Homework Name_____

1a) Make a quantitative estimate (within a factor of 10, say) of how much charge is on a freshly charged tape. Use the actual Coulomb force law and your experience from the lab.

Gravitational force on tape about equal to electric force.

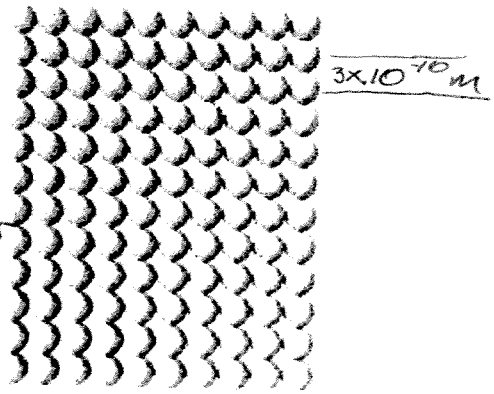
$$mg \approx \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2}$$

$$q = \sqrt{(4\pi\varepsilon_0)\, mgr^2} \approx 10^{-9}\,C$$

b) How many electrons does this represent?

$$N = \frac{Q}{e} = \frac{10^{-9}}{1.6\times10^{-19}} \approx 6\times10^{9}$$

2. Assume that the molecules on the surface of the tape are arranged in a regular array as shown, and that the distance between adjacent molecules is about 3.0×10^{-10} m, as shown. Estimate how many molecules there are over the entire surface of your tape and what fraction of them have had an electron removed in the charging process.



$$\#\text{ of molecules} \approx \frac{\text{Tape area}}{d^2} = \frac{10^{-4}\,m^2}{(3\times10^{-10})^2} \approx 1.1\times10^{15}$$

$$N = f(\#\text{ of molecules}) \qquad f = \frac{6\times10^{9}}{1.1\times10^{15}} = 5.4\times10^{-6}$$

3. The surface charge density σ for your tape is defined as σ=(total charge on the tape)/(total area of the tape). If the density of charge on the surface is greater than about $5.0\times10^{-5}\,C/m^2$ the charges will exert electric forces on the neighboring air sufficient to trigger a spark in the air. How does the density of charge on your tapes compare with this density?

$$\frac{Q}{\text{Area}} = \frac{10^{-9}}{10^{-4}} \approx 10^{-5}\,C/m^2$$