PH 202 - Chapter 18 Solutions

6) $m(\text{molar}) = 18.0\ \text{g/mol} = 18.0 \times 10^{-3}\ \text{kg/mol}$

$N_e = 10N$

(a) $V = 1\ \text{liter} = 1.00 \times 10^{-3}\ \text{m}^3$ $\quad N_e = ?$ $\quad \rho = 10^3\ \text{kg/m}^3$

$N_e = 10N = 10 N_A n \qquad m(\text{molar}) = \dfrac{m}{n} \qquad \rho = \dfrac{m}{V}$

$m = \rho V \qquad m(\text{molar}) = \dfrac{\rho V}{n} \qquad n = \dfrac{\rho V}{m(\text{molar})}$

$$N_e = 10 N_A \left(\frac{\rho V}{m(\text{molar})} \right) = \frac{10 N_A \rho V}{m(\text{molar})}$$

$$N_e = \frac{(10)(6.022 \times 10^{23})(10^3)(10^{-3})}{(18 \times 10^{-3})} = 3.36 \times 10^{26}$$

(b) $Q = N_e Q_e = (3.36 \times 10^{26})(-1.60 \times 10^{-19}) = -5.35 \times 10^{7}\ C$

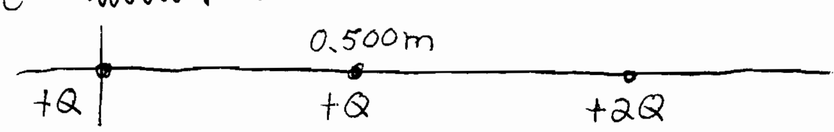
8) $R = 1.80 \times 10^{-3}\ \text{m} \qquad Q_1 = Q_2 = Q \qquad F_e = 4.55 \times 10^{-21}\ \text{N}$

$$F_e = \frac{k Q_1 Q_2}{R^2} = \frac{kQ^2}{R^2} \qquad Q = \sqrt{\frac{F_e R^2}{k}} \qquad Q = N_e |Q_e|$$

$$N_e = \frac{Q}{|Q_e|} = \frac{1}{|Q_e|} \sqrt{\frac{F_e R^2}{k}} = \frac{1}{(1.6 \times 10^{-19})} \left(\frac{(4.55 \times 10^{-21})(1.8 \times 10^{-3})^2}{(8.99 \times 10^9)} \right)^{1/2}$$

$N_e = 8$

10)



$$F_0 = \frac{k Q_1 Q_2}{R^2} = \frac{kQ^2}{(1/2)^2} = 4kQ^2 \qquad F = 2F_0 \qquad R_3 = ?$$

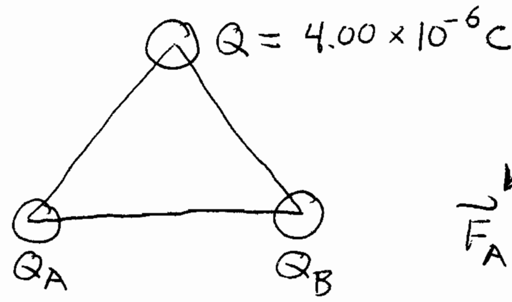
$$F = 4kQ^2 + \frac{k(Q)(2Q)}{(R_3)^2} \qquad 8kQ^2 = 4kQ^2 + \frac{2kQ^2}{(R_3)^2}$$

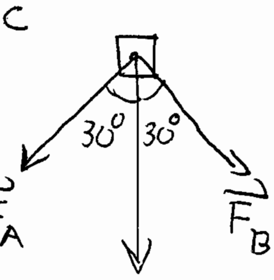
$$\frac{2kQ^2}{R_3^2} = 4kQ^2 \qquad R_3^2 = \frac{2kQ^2}{4kQ^2} = \frac{1}{2} \qquad R_3 = 0.707\ \text{m}$$

16) $|Q_1| = Q_e \qquad |Q_2| = 2Q_e \qquad a_c = ?$

$$\Sigma \vec{F} = m\vec{a} \qquad F_e = m_e a_c \qquad \frac{k|Q_1 Q_2|}{R^2} = m_e a_c$$

$$a_c = \frac{2kQ_e^2}{m_e R^2} = \frac{(2)(8.99\times10^9)(-1.60\times10^{-19})^2}{(9.11\times10^{-31})(2.65\times10^{-11})^2} = 7.19\times10^{23}\ m/s^2$$

18) 



$F = 405 N$

$L = 2.00\times10^{-2} m$

$Q_A = ? \quad Q_B = ?$

The forces are attractive, so Q_A and Q_B must have the oppositive sign of Q, i.e. negative

Since the net force is straight down, the x-components of the two forces must cancel, i.e. $Q_A = Q_B$.

