4.1 $E = V/x = 500/10^{-3} = 5\times10^{5}$ $\quad \alpha/4\pi\epsilon_0 = 0.66\times10^{-30}$

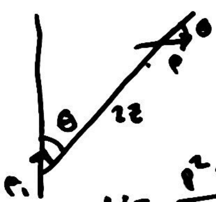
$\alpha = 4\pi(8.85\times10^{-12})(0.66\times10^{-30}) = 7.34\times10^{-41}$ $\quad p = \alpha E = qd \quad d = \alpha E/q$

$d = 7.34\times10^{-41}(5\times10^{5})/1.6\times10^{-19} = 2.29\times10^{-16}\ \text{m}$ $\quad d/R = \dfrac{2.29\times10^{-16}}{0.5\times10^{-10}} = 4.6\times10^{-6}$

$d = R \quad R = \alpha E/q = \alpha V/qx \quad V = Rqx/\alpha$

$= (0.5\times10^{-10})(1.6\times10^{-19})(10^{-3})/7.34\times10^{-41} = 10^{8}\ \text{V}$

4.6



$E_i = \dfrac{p}{4\pi\epsilon_0(2z)^3}(2\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta})$ $\quad p = p\cos\theta\,\hat{r} + p\sin\theta\,\hat{\theta}$

$N = p\times E_i = \dfrac{p^2}{4\pi\epsilon_0(2z^3)}\left((\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta})\times(\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta})\right.$

$= \quad \downarrow \quad \left(\cos\theta\sin\theta\,\hat{\phi} + 2\sin\theta\cos\theta(-\hat{\phi})\right)$

$N = \dfrac{p^2\sin 2\theta}{4\pi\epsilon_0(16z^3)}$ out $\quad = \dfrac{p^2\sin\theta\cos\theta}{4\pi\epsilon_0(2z)^3}(-\hat{\phi})$ out $\quad \sin\theta\cos\theta = (1/2)\sin 2\theta$

4.7 $W = QV(r) \quad -q, r \quad +q, r+d$

$U = qV(r+d) - qV(r) = q(V(r+d) - V(r)) = q\left(-\int_r^{r+d} E\cdot dl\right)$

$E\cdot d \quad U = -qE\cdot d = -p\cdot E \quad p = qd \quad W = Q(V(r) - V(r_0))$

$U = q(V(r+d) - V(r_0)) - q(V(r) - V(r_0)) = q(V(r+d) - V(r))$

4.10 a) $\sigma_b = P\cdot\hat{n} = kR \quad \rho_b = -\nabla\cdot P = -\frac{1}{r^2}\frac{\partial}{\partial r}(r^2 kr) = -\frac{1}{r^2}3kr^2 = -3k$

b) $r < R \quad E = \frac{1}{3\epsilon_0}\rho r\,\hat{r} \quad E = -(k/\epsilon_0)r$

$r > R \quad Q_{tot} = (kR)(4\pi R^2) + (-3k)(\frac{4}{3}\pi R^3) = 0 \quad E = 0$

4.15 a) $\rho_b = -\nabla\cdot P = -\frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{k}{r}) = -\frac{k}{r^2} \quad \sigma_b = P\cdot\hat{n} = \begin{cases} +P\cdot\hat{r} = k/b & r = b \\ -P\cdot\hat{r} = -k/a & r = a \end{cases}$

$r < a \quad E = 0 \quad r > b \quad E = 0$

$a < r < b \quad Q_{enc} = -\frac{k}{a}4\pi a^2 + \int_a^r -\frac{k}{\bar{r}^2}4\pi\bar{r}^2 d\bar{r} = -4\pi kr \quad E = -(k/\epsilon_0 r)\hat{r}$

b) $\oint D\cdot da = Q_{free} = 0 \quad D = 0 \quad D = \epsilon_0 E + P = 0 \quad E = (-1/\epsilon_0)P$

$E = 0 \quad r < a \ + \ r > b \quad E = -k/\epsilon_0 r\,\hat{r} \quad a < r < b$

4.1 a) $\oint D \cdot da = Q_{free}$ $DA = \sigma A$ $D = \sigma$

b) $D = \epsilon E$ $E = \sigma/\epsilon_1$ s_1 $E = \sigma/\epsilon_2$ s_2 $\epsilon = \epsilon_0 \epsilon_r$ $\epsilon_1 = 2\epsilon_0$

$\epsilon_2 = \frac{3}{2}\epsilon_0$ $E_1 = \sigma/2\epsilon_0$ $E_2 = 2\sigma/3\epsilon_0$

c) $P = \epsilon_0 \chi_e E$ $P = \epsilon_0 \chi_e \sigma/(\epsilon_0 \epsilon_r) = (\chi_e/\epsilon_r)\sigma$

$\chi_e = \epsilon_r - 1$ $P = (1 - \epsilon_r^{-1})\sigma$ $P_1 = \sigma/2$ $P_2 = \sigma/3$

d) $V = E_1 a + E_2 a = (\sigma a/6\epsilon_0)(3+4) = 7\sigma a/6\epsilon_0$

e) $\rho_b = 0$ $\sigma_b = +P_1$ bottom s_1 $\sigma/2$ $\sigma_b = +P_2$ bottom s_2 $\sigma/3$

$\sigma_b = -P_1$ top s_1 $-\sigma/2$ $\sigma_b = -P_2$ top s_2 $-\sigma/3$

f) above $\sigma - (\sigma/2) = \sigma/2$ $E_1 = \frac{\sigma}{2\epsilon_0}$

below $(\sigma/2) - (\sigma/3) + (\sigma/2$ ... $\sigma/2$

above $\sigma - (\sigma/2) + (\sigma/2) - \sigma/3) = 2\sigma/3$ $E_2 = \frac{2\sigma}{3\epsilon_0}$

below $\sigma/3 - \sigma = -2\sigma/3$