E27-21 The problem has cylindrical symmetry, so use a Gaussian surface which is a cylindrical shell. The $\vec{E}$ field will be perpendicular to the curved surface and parallel to the end surfaces, so Gauss' law will simplify to

$$q_{enc}/\epsilon_0 = \oint \vec{E} \cdot d\vec{A} = \int E\,dA = E \int dA = 2\pi r L E,$$

where L is the length of the cylinder. Note that $\sigma = q/2\pi r L$ represents a surface charge density.

(a) $r = 0.0410\,\text{m}$ is between the two cylinders. Then

$$E = \frac{(24.1\times10^{-6}\text{C/m}^2)(0.0322\,\text{m})}{(8.85\times10^{-12}\text{C}^2/\text{N}\cdot\text{m}^2)(0.0410\,\text{m})} = 2.14\times10^6\text{N/C}.$$

It points outward.

(b) $r = 0.0820\,\text{m}$ is outside the two cylinders. Then

$$E = \frac{(24.1\times10^{-6}\text{C/m}^2)(0.0322\,\text{m}) + (-18.0\times10^{-6}\text{C/m}^2)(0.0618\,\text{m})}{(8.85\times10^{-12}\text{C}^2/\text{N}\cdot\text{m}^2)(0.0820\,\text{m})} = -4.64\times10^5\text{N/C}.$$

The negative sign is because it is pointing inward.

E27-22 The problem has cylindrical symmetry, so use a Gaussian surface which is a cylindrical shell. The $\vec{E}$ field will be perpendicular to the curved surface and parallel to the end surfaces, so Gauss' law will simplify to

$$q_{enc}/\epsilon_0 = \oint \vec{E} \cdot d\vec{A} = \int E\,dA = E \int dA = 2\pi r L E,$$

where L is the length of the cylinder. The charge enclosed is

$$q_{enc} = \int \rho\, dV = \rho\pi L\left(r^2 - R^2\right)$$

The electric field is given by

$$E = \frac{\rho\pi L\left(r^2 - R^2\right)}{2\pi\epsilon_0 r L} = \frac{\rho\left(r^2 - R^2\right)}{2\epsilon_0 r}.$$

At the surface,

$$E_s = \frac{\rho\left((2R)^2 - R^2\right)}{2\epsilon_0 2R} = \frac{3\rho R}{4\epsilon_0}.$$

Solve for r when E is half of this:

$$\begin{aligned} \frac{3R}{8} &= \frac{r^2 - R^2}{2r}, \\ 3rR &= 4r^2 - 4R^2, \\ 0 &= 4r^2 - 3rR - 4R^2. \end{aligned}$$

The solution is $r = 1.443R$. That's $(2R - 1.443R) = 0.557R$ beneath the surface.

E27-23 The electric field must do work on the electron to stop it. The electric field is given by $E = \sigma/2\epsilon_0$. The work done is $W = Fd = Eqd$. d is the distance in question, so

$$d = \frac{2\epsilon_0 K}{\sigma q} = \frac{2(8.85\times10^{-12}\text{C}^2/\text{N}\cdot\text{m}^2)(1.15\times10^5\,\text{eV})}{(2.08\times10^{-6}\text{C/m}^2)e} = 0.979\,\text{m}$$

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