

Assignment 2

1 1 cm^3 of H_2O weighs 1 gm .

Molecular weight of $\text{H}_2\text{O} = 18 \text{ gm}$.

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

$$\# \text{ electrons in } 1 \text{ cm}^3 = \frac{1}{18} \times N_{\text{AVOG}} \times \left(\begin{array}{l} \# \text{ electrons per} \\ \text{H}_2\text{O molecule} \end{array} \right)$$

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

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

$$\begin{aligned} \text{Charge of } 3.3 \times 10^{23} \text{ electrons} &= 3.3 \times 10^{23} \times 4.8 \times 10^{-10} \frac{\text{esu}}{\text{electron}} \\ &= 1.6 \times 10^{14} \text{ esu.} \end{aligned}$$

$$\begin{aligned} \text{or } 3.3 \times 10^{23} \times 1.6 \times 10^{-19} \frac{\text{Coul.}}{\text{electron}} \\ = 5.3 \times 10^4 \text{ Coulomb.} \end{aligned}$$

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

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

$$\frac{F_{\text{grav}}}{F_{\text{coul}}} = \frac{G m_1 m_2}{q_1 q_2}$$

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

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

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

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

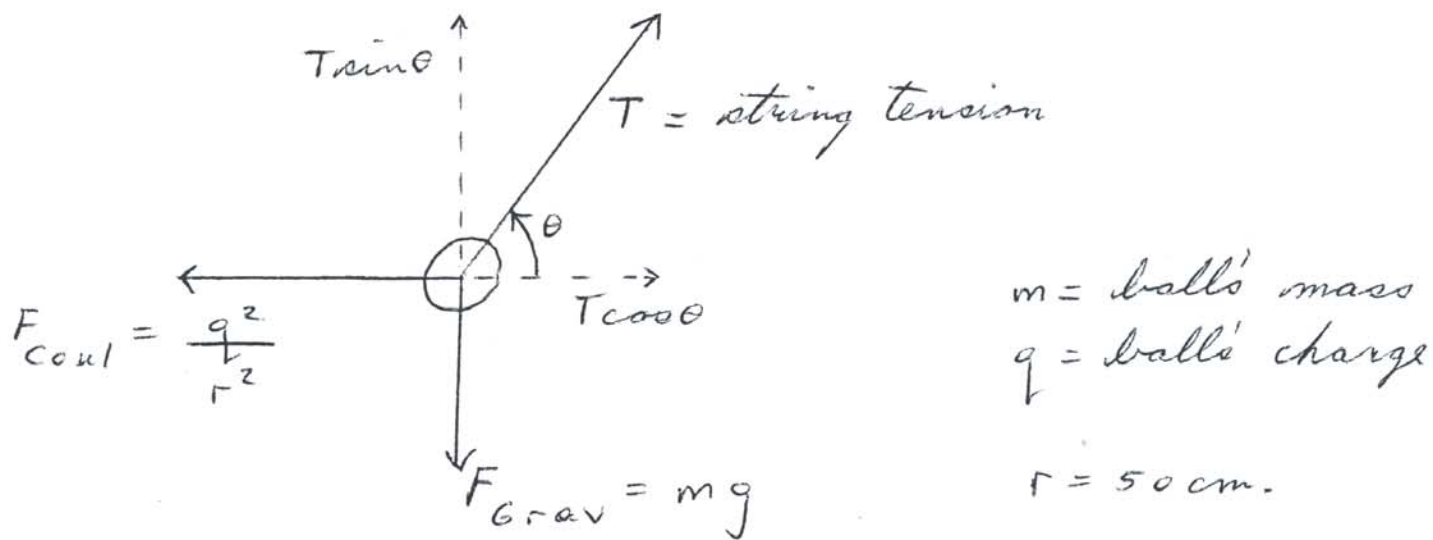
$$b) \quad m_{\text{elect}} = 9.11 \times 10^{-28} \text{ gm.}$$

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

$$\frac{F_{\text{grav}}}{F_{\text{coul}}} = \frac{6.67 \times 10^{-8} \times (9.11 \times 10^{-28})^2}{(4.8 \times 10^{-10})^2}$$

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

3. First we draw all forces acting on ball.



Due to equilibrium forces cancel in vertical and horizontal directions.

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

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

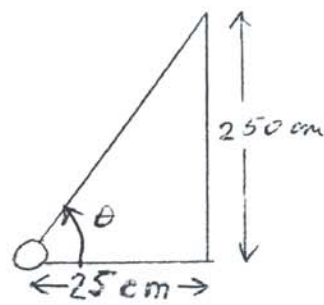
$$(2) \div (1) \Rightarrow \tan \theta = \frac{mg r^2}{q^2}$$

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

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

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

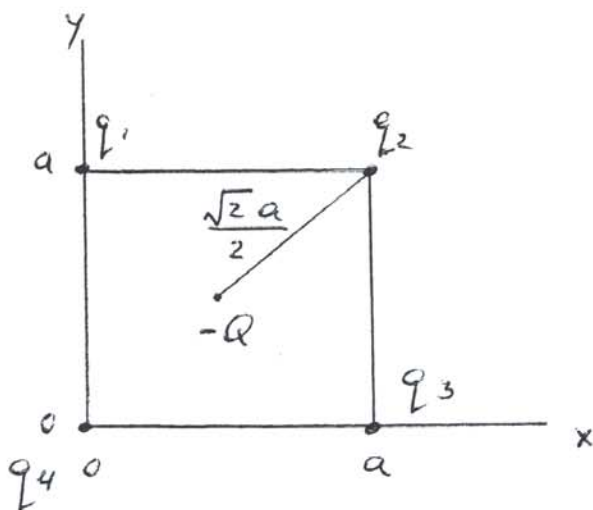
$\therefore q = 8570 \text{ esu.}$ is charge on ball.



Electrical force between balls

$$\begin{aligned}
 F_{\text{Coul}} &= \frac{q^2}{r^2} \\
 &= \frac{(8570 \text{ esu})^2}{(50 \text{ cm})^2} \\
 &= 29,400 \text{ dyne}
 \end{aligned}$$

4.



$$q_1 = q_2 = q_3 = q_4 = q$$

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

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

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

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

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

$$\begin{aligned}\therefore Q &= \frac{1}{\sqrt{2}} \left(1 + \frac{1}{2\sqrt{2}} \right) q \\ &= .957 q\end{aligned}$$

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.