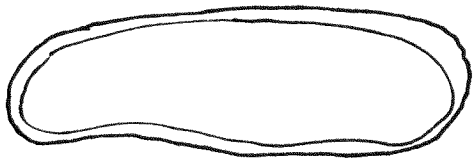
# Ch. 8 Prob. 54

$\sigma = 0.50 \times 10^{-3}\ C/m^2$

$d = 5.0 \times 10^{-9}\ m$

$K = 5.4$



a) Find the electric field ~~between~~ across the cell wall.

First $C = \frac{Q}{\Delta V} = \frac{Q}{E \cdot d}$ with a dielectric $\left(C = \frac{KQ}{E \cdot d}\right)$

Next for parallel plate capacitors $C = \frac{\varepsilon_0 A}{d}$

so $\frac{\varepsilon_0 A}{d} = \frac{KQ}{Ed} \rightarrow \varepsilon_0 A = \frac{QK}{E}$

Solve for $E \Rightarrow E = \frac{QK}{\varepsilon_0 A} = \frac{K}{\varepsilon_0}\left(\frac{Q}{A}\right)$

$$E = \frac{K\sigma}{\varepsilon_0}$$

Substitute in values gives

$$E = 5.4\,\frac{(0.50 \times 10^{-3}\ C/m^2)}{8.85 \times 10^{-12}\ C^2/N \cdot m^2} = \boxed{3.05 \times 10^7\ \frac{V}{m}}$$

b) Find the potential between the inside & outside of the cell wall.

$$\Delta V = E \cdot d = \left(3.05 \times 10^7\ \frac{V}{m}\right)(5.0 \times 10^{-9}\ m) = \boxed{0.153\ V}$$

(outside is positive charge so outside is at a higher potential.)

c) $V = 10^{-16}\ m^3$

Find the energy ~~in~~ in the cell wall.

First find the radius, assuming the cell is a sphere.

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$V = 4/3\pi r^3 \rightarrow \quad \frac{3V}{4\pi} = r^3$

$r = \sqrt[3]{\frac{3V}{4\pi}} = \sqrt[3]{\frac{3(10^{-16}m^3)}{4\pi}} = 2.88\times10^{-6}\,m$

surface area of the cell is then

$A = 4\pi r^2 = 4\pi(2.88\times10^{-6}m)^2$

$A = 1.04\times10^{-10}\,m^2$

Capacitance of the cell wall is then

$C = \frac{\kappa\varepsilon_0 A}{d} = \frac{(5.4)(8.85\times10^{-12}C^2/Nm^2)(1.04\times10^{-10}m^2)}{(5.0\times10^{-9}m)}$

$= 9.96\times10^{-13}\,F \simeq 1\,pF$

Energy in the capacitor is

$U_E = \frac{1}{2}CV^2 = \frac{1}{2}(9.96\times10^{-13}F)(0.153V)^2$

$U_E = 1.17\times10^{-14}\,J$