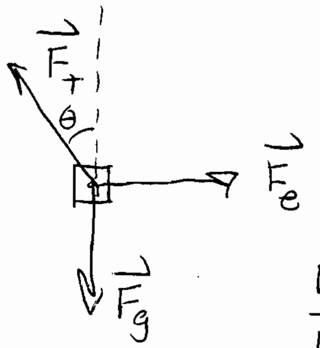
$$\Sigma \vec{F}_Y = \vec{F}_{AY} + \vec{F}_{BY} = 2\vec{F}_{AY} = \left(2\frac{k|Q_A Q|}{L^2}\cos 30°, \text{down}\right)$$

$$2\frac{k|Q_A Q|}{L^2}\frac{\sqrt{3}}{2} = F \qquad |Q_A| = \frac{FL^2}{\sqrt{3}\,kQ}$$

$$|Q_A| = \frac{(405)(0.02)^2}{\sqrt{3}(8.99\times10^9)(4\times10^{-6})} = 2.60\times10^{-6}\ C$$

$$Q_A = Q_B = -2.60\,\mu C$$

23)



$$\Sigma \vec{F}_x = F_e - F_T \sin\theta = 0 \qquad F_e = F_T \sin\theta$$

$$\Sigma \vec{F}_y = -F_g + F_T \cos\theta = 0 \qquad F_g = F_T \cos\theta$$

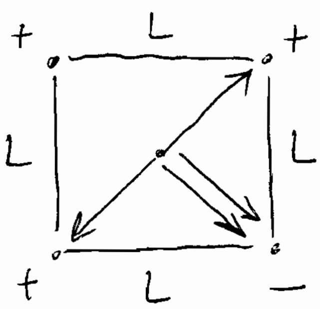
$$\frac{F_e}{F_g} = \frac{\sin\theta}{\cos\theta} = \tan\theta \qquad \theta = \tan^{-1}\left(\frac{F_e}{F_g}\right)$$

$$\theta = \tan^{-1}\left(\frac{\frac{k|Q_1 Q_2|}{R^2}}{mg}\right) = \tan^{-1}\left(\frac{k|Q_1 Q_2|}{mgR^2}\right)$$

$$\theta = \tan^{-1}\left(\frac{(8.99\times10^9)|(0.6\times10^{-6})(-0.9\times10^{-6})|}{(0.08)(9.8)(0.15)^2}\right) = 15.4^\circ$$

$$F_T\cos\theta = F_g \qquad F_T = \frac{F_g}{\cos\theta} = \frac{mg}{\cos\theta} = \frac{(0.08)(9.8)}{\cos(15.4^\circ)} = 0.813\text{ N}$$

28)



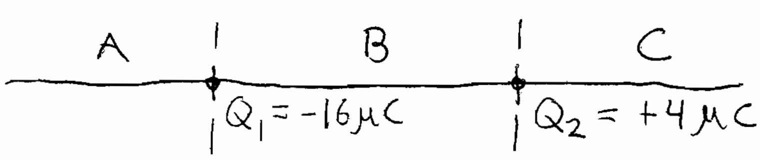
$$\vec{E} = 2\vec{E}_1 \qquad E = 2E_1$$

$$E = 2\left(\frac{kQ}{R^2}\right) = \frac{2k|Q|}{R^2} \qquad R = \frac{\sqrt{2}L}{2}$$

$$E = \frac{2k|Q|}{\left(\frac{\sqrt{2}L}{2}\right)^2} = \frac{2k|Q|}{\frac{2L^2}{4}} = \frac{4k|Q|}{L^2}$$

$$E = \frac{(4)(8.99\times10^9)(2.4\times10^{-12})}{(4\times10^{-2})^2} = 5.39\times10 = 53.9\text{ N/C}$$

29)



The net electric field in region B can't be zero because both electric field vectors point to the left there.
The net electric field in region A can't be zero because the magnitude of Q_1 is greater than the magnitude of Q_2 and points in region A are closer to Q_1.

Region C: $x = 3.00\,m$ $\quad R_1 = R_2 + x = R_2 + 3$

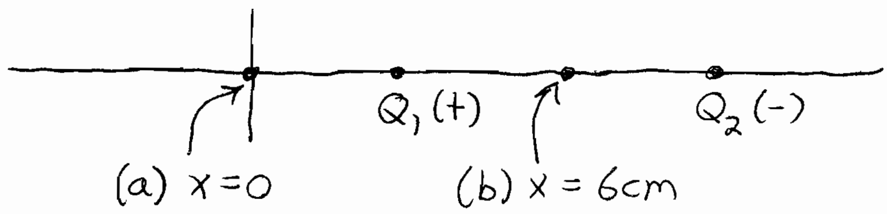
(a) $E_1 = E_2 \quad \dfrac{k|Q_1|}{R_1^2} = \dfrac{k|Q_2|}{R_2^2} \quad \dfrac{|Q_1|}{(R_2+3)^2} = \dfrac{|Q_2|}{R_2^2}$ (square root)

$$\frac{\sqrt{|Q_1|}}{(R_2+3)} = \frac{\sqrt{|Q_2|}}{R_2} \quad \sqrt{|Q_1|}\,R_2 = \sqrt{|Q_2|}\,(R_2+3) \quad \left(\sqrt{|Q_1|} - \sqrt{|Q_2|}\right)R_2 = \sqrt{|Q_2|}\,3$$

