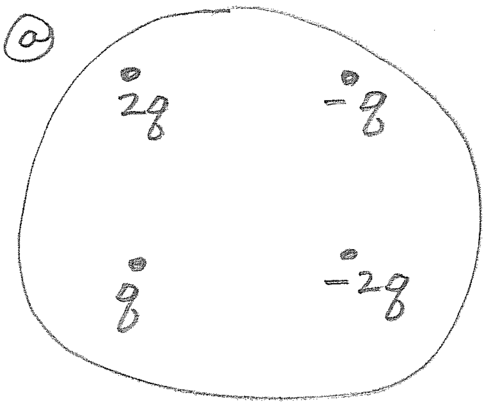
Solutions to Second Homework
PHY 133

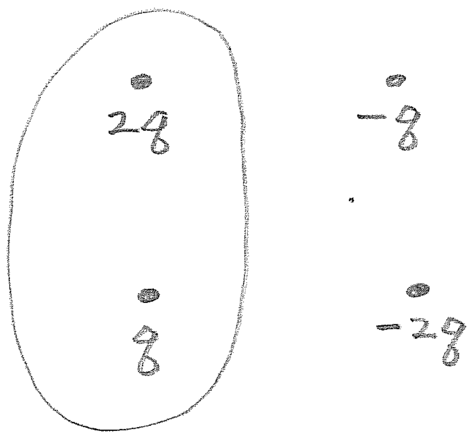
(1) $\Phi_E = |\vec{E}| A \cos 35^\circ$

$= \left(5 \frac{N}{C}\right)(.009\,m)^2 \cos 35^\circ = \boxed{3.32 \times 10^{-4} \frac{N m^2}{C}}$

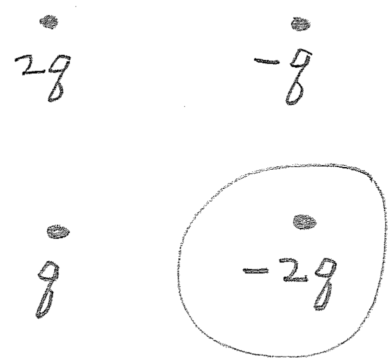
(2) (a)



(b)

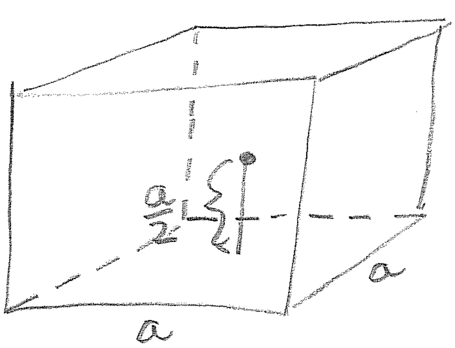


(c)



There are other possibilities as well.

(3) Construct 5 other sides to form a cubical surface:



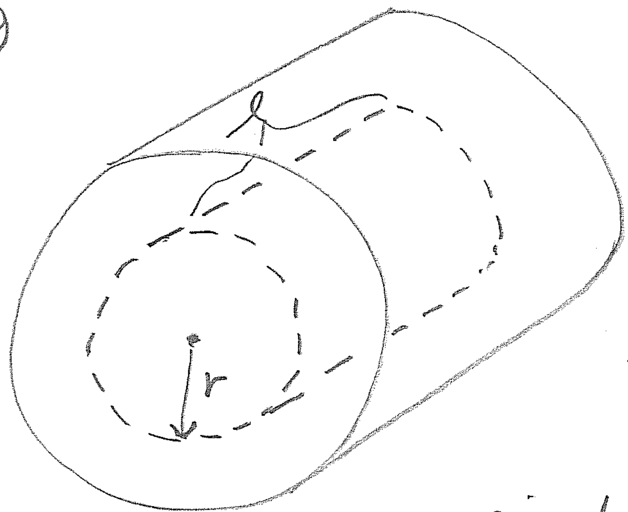
By symmetry,

$\Phi_{\text{one side}} = \frac{1}{6} \Phi_{\text{whole cube}}$

$= \frac{1}{6} \frac{q}{\epsilon_0}$ from Gauss' Law

$= \boxed{\frac{q}{6 \epsilon_0}}$

4 a



By symmetry

① $\vec{E}$ points away from the center axis.

② $|\vec{E}|$ only depends on the distance from the center axis

choosing a cylinder as our surface,

$$\oiint \vec{E}\cdot d\vec{A} = \frac{Q_{enclosed}}{\epsilon_0}$$

$$\iint_{\text{left end}} + \iint_{\text{sides}} + \iint_{\text{right end}} = \frac{\pi r^2 l \rho}{\epsilon_0}$$

$$0 + 2\pi r l E + 0 = \frac{\pi r^2 l \rho}{\epsilon_0}$$

$$\boxed{E = \frac{\rho r}{2\epsilon_0}} \quad \text{for } r < R$$

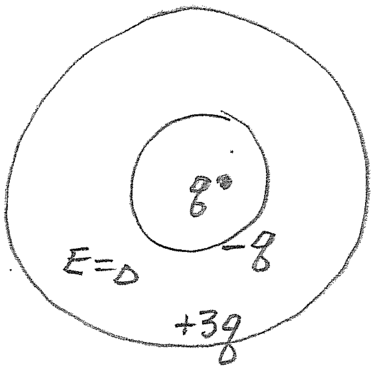
b

$$V(a) - V(b) = \int_0^R E\, dr$$

$$V(a) - V(b) = \int_0^R \frac{\rho r}{2\epsilon_0}\, dr = \left.\frac{\rho r^2}{4\epsilon_0}\right|_0^R$$

$$V(a) - V(b) = \boxed{\frac{\rho R^2}{4\epsilon_0}}$$

5



Since $\vec{E}=0$ inside the conductor,

a) on the inner surface the total charge is $\boxed{-q}$

b) $q_{\substack{\text{outer}\\ \text{surface}}} - q = +2q$

so $q_{\substack{\text{outer}\\ \text{surface}}} = \boxed{+3q}$

c) The electric field outside the conductor is $\boxed{\dfrac{k3q}{r^2}}$

6

$$P.E. = \frac{kq_1q_2}{r}$$

$$= \frac{(9\times10^{9})(1.6\times10^{-19})^2}{(.5\times10^{-10})}$$

$$= \boxed{4.608\times10^{-18}\ \text{J}}$$

$$= 28.8\ \text{eV}$$

The actual ionization energy of a hydrogen atom is 13.6 eV

(7) (a) $U = \frac{kq^2}{a} + \frac{kq^2}{a} + \frac{kq^2}{a}$ Since there are 3 different pairs

$$U = \boxed{\frac{3kq^2}{a}}$$

(b) $(K.E.)_{final} + (P.E.)_{final} = (K.E.)_{initial} + (P.E.)_{initial}$

$$3\left(\frac{m}{2}v^2\right) + 0 = 0 + 3\frac{kq^2}{a}$$

$$v^2 = \frac{2kq^2}{ma}$$

$$\boxed{v = \sqrt{\frac{2kq^2}{ma}}}$$