Physics 2220
Sept 2000

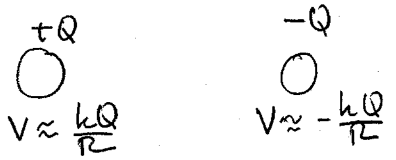
Collab # 4 Solutions

Part 1 This can be approximated as a parallel plate capacitor

$$C = \epsilon_0 A/s = 8.85\times10^{-12}\,\frac{\pi(1)^2}{10^{-3}} = 2.78\times10^{-8}\,F$$

Part 2 $U = \frac{1}{2C}Q^2 = \frac{1}{2}\frac{1}{2.78\times10^{-8}}(10^{-9})^2 = 1.8\times10^{-11}\,J$

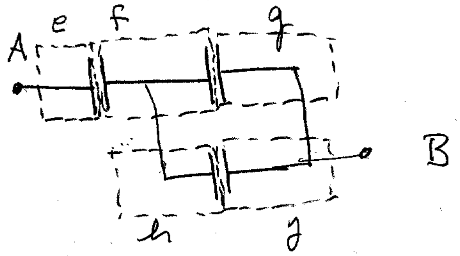
Part 3 To rough order of magnitude the answer should be the same as for spheres of radius R=1m. Consider charge ±Q on such spheres



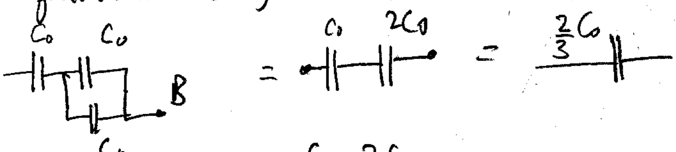
$$\Delta V = \frac{2kQ}{R} \Rightarrow C = \frac{Q}{\Delta V} = \frac{R}{2k} = \frac{1}{18\times10^{9}}$$

$$\therefore C = 5.56\times10^{-11}\,F$$

Part 4

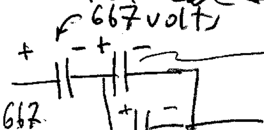


part 5 Equivalent ckts, with $C_0 = 2.78\times10^{-8}\,F$



$$C = \tfrac{2}{3}C_0 = \tfrac{2}{3}(2.78\times10^{-8}\,F) = \boxed{1.85\times10^{-8}\,F}$$

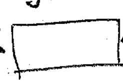
part 6 View ckt as  Then we see voltage distribution is 667 volts and 333 Volts, so



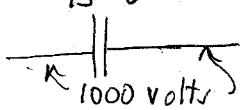
$Q = CV = 2.78\times10^{-8}\times333 = .927\times10^{-5}\,C$ (positive)

$Q = (2.78\times10^{-8})\,667$ (C, V) $= 1.85\times10^{-5}\,C$ (negative)

cylinder f

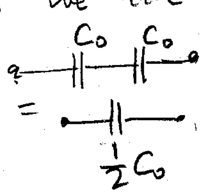


$$\therefore |Q_f| = 1.85\times10^{-5}\,C - .927\times10^{-5}\,C = \boxed{9.27\times10^{-6}\,C}$$

Prob 7
View it as 

$$U = \tfrac{1}{2}CV^2 = \tfrac{1}{3}C_0V^2 = \tfrac{1}{3}(2.78\times10^{-8})(10^3)^2 = \boxed{9.27\times10^{-3}\,J}$$

Prob 8 Without h we have



$C = \frac{1}{2}C_0$ ∴ The charge on the system is the same as in part 7

$$Q = \tfrac{2}{3}C_0(1000\,V) = 1.85\times10^{-5}\,C$$

$$\therefore U = \frac{1}{2C}Q^2 = \frac{1}{C_0}Q^2 = 1.24\times10^{-2}\,J$$

Thus work required $= \underbrace{1.24\times10^{-2}\,J}_{U \text{ without } h} - \underbrace{9.27\times10^{-3}}_{U \text{ with } h} = \boxed{3.09\times10^{-3}\,J}$