5.

$$E = \frac{\sigma}{2\varepsilon_0} = \frac{1\times 10^{-7}}{2\left(8.85\times 10^{-12}\right)} = 5.68\times 10^{3}\ \frac{n}{C}$$

$$V = Ed$$

$$50\,\frac{j}{C} = \left(5.68\times 10^{3}\ \frac{n}{C}\right)d$$

$$d = 8.8\times 10^{-3}\ \text{meters}$$

14.

$$\text{a) } V_A = \frac{\left(9\times 10^{9}\right)\left(1\times 10^{-6}\right)}{2} = 4.5\times 10^{3}$$

$$V_A = \frac{\left(9\times 10^{9}\right)\left(1\times 10^{-6}\right)}{1} = 9\times 10^{3}$$

b) Has to be the same as a).

19.

Let $+q$ be at the origin and $-3q$ be a distance d down the x – axis.

$$V = \frac{kq}{x} + \frac{k(-3q)}{(d-x)} = 0$$

$$\frac{kq}{x} = \frac{3kq}{(d-x)}$$

$$3x = d - x$$

$$x = \frac{d}{4}$$

There is a place to the left $(x < 0)$ of $+q$ where the potential is zero also.

$$V = \frac{kq}{-x} + \frac{k(-3q)}{(d-x)} = 0$$

$$\frac{kq}{-x} = \frac{3kq}{(d-x)}$$

$$-3x = d - x$$

$$x = -\frac{d}{2}$$

36.

$$V = 1500x^2$$

$$E = -\frac{dV}{dx} = -3000x$$

$$@\, x = .013 \quad E = 39\frac{V}{m}$$

43.

The charges will be brought in starting with the top left and going clockwise. Their subscripts 1, 2, 3, and 4 will follow this order.

$$W_{ab} = q_0\int_a^b E \circ dl$$

For a point charge, $E = \frac{kq}{r^2}$.

$$W = q_0\int_a^b \frac{kq}{r^2}dr = q_0 qk\left(-\frac{1}{r}\right)\Bigg|_a^b$$

$$W = q_0 qk\left(\frac{1}{r_a} - \frac{1}{r_b}\right)$$

If b is at infinity, then $W = \frac{q_0 qk}{a}$.

To bring in the second charge, $W = -\frac{q_0 qk}{a}$.

The third charge? $W = -\frac{q_0 qk}{a} + \frac{q_0 qk}{\sqrt{2}\,a}$

Fourth charge? $W = -\frac{q_0 qk}{a} + \frac{q_0 qk}{\sqrt{2}\,a} - \frac{q_0 qk}{a}$

$$\text{Total Work} = \frac{q_0 qk}{a}\left(-4 + 2\frac{1}{\sqrt{2}}\right) = \frac{q_0 q}{a}\frac{1}{4\pi\varepsilon_0}\left(-4 + \sqrt{2}\right)$$

$$\text{Total Work} = -.21\frac{q^2}{a\varepsilon_0}$$

45.

$$W_e = -q(V_2 - V_1) = -q\left(\frac{kQ}{r_2} - \frac{kQ}{r_1}\right) = q\left(\frac{kQ}{r_1} - \frac{kQ}{r_2}\right)$$

For uniform circular motion:

$$F = \frac{kQq}{r^2} = \frac{mv^2}{r}$$

Need to know how much KE is available.

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{kQq}{r}$$

$$\text{KE available for work} = K_1 - K_2 = \frac{1}{2}kQq\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

Work an external agent must do:

$$W = W_e - (K_1 - K_2) = \frac{kQq}{2}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

73.

$$V = \frac{kq}{r} = \frac{(9\times10^9)(4\times10^{-6})}{.1\text{m}}$$

$$V = 36\times10^4 \text{ volts}$$

What is the E – field on a 10cm sphere?

$$V = Ed \Rightarrow E = \frac{V}{d}$$

$$E = \frac{36\times10^4}{.1\text{m}} = 3.6\frac{\text{MV}}{\text{m}} > 3.0\frac{\text{MV}}{\text{m}}$$

b)no

99.

$$V = \int \frac{k\,dq}{\sqrt{r^2 + a^2}}$$

$\sqrt{r^2 + a^2}$ = constant, so

$$V = \frac{k}{\sqrt{r^2 + a^2}} \int dq = \frac{kq}{\sqrt{r^2 + a^2}}$$

$$E = -\nabla V$$

$$E = -\frac{d}{dr}\left[\frac{kq}{\sqrt{r^2 + a^2}}\right] = -kq\frac{d}{dr}\left(r^2 + a^2\right)^{-\frac{1}{2}}$$

$$E = -kq\left(-\frac{1}{2}\right)\left(r^2 + a^2\right)^{-\frac{3}{2}}(2r)$$

$$E = \frac{kqr}{\left(r^2 + a^2\right)^{\frac{3}{2}}}$$

98.

d = 1.3 meters so the diagonal = 1.84 meters.

$$U = \frac{kqq}{r}$$

$$U = k\left(\frac{(12)(-24)}{1.3} + \frac{(12)(17)}{1.84} + \frac{(12)(31)}{1.3} + \frac{(-24)(17)}{1.3} + \frac{(-24)(31)}{1.84} + \frac{(31)(17)}{1.3}\right)10^{-18}$$

$$U = k(-224 + 286 + 111 - 314 - 404 + 405)10^{-18}$$

$$U = -1.24 \times 10^{-6} \text{ joules}$$

104.

$$V = \frac{kq}{r} = \frac{\left(9 \times 10^{9}\right)\left(1.5 \times 10^{-8}\right)}{.16} = 840 \text{ volts}$$

Additional Problem

(8.)

a) $V_F - V_I = -\int_I^F \vec{E} \circ d\vec{s}$ Let V(center) = 0.

$$V_F - V_0 = -\int_0^F \frac{qr}{4\pi\varepsilon_0 R^3} dr = -\frac{q}{4\pi\varepsilon_0 R^3} \int_0^r r\, dr$$

$$V_F - V_0 = -\frac{qr^2}{8\pi\varepsilon_0 R^3}$$

b) Using $V_F - V_0 = -\frac{qr^2}{8\pi\varepsilon_0 R^3}$ with r = R

$$V_R - V_0 = -\frac{qR^2}{8\pi\varepsilon_0 R^3} = \frac{q}{8\pi\varepsilon_0 R}$$

c) If $q > 0$, then $V_F - V_0 < 0$. So $V_F < V_0$.

The center has a higher potential.