Unit 19 - Homework Solution

22-2

- Each hydrogen atom (H) is composed of one electron and one proton.

$$1 \text{ mole of } H_2 = 6.02\times10^{23} \ H_2 \text{ molecules}$$

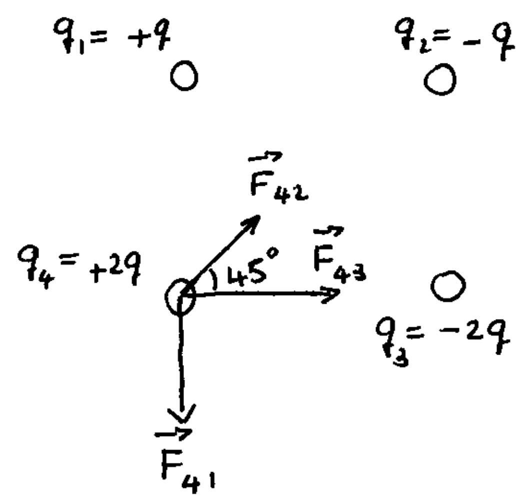
$$= 2\times6.02\times10^{23} \ H \text{ atoms}$$

$$\#\text{ of electrons} = 2\times6.02\times10^{23}$$

$$Q = (2\times6.02\times10^{23})(1.6\times10^{-19}\ C) = 1.93\times10^{5}\ C$$

$$= 0.193 \ MC$$

22-13



$$|\vec{F}_{41}| = \frac{kq_1q_4}{a^2} = \frac{2kq^2}{a^2}$$

$$|\vec{F}_{42}| = \frac{kq_2q_4}{2a^2} = \frac{2kq^2}{2a^2} = \frac{kq^2}{a^2}$$

$$|\vec{F}_{43}| = \frac{kq_3q_4}{a^2} = \frac{4kq^2}{a^2}$$

$$F_x^{net} = F_{41,x} + F_{42,x} + F_{43,x} = 0 + F_{42}\cos45° + F_{43}$$

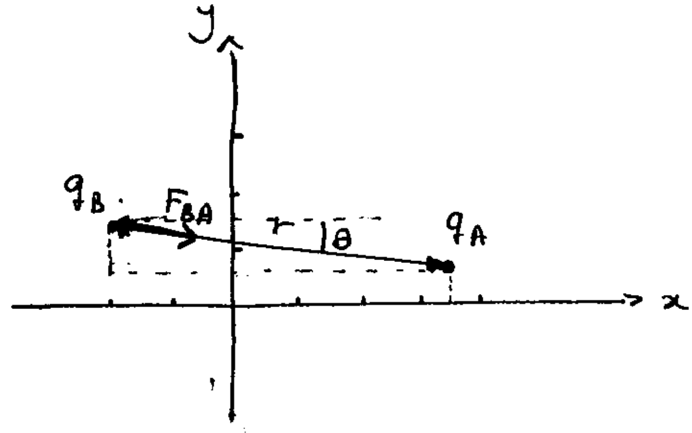
$$= \frac{kq^2}{a^2}\cos45° + \frac{4kq^2}{a^2} = \frac{kq^2}{a^2}(\cos45°+4) = 4.71\ \frac{kq^2}{a^2}$$

$$F_y^{net} = F_{41,y} + F_{42,y} + F_{43,y} = -F_{41} + F_{42}\sin45° + 0$$

$$= -\frac{2kq^2}{a^2} + \frac{kq^2}{a^2}\sin45° = \frac{kq^2}{a^2}(-2+\sin45°) = -1.29\ \frac{kq^2}{a^2}$$

$$\frac{kq^2}{a^2} = \frac{9\times10^9\times(1\times10^{-7})^2}{(0.05)^2} = 0.036 \Longrightarrow \begin{cases} F_x = 1.7\times10^{-1}\ N \\ F_y = -4.6\times10^{-2}\ N \end{cases}$$

22 - 20



$$r_{BA}^2 = (y_B - y_A)^2 + (x_B - x_A)^2$$

$$= (1.5 - 0.5)^2 + (-2 - 3.5)^2$$

$$= 1 + 30.25 = 31.25 \quad cm^2$$

$$= 31.25 \times 10^{-4} \quad m^2 \qquad r_{BA} = 0.055 \text{ m} = 5.5 \text{ cm}$$

a) $$|\vec{F}_{BA}| = \frac{k q_A q_B}{r_{BA}^2} = \frac{9\times10^9 \times 3\times10^{-6} \times 4\times10^{-6}}{31.25 \times 10^{-4}} = 3.5 \times 10 = 35 \text{ N}$$

