PHYS 2020 Assignment 1

1 $1\ cm^3$ of H_2O weighs $1\ gm$.

Molecular Weight of $H_2O = 18\ gm$.

$\therefore$ # water molecules in $1\ cm^3 = \frac{1}{18} \times N_{AVOG.}$

$$\text{\# electrons in } 1\ cm^3 = \frac{1}{18} \times N_{AVOG} \times \left(\begin{array}{c} \text{\# electrons per} \\ H_2O \text{ molecule} \end{array} \right)$$

$$= \frac{1}{18} \times 6 \times 10^{23} \times 10$$

$$= 3.3 \times 10^{23}$$

$$\text{Charge of } 3.3 \times 10^{23} \text{ electrons} = 3.3 \times 10^{23} \times 4.8 \times 10^{-10} \frac{esu}{electron}$$

$$= 1.6 \times 10^{14}\ esu.$$

$$\text{or } 3.3 \times 10^{23} \times 1.6 \times 10^{-19} \frac{Coul.}{electron}$$

$$= 5.3 \times 10^{4} \text{ Coulomb.}$$

2. $F_{Grav} = \frac{G m_1 m_2}{r^2}$ $\qquad G = 6.67 \times 10^{-8} \frac{dyne\ cm^2}{gm^2}$

$F_{Coul} = \frac{q_1 q_2}{r^2}$

$\frac{F_{Grav}}{F_{Coul}} = \frac{G m_1 m_2}{q_1 q_2}$

a) $m_{proton} = 1.67 \times 10^{-24}$ gm.

$q_{proton} = 4.8 \times 10^{-10}$ esu.

$$\frac{F_{Grav}}{F_{Coul}} = \frac{6.67 \times 10^{-8} \frac{dyne\ cm^2}{gm^2} \times (1.67 \times 10^{-24} gm)^2}{(4.8 \times 10^{-10} esu)^2}$$

$$= 8.0 \times 10^{-37}$$

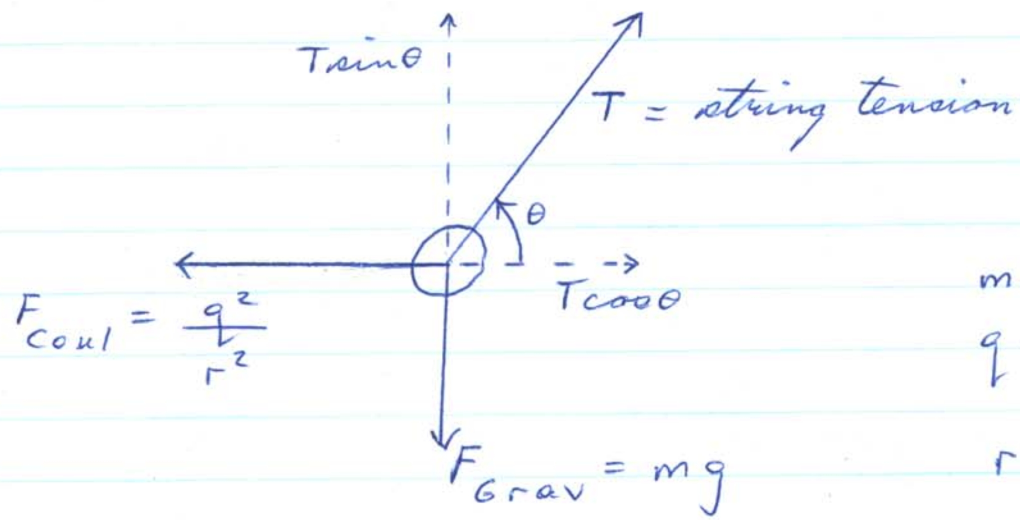
b) $m_{elect} = 9.11 \times 10^{-28}$ gm.

