Physics 260 Homework Solution 9

Chapter 23

1 PSE6 23.P.002

a.

numbers of electrons =
$$\frac{(47 \frac{\text{electrons}}{\text{atom}})(6.02 \times 10^{-23} \frac{\text{atoms}}{\text{mole}})m}{107.87 \frac{\text{g}}{\text{mole}}}$$

b.

number of electrons added =
$$\frac{Q}{1.602 \times 10^{-19} \text{C}}$$

Divide this value by 10^9 to get numbers of electrons added for every 10^9 electrons already present.

2 PSE6 23.P.005

a. It is a repulsive force since protons have positive charges. The magnitude of the force is given by the Coulomb's law

$$F = \frac{k_e q^2}{r^2}$$

b.

$$F_{\rm G} = \frac{Gm_1m_2}{r^2}$$
$$\frac{F_{\rm E}}{F_{\rm G}} = \frac{k_eq^2}{Gm^2}$$

where $G = 6.673 \times 10^{-11} \text{Nm}^2/\text{kg}^2$ and $k_e = 8.988 \times 10^9 \text{Nm}^2/\text{C}^2$. c. $k_e a^2 = Gm^2$

$$\frac{k_e q^2}{r^2} = \frac{\mathrm{G}m^2}{r^2}$$
$$\frac{q}{m} = \sqrt{\frac{\mathrm{G}}{k_e}}$$

3 PSE6 23.P.008

The numbers of electrons and protons present are the same.

number of electrons(protons) =
$$\frac{6.02 \times 20^{23} \frac{\text{electrons}}{\text{mole}} \times m}{1 \frac{\text{g}}{\text{mole}}}$$

The force between electrons and protons is then

$$F = \frac{k_e q_e q_p}{r^2} = \frac{k_e e^2 \times (\text{numbers of electrons})^2}{4R^2}$$

where e is the magnitude of the charge of a single electron(proton) and R is the radius of the Earth.

4 PSE6 23.P.009

a. It is an attractive force given by the equation

$$F = \frac{k_e q_1 q_2}{r^2}$$

b. After the system comes to equilibrium, the net charge is $q_1 + q_2$ and they should be distributed equally in two spheres. Therefore, each sphere has charge $(q_1 + q_2)/2$. Use the same expression used in part (a) to find the new electric force between two spheres. But now the force is repulsion since both spheres have like charges.

5 PSE6 23.P.018

The electric field due to the 7.00μ C charge is

$$E_{7\mu C} = \frac{k_e (7.00 \times 10^{-6} C)}{L^2} (-\sin 60^{\circ} \hat{\mathbf{i}} - \cos 60^{\circ} \hat{\mathbf{j}})$$

The electric field due to the -4.00μ C charge is

$$E_{-4\mu C} = \frac{k_e (4.00 \times 10^{-6} C)}{L^2} \hat{\mathbf{i}}$$

Add up two electric fields to get the resultant E field at the position of charge q.

b.

$$F = qE$$

6 PSE6 23.P.021

a.

$$E = \Sigma \frac{kq_i}{r_i^2} = \frac{kAq}{a^2} \hat{\mathbf{i}} + \frac{kBq}{2a^2} (\sin 45^\circ \hat{\mathbf{i}} + \cos 45^\circ \hat{\mathbf{j}}) + \frac{kCq}{a^2} \hat{\mathbf{j}}$$

The magnitude of the electric field is $\sqrt{E_{\mathbf{i}}^2 + E_{\mathbf{j}}^2}$ and the angle is $\tan \theta = E_{\mathbf{j}}/E_{\mathbf{i}}$.

b.

F = qE

at the same angle as in part (a).

7 PSE6 23.P.042

For proton, it experiences a force in the same directions as E field with magnitude F = qE. This force accelerates the proton. Therefore, $F = qE = m_p a_p$. Solve for the acceleration of the proton a_p . Since the proton starts out at rest, $v_{f,p} = a_p t = qEt/m_p$. Similarly, $v_{f,e} = a_e t = qEt/m_e$ and it is in the direction opposite to the electric field because electron has negative charge.

8 PSE6 23.P.054

First, draw a free body diagram. There are three forces present in this problem. One is the gravitational force (F_g) pointing downward. One is the tension (T) along the string. The other one is the electric force (F_e) pointing to the right. Since the ball is in equilibrium, these three forces should balance out. From $\Sigma F_y = 0$, get

$$F_q = mg = T\cos\theta$$

Solve for T. From $\Sigma F_x = 0$, get

$$F_e = qE = T\sin\theta$$

Solve for q.

9 PSE6 23.P.057

Label the other three point charges as follows: 1 - upper left corner; 2 - upper right corner; and 3 - lower right corner. The forces due to these three charges are

$$F_{1} = \frac{k_{e}q^{2}}{W^{2}}(-\hat{\mathbf{j}})$$
$$F_{2} = \frac{k_{e}q^{2}}{W^{2}}(-\frac{L}{\sqrt{L^{2} + W^{2}}}\hat{\mathbf{i}} - \frac{W}{\sqrt{L^{2} + W^{2}}}\hat{\mathbf{j}})$$

$$F_3 = \frac{k_e q^2}{L^2} (-\hat{\mathbf{i}})$$

Therefore, the net force is $F = F_1 + F_2 + F_3$. Use pythagorean theorem to calculate the resultant force and the angle.

10 PSE6 23.P.062

Draw a free body diagram to locate all the forces in one of the spheres. For the positively charged sphere, there are four forces acting on it. The first one is the gravitational force acting downward $(F_g = mg)$. The second one is the tension along the string (T). The third one is the electric force to the right $(F_e = qE)$. The last one is the attractive force to the left due to the negatively charged sphere $(F_a = \frac{k_e q^2}{r^2})$, where $r = 2l \sin \theta$ and l is the length of the string). Since the sphere is at equilibrium, all the forces should balance out. So

$$mg = T\cos\theta$$
$$qE = F_a + T\sin\theta$$

Solve for E.

11 PSE6 23.QQ.002

Objects A and C possess charges of the same sign.

12 PSE6 23.QQ.006

It is unaffected.

13 PSE6 23.QQ.007

A > B > C

14 PSE6 23.QQ.008

The false statement is electric field line can never intersect with one another.