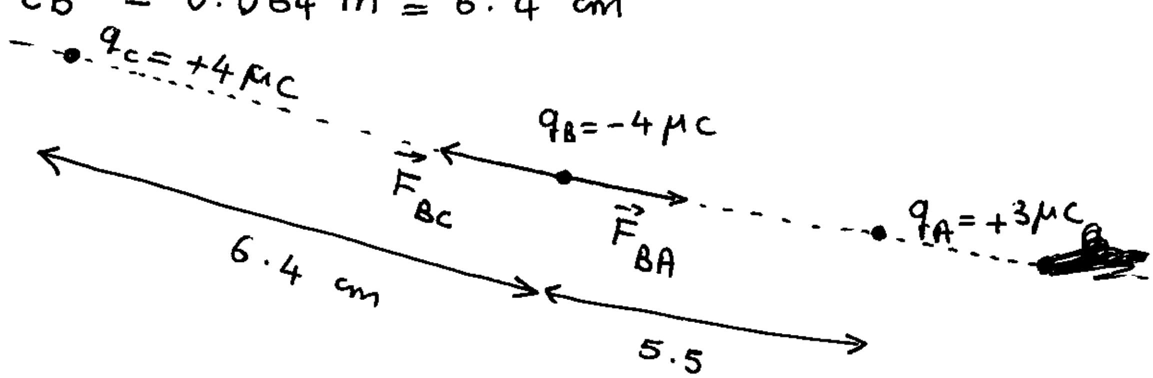
$$\theta = \tan^{-1}\frac{F_y}{F_x} \quad \text{or} \quad \theta = \tan^{-1}\frac{y_B - y_A}{x_B - x_A} = \tan^{-1}\frac{1.0}{-5.5} = -0.18 \text{ rad}$$

$\theta =$

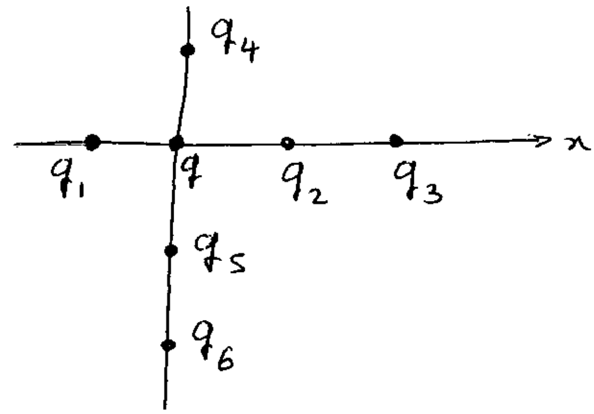
b) The third charge q_c should act a force equal to $\vec{F}_{BA}$ in magnitude but in opposite direction.

$$|\vec{F}_{BC}| = 35 \text{ N} = \frac{9\times10^9 \times 4\times10^{-6} \times 4\times10^{-6}}{r_{cB}^2}$$

$$\Rightarrow r_{cB} = 0.064 \text{ m} = 6.4 \text{ cm}$$



22 _ 36



force acting on q from q_1

$$\vec{F}_1 = \left(\frac{k q q_1}{d^2}\right)\hat{i} = k\,\frac{(12e^2)}{d^2}\hat{i}$$

$$\vec{F}_1 = 12k\,\frac{e^2}{d^2}\,\hat{i}$$

$$\vec{F}_2 = -\frac{k q q_2}{d^2}\,\hat{i} = \frac{k\,(6e^2)}{d^2}(-\hat{i}) = 6k\,\frac{e^2}{d^2}(-\hat{i})$$

$$\vec{F}_3 = \frac{k q q_3}{4d^2}(-\hat{i}) = \frac{k(24e^2)}{4d^2}(-\hat{i}) = 6k\,\frac{e^2}{d^2}(-\hat{i})$$

$$\vec{F}_4 = \frac{k q q_4}{d^2}(-\hat{j}) = \frac{k(24e^2)}{d^2}(-\hat{j}) = 24\,\frac{ke^2}{d^2}(-\hat{j})$$

$$\vec{F}_5 = \frac{k q q_5}{d^2}(\hat{j}) = \frac{12ke^2}{d^2}\,\hat{j}$$

$$\vec{F}_6 = \frac{k q q_6}{4d^2}(\hat{j}) = \frac{48ke^2}{4d^2}\,\hat{j} = \frac{12ke^2}{d^2}\,\hat{j}$$

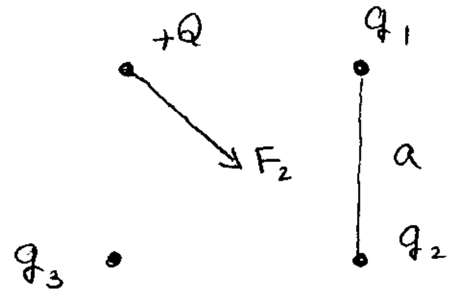
$$\vec{F}^{net} = 12k\frac{e^2}{d^2}\hat{i} - 6k\frac{e^2}{d^2}\hat{i} - 6\frac{ke^2}{d^2}\hat{i} - 24\frac{ke^2}{d^2}\hat{j} + \frac{12ke^2}{d^2}\hat{j} + \frac{12ke^2}{d^2}\hat{j}$$

$$\cancel{\vec{F}^{net} = 18\frac{ke^2}{d^2}\hat{j} = \frac{18\times9\times10^{9}\times(1.6\times10^{-19})^2}{(0.01)^2}\hat{j} = 3.7\times10^{-23}\,N\,\hat{j}}$$

$$\boxed{\vec{F}^{net} = 0}$$

22-37

q_1 and q_3 both should be positive in order to cancel the effect of q_2.



