + z^2)^{-5/2}(2x)\right] = \boxed{3E_0 a^3 xz(x^2 + y^2 + z^2)^{-5/2}}$

$$E_y = -\frac{\partial V}{\partial y} = -\frac{\partial}{\partial y}\left(V_0 - E_0 z + E_0 a^3 z(x^2 + y^2 + z^2)^{-3/2}\right)$$

$$E_y = -E_0 a^3 z(-3/2)(x^2 + y^2 + z^2)^{-5/2}\, 2y = \boxed{3E_0 a^3 yz(x^2 + y^2 + z^2)^{-5/2}}$$

$$E_z = -\frac{\partial V}{\partial z} = E_0 - E_0 a^3 z(-3/2)(x^2 + y^2 + z^2)^{-5/2}(2z) - E_0 a^3 (x^2 + y^2 + z^2)^{-3/2}$$

$$E_z = \boxed{E_0 + E_0 a^3 (2z^2 - x^2 - y^2)(x^2 + y^2 + z^2)^{-5/2}}$$

24.34 (a) $\rho = \dfrac{Q}{\frac{4}{3}\pi a^3} = \dfrac{5.70\times10^{-6}}{\frac{4}{3}\pi(0.0400)^3} = 2.13\times10^{-2}\ \mathrm{C/m^3}$

$q_{\text{in}} = \rho\left(\frac{4}{3}\pi r^3\right) = \left(2.13\times10^{-2}\right)\left(\frac{4}{3}\pi\right)(0.0200)^3 = 7.13\times10^{-7}\ \mathrm{C} = \boxed{713\ \mathrm{nC}}$

(b) $q_{\text{in}} = \rho\left(\frac{4}{3}\pi r^3\right) = \left(2.13\times10^{-2}\right)\left(\frac{4}{3}\pi\right)(0.0400)^3 = \boxed{5.70\ \mu\mathrm{C}}$

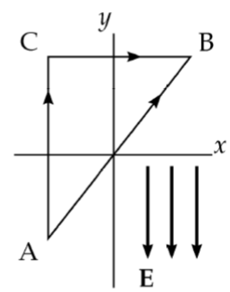
24.49 (a) $\boxed{E = 0}$

(b) $E = \dfrac{k_e Q}{r^2} = \dfrac{\left(8.99\times10^9\right)\left(8.00\times10^{-6}\right)}{(0.0300)^2} = 7.99\times10^7\ \mathrm{N/C} = \boxed{79.9\ \mathrm{MN/C}}$

(c) $\boxed{E = 0}$

(d) $E = \dfrac{k_e Q}{r^2} = \dfrac{\left(8.99\times10^9\right)\left(4.00\times10^{-6}\right)}{(0.0700)^2} = 7.34\times10^6\ \mathrm{N/C} = \boxed{7.34\ \mathrm{MN/C}}$

***25.10** $V_B - V_A = -\int_A^B \mathbf{E}\cdot d\mathbf{s} = -\int_A^C \mathbf{E}\cdot d\mathbf{s} - \int_C^B \mathbf{E}\cdot d\mathbf{s}$



$V_B - V_A = (-E\cos 180°)\int_{-0.300}^{0.500} dy - (E\cos 90.0°)\int_{-0.200}^{0.400} dx$

$V_B - V_A = (325)(0.800) = \boxed{+260\ \mathrm{V}}$

24.16 (a) $\Phi_{E,\,\text{shell}} = \dfrac{q_{\text{in}}}{\epsilon_0} = \dfrac{12.0\times10^{-6}}{8.85\times10^{-12}} = 1.36\times10^{6}\ \text{N}\cdot\text{m}^2/\text{C} = \boxed{1.36\ \text{MN}\cdot\text{m}^2/\text{C}}$

(b) $\Phi_{E,\,\text{half shell}} = \frac{1}{2}(1.36\times10^{6}\ \text{N}\cdot\text{m}^2/\text{C}) = 6.78\times10^{5}\ \text{N}\cdot\text{m}^2/\text{C} = \boxed{678\ \text{kN}\cdot\text{m}^2/\text{C}}$

(c) No, the same number of field lines will pass through each surface, no matter how the radius changes.

24.18 If $R \le d$, the sphere encloses no charge and $\Phi_E = q_{\text{in}}/\epsilon_0 = \boxed{0}$

If $R > d$, the length of line falling within the sphere is $2\sqrt{R^2 - d^2}$

so $\Phi_E = \boxed{2\lambda\sqrt{R^2 - d^2}/\epsilon_0}$

24.24 (a) $\Phi_E = \dfrac{q_{\text{in}}}{\epsilon_0}$

$8.60\times10^{4} = \dfrac{q_{in}}{8.85\times10^{-12}}$

$q_{in} = 7.61\times10^{-7}\ \text{C} = \boxed{761\ \text{nC}}$

(b) Since the net flux is positive, the net charge must be positive. It can have any distribution.

(c) The net charge would have the same magnitude but be negative.

24.26 The charge distributed through the nucleus creates a field at the surface equal to that of a point charge at its center: $E = k_e q/r^2$

$$E = \frac{(8.99\times10^{9}\ \text{Nm}^2/\text{C}^2)(82\times1.60\times10^{-19}\ \text{C})}{\left[(208)^{1/3}\ 1.20\times10^{-15}\ \text{m}\right]^2}$$

$E = \boxed{2.33\times10^{21}\ \text{N/C}}$ away from the nucleus