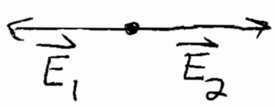
$R_2 = \dfrac{\sqrt{|Q_2|}\;3}{\left(\sqrt{|Q_1|} - \sqrt{|Q_2|}\right)} = \dfrac{6}{(4-2)} = 3.00\,m$ (to the right of Q_2)

(b) $\vec{F} = Q\vec{E} = Q(0) = 0.$

31)



(a)

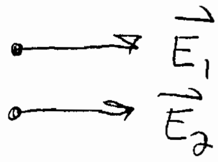


$\vec{E} = \vec{E}_1 + \vec{E}_2 = (-E_1) + E_2 = E_2 - E_1$

$$\vec{E} = \frac{k|Q_2|}{R_2^2} - \frac{k|Q_1|}{R_1^2} = k\left(\frac{|Q_2|}{R_2^2} - \frac{|Q_1|}{R_1^2}\right) = (8.99\times10^9)\left(\frac{(21\times10^{-6})}{(0.09)^2} - \frac{(8.5\times10^{-6})}{(0.03)^2}\right)$$

$$\vec{E} = (8.99\times10^9)(2592.59 - 9444.44)(10^{-6}) = -6.16\times10^7\ N/C$$

(b)



$\vec{E} = \vec{E}_1 + \vec{E}_2 = E_1 + E_2$

$$\vec{E} = \frac{k|Q_1|}{R^2} + \frac{k|Q_2|}{R^2} = \frac{k}{R_2^2}\left(|Q_1| + |Q_2|\right) = \frac{(8.99\times10^9)}{(0.03)^2}\left(21 + 8.5\right)(10^{-6})$$

$$\vec{E} = +2.95\times10^8\ N/C$$

33) $\uparrow \quad \vec{E} = +8480\ \text{N/C} \qquad m = 3.50 \times 10^{-9}\ \text{kg}$

(a) The excess charge is positive because an upward electric force is needed to counteract the gravitational force which is downward.

(b) Since the excess charge is positive, the excess charges are protons.

$$\Sigma \vec{F} = 0 \qquad \vec{F}_e + \vec{F}_g = 0 \qquad (+F_e) + (-F_g) = 0 \qquad F_e = F_g$$

$$QE = mg \qquad NeE = mg \qquad N = \frac{mg}{eE} = \frac{(3.50 \times 10^{-9})(9.80)}{(1.60 \times 10^{-19})(8480)}$$

$N = 2.53 \times 10^{7}$ protons

64) $$\Sigma \vec{F}(\text{Charge A}) = \left(-\frac{kQ^2}{d^2}\right) + \left(-\frac{kQ^2}{(2d)^2}\right) + \left(+\frac{kQ^2}{(3d)^2}\right)$$

$$= kQ^2\left[-\frac{36}{36d^2} - \frac{9}{36d^2} + \frac{4}{36d^2}\right] = -\frac{41kQ^2}{36d^2}$$

(direction)

$$\Sigma \vec{F}(\text{Charge B}) = \left(+\frac{kQ^2}{(2d)^2}\right)$$ (The forces caused by charges A and C cancel.)

$$= +\frac{9kQ^2}{36d^2}$$

$$\Sigma \vec{F}(\text{Charge C}) = \left(+\frac{kQ^2}{(2d)^2}\right) + \left(+\frac{kQ^2}{d^2}\right) + \left(+\frac{kQ^2}{d^2}\right)$$

$$= kQ^2\left[\frac{9}{36d^2} + \frac{36}{36d^2} + \frac{36}{36d^2}\right] = +\frac{81kQ^2}{36d^2}$$

$$\Sigma \vec{F}(\text{Charge D}) = \left(-\frac{kQ^2}{(3d)^2}\right) + \left(-\frac{kQ^2}{(2d)^2}\right) + \left(-\frac{kQ^2}{d^2}\right)$$

$$= kQ^2\left[-\frac{4}{36d^2} - \frac{9}{36d^2} - \frac{36}{36d^2}\right] = -\frac{49kQ^2}{36d^2}$$

$$\frac{|\Sigma \vec{F}|\ \text{largest}}{|\Sigma \vec{F}|\ \text{smallest}} = \frac{81}{9} = 9.00$$