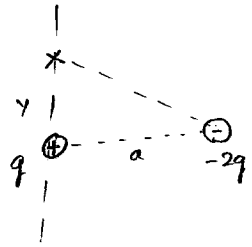
(MT-02, PHYS-203B, Fall 2015) Solutions

Prob. 1

Electric potential is a constant inside a perfect conductor, and is equal to the potential at the surface. Thus,

$$V = \frac{kQ}{R} = \frac{9.0\times10^{9} \times 1.0\times10^{-6}}{(10.0\times10^{-2}\,m)} = 9.0\times10^{4}\ \text{Volt}.$$

Prob. 2



$$V = \frac{kq}{y} - \frac{k2q}{\sqrt{a^2+y^2}} = 0$$

$$\frac{kq}{y} = \frac{k2q}{\sqrt{a^2+y^2}}$$

$$a^2 + y^2 = 4y^2$$

$$a^2 = 3y^2 \quad \Rightarrow \quad y = \pm\frac{a}{\sqrt{3}} = \pm\ 2.31\ m$$

Prob. 3

$$U = \frac{kq^2}{L} - \frac{kq^2}{L} - \frac{kq^2}{L} = -\frac{kq^2}{L}$$

$$= -\frac{9.0\times10^{9} \times (1.0\times10^{-6})^2}{(10\times10^{-2}\,m)} = -9.0\times10^{-2}\ J$$

Prob. 4

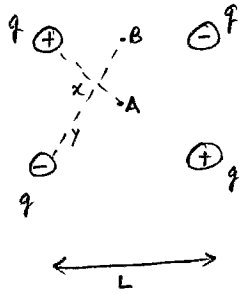
$$K = \frac{1}{2}mv^2 = qV$$

$$= qEd$$

$$= 1.6\times10^{-19}\ C \times 3.9\times10^{6}\ \frac{V}{m} \times 3.0\times10^{-2}\ m$$

$$= 1.9\times10^{-14}\ \text{Joules}.$$

Prob. 5



$$V_A = +\frac{ke}{x} - \frac{ke}{x} + \frac{ke}{x} - \frac{ke}{x} = 0$$

$$V_B = +\frac{ke}{L/2} - \frac{ke}{L/2} + \frac{ke}{y} - \frac{ke}{y} = 0$$

Thus, $U_{AB} = q(V_B - V_A)$

$= 0.$

Prob. 6

$$U_A = \frac{Q_A^2}{2C_A}$$

$$U_B = \frac{Q_B^2}{2C_B}$$

$$\frac{U_A}{U_B} = \frac{Q_A^2}{Q_B^2}$$

$$Q_A = Q_B\sqrt{\frac{U_A}{U_B}} = 1.0\,\mu C\sqrt{\frac{8.0\times10^{-3}\,J}{2.0\times10^{-3}\,J}} = 2.0\,\mu C.$$

Prob. 7

$$P = \frac{V^2}{R} \quad \text{and} \quad R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$$

$$P = \frac{V^2}{\rho l}\pi r^2 = \frac{(120\,V)^2\,\pi\,(6.50\times10^{-4}\,m)^2}{(1.50\times10^{-6}\,\Omega m)(15\,m)} = 850\,W$$

Prob. 8

$$25.00\ USD = 25.00\ USD\ \frac{kWh}{0.15\ USD}$$

$$= \frac{25.00}{0.15}\times10^3\ \frac{J}{\cancel{s}}\ 60\times60\ \cancel{s}$$

$$= 6.0\times10^8\ J$$

Prob. 9

(a) $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{100} + \frac{1}{200} = \frac{3}{200}$ $\Rightarrow$ $R_{eq} = 66.7\,\Omega$

(b) $V_1 = V_2 = 10.0\ V$

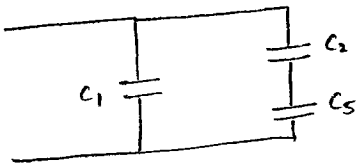
(c) $I_1 = \frac{V_1}{R_1} = \frac{10.0}{100} = 0.100\ A$

$I_2 = \frac{V_2}{R_2} = \frac{10.0}{200} = 0.050\ A$

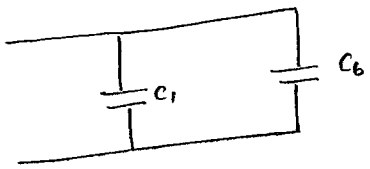
(d) $P_1 = \frac{V_1^2}{R_1} = \frac{10.0^2}{100} = 1.00\ W$

$P_2 = \frac{V_2^2}{R_2} = \frac{10.0^2}{200} = 0.50\ W$

Prob. 10



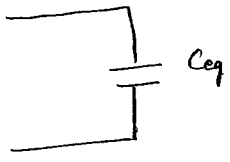
$C_5 = C_3 + C_4$
$= (3.0 + 4.0)\,\mu F = 7.0\,\mu F$



$\frac{1}{C_6} = \frac{1}{C_2} + \frac{1}{C_5} = \frac{1\times7}{2\times7} + \frac{1\times2}{7\times2}$

$= \frac{9}{14}$

$C_6 = \frac{14}{9} = 1.56\,\mu F$



$C_{eq} = C_1 + C_6$
$= 1.0\,\mu F + 1.56\,\mu F$
$= 2.6\,\mu F$