$$F_2 = \frac{kQq_2}{2a^2} = \frac{k \times 2Q \times Q}{2a^2} = \frac{kQ^2}{a^2}$$

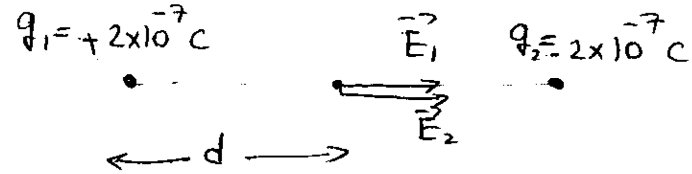
$$F^{net} = -\sqrt{F_1^2 + F_3^2} + F_2 = -\sqrt{2F^2} + F_2 = -F\sqrt{2} + F_2 = -\frac{kqQ}{a^2}\sqrt{2} + \frac{kQ^2}{a^2} = 0$$

$$\Rightarrow \frac{\cancel{k}qQ\sqrt{2}}{\cancel{a^2}} = \frac{\cancel{k}Q^2}{\cancel{a^2}} \Rightarrow q = \frac{Q}{\sqrt{2}} = 0.71Q$$

22-51

- A is negatively charged due to touchig the plastic rod.
- B and C are neutral because of no interaction between them.
- B and C are attracted to A as the result of induction.
- B, and C are attracted to D, so D is not neutral.
- D is attracted to A, so it is positively charged.

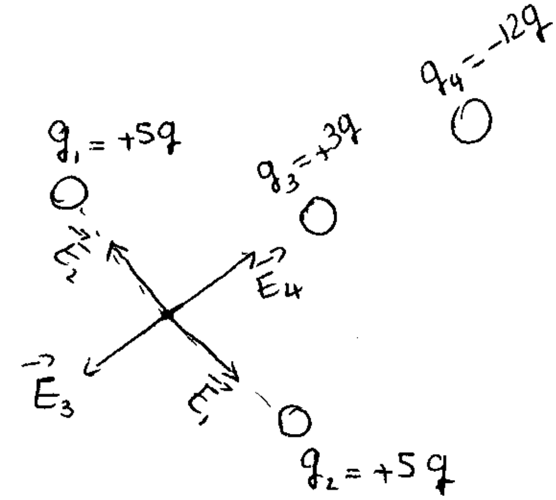
23-4



$$E^{net} = 2E = 2\frac{kq}{d^2}$$

$$= \frac{2\times9\times10^{9}\times2\times10^{-7}}{(7.5\times10^{-2})^2} = 6.4\times10^{5}\ \text{N/C}$$

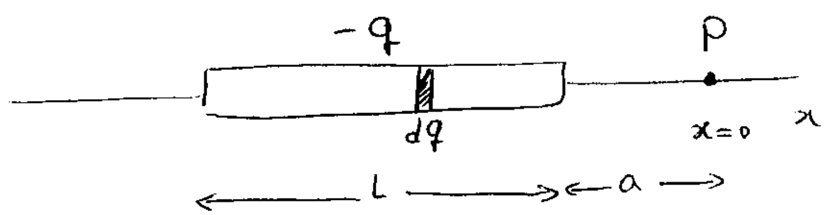
23-7



$$|\vec{E}_1| = |\vec{E}_2| \Rightarrow \vec{E}_1 + \vec{E}_2 = 0$$

$$|\vec{E}_3| = |\vec{E}_4| \Rightarrow \vec{E}_3 + \vec{E}_4 = 0$$

23-25



$$dE = \frac{k\,dq}{x^2} \qquad \lambda = \frac{-q}{L}$$

$$E = \int \frac{k\,dq}{x^2} = \int_{-a}^{-a-L} \frac{k\lambda\,dx}{x^2}$$

$$= k\lambda \int_{-a}^{-a-L} x^{-2}\,dx = -k\lambda\left(\frac{1}{-a-L} - \frac{1}{-a}\right) = k\lambda\left(\frac{1}{a+L} - \frac{1}{a}\right)$$

$$= k\lambda\,\frac{-L}{a(a+L)} = \frac{-k\lambda L}{a(a+L)}$$ shows the $\vec{E}$ is in $-x$ direction.

if $a \gg L$ then $L + a \approx a \Rightarrow E = \underbrace{\frac{kq}{a^2}}_{\text{the electric field of a point charge}}$