$q_{elect} = 4.8 \times 10^{-10}$ esu

$$\frac{F_{Grav}}{F_{Coul}} = \frac{6.67 \times 10^{-8} \times (9.11 \times 10^{-28})^2}{(4.8 \times 10^{-10})^2}$$

$$= 2.4 \times 10^{-43}.$$

3. First we draw all forces acting on ball.



m = ball's mass
q = ball's charge

$r = 50$ cm.

Due to equilibrium forces cancel in vertical and horizontal directions.

$$\therefore \quad \frac{q^2}{r^2} = T\cos\theta \qquad (1)$$

$$mg = T\sin\theta \qquad (2)$$

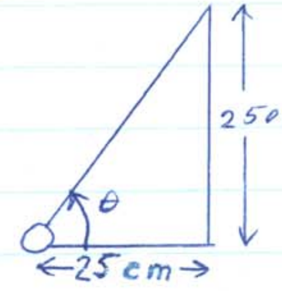
$$(2) \div (1) \Rightarrow \quad \tan\theta = \frac{mgr^2}{q^2}$$

$$q = \left(\frac{mgr^2}{\tan\theta}\right)^{1/2}$$

$$\therefore q = \left(\frac{300\text{ gm} \times 980\text{ cm/sec}^2 \times (50\text{ cm})^2}{250/25}\right)^{1/2}$$

$$= 8570 \sqrt{\text{dyne cm}^2}$$

$\therefore q = 8570$ esu. is charge on ball.



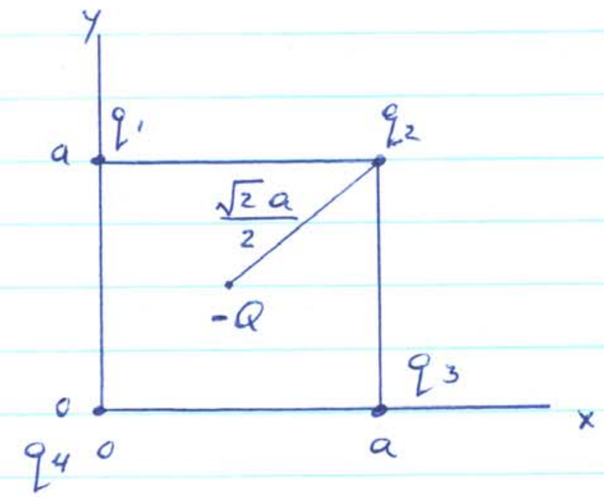
Electrical force between balls

$$F_{coul} = \frac{q^2}{r^2}$$

$$= \frac{(8570\ esu)^2}{(50\ cm)^2}$$

$$= 29,400 \text{ dyne}$$

4.



$q_1 = q_2 = q_3 = q_4 \equiv q$

Force on q_2 is $\vec{F}_2 = \vec{F}_{21} + \vec{F}_{23} + \vec{F}_{24} + \vec{F}_{2(-Q)}$

$$\vec{F}_2 = \frac{q^2}{a^2}\hat{x} + \frac{q^2}{a^2}\hat{y} + \frac{q^2}{2a^2}\left(\frac{\hat{x}+\hat{y}}{\sqrt{2}}\right)$$

$$- \frac{qQ}{\left(\frac{\sqrt{2}a}{2}\right)^2}\left(\frac{\hat{x}+\hat{y}}{\sqrt{2}}\right)$$

$$\therefore F_{2x} = F_{2y} = \frac{q^2}{a^2} + \frac{q^2}{2\sqrt{2}a^2} - \frac{qQ}{\frac{\sqrt{2}a^2}{2}}$$

For zero force $1 + \frac{1}{2\sqrt{2}} - \sqrt{2}\frac{Q}{q} = 0.$

$$\therefore\ Q = \frac{1}{\sqrt{2}}\left(1 + \frac{1}{2\sqrt{2}}\right) q$$

$$= .957\, q$$

Suppose $-Q$ moves slightly toward q_2. It then experiences a net force toward q_2 since it is closer to q_2 than to q_4. Hence it accelerates toward q_2. The equilibrium is therefore unstable since charges don't feel a braking force that restores them to their initial positions.