

Chapter 19

4. (a) $Q = \frac{1 \text{ kg}}{9.11 \times 10^{-31} \text{ kg}} (-1.60 \times 10^{-19} \text{ C}) = \boxed{-2 \times 10^{11} \text{ C}}$

(b) $Q = \frac{1 \text{ kg}}{1.673 \times 10^{-27} \text{ kg}} (1.60 \times 10^{-19} \text{ C}) = \boxed{1 \times 10^8 \text{ C}}$

6. $F = k \frac{q_1 q_2}{r^2}$

$$r = \sqrt{\frac{k q_1 q_2}{F}} = \sqrt{\frac{(8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2})(17.2 \times 10^{-6} \text{ C})(21.9 \times 10^{-6} \text{ C})}{2.77 \text{ N}}} = \boxed{1.11 \text{ m}}$$

12. Let the x -axis be along the line of the three charges with the positive direction pointing from q_2 to q_3 .

$$\mathbf{F}_{12} = k \frac{q_1 q_2}{d^2} \hat{\mathbf{x}}$$

$$\mathbf{F}_{13} = -k \frac{q_1 q_3}{(2d)^2} \hat{\mathbf{x}}$$

$$\mathbf{F}_1 = \mathbf{F}_{12} + \mathbf{F}_{13}$$

$$= \frac{k}{d^2} (q_1 q_2 - \frac{1}{4} q_1 q_3) \hat{\mathbf{x}}$$

$$= \frac{k}{d^2} [q(2.0q) - \frac{1}{4} q(3.0q)] \hat{\mathbf{x}}$$

$$= \frac{(8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2})(12 \times 10^{-6} \text{ C})^2}{(0.16 \text{ m})^2} (2.0 - \frac{3.0}{4}) \hat{\mathbf{x}}$$

$$= \boxed{(63 \text{ N}) \hat{\mathbf{x}}}$$

13. (a) Let the x -axis be along the line of the three charges with the positive direction pointing from q_2 to q_3 .

$$\mathbf{F}_{21} = -k \frac{q_2 q_1}{d^2} \hat{\mathbf{x}}$$

$$\mathbf{F}_{23} = k \frac{q_2 q_3}{d^2} \hat{\mathbf{x}}$$

$$\mathbf{F}_2 = \mathbf{F}_{21} + \mathbf{F}_{23}$$

$$= \frac{k}{d^2} [-q_2 q_1 + q_2 q_3] \hat{\mathbf{x}}$$

$$= \frac{k}{d^2} [-(2.0q)q + (2.0q)(3.0q)] \hat{\mathbf{x}}$$

$$= \frac{(8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2})(12 \times 10^{-6} \text{ C})^2}{(0.16 \text{ m})^2} (-2.0 + 6.0) \hat{\mathbf{x}}$$

$$= (200 \text{ N}) \hat{\mathbf{x}}$$

The net electrostatic force exerted on q_2 is $\boxed{200 \text{ N towards } q_3}$.

- (b) If d were tripled, the answer to part (a) would decrease by a factor of $1/9$.

29. $\mathbf{F} = qE\hat{\mathbf{y}}$

$$E = \frac{F}{q} = \frac{0.20 \text{ N}}{5.0 \times 10^{-6} \text{ C}} = 4.0 \times 10^4 \text{ N/C}$$

$$\mathbf{F} = qE\hat{\mathbf{y}} = (-2.7 \times 10^{-6} \text{ C})(4.0 \times 10^4 \frac{\text{N}}{\text{C}})\hat{\mathbf{y}} =$$

$$\boxed{(-0.11 \text{ N})\hat{\mathbf{y}}}$$

30. (a)

$$\begin{aligned} \mathbf{E} &= \frac{kq_1}{r_1^2}(-\hat{\mathbf{x}}) + \frac{kq_2}{r_2^2}\hat{\mathbf{x}} \\ &= k\left(-\frac{q_1}{r_1^2} + \frac{q_2}{r_2^2}\right)\hat{\mathbf{x}} \\ &= (8.99 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2})\left[-\frac{6.2 \times 10^{-6} \text{ C}}{(0.040 \text{ m})^2} + \frac{9.5 \times 10^{-6} \text{ C}}{(0.100 \text{ m} + 0.040 \text{ m})^2}\right]\hat{\mathbf{x}} \\ &= \boxed{(-3.0 \times 10^7 \text{ N/C})\hat{\mathbf{x}}} \end{aligned}$$

(b) $\mathbf{E} = \frac{kq_1}{r_1^2}\hat{\mathbf{x}} + \frac{kq_2}{r_2^2}\hat{\mathbf{x}}$

$$\begin{aligned} &= k\left(\frac{q_1}{r_1^2} + \frac{q_2}{r_2^2}\right)\hat{\mathbf{x}} \\ &= (8.99 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2})\left[\frac{6.2 \times 10^{-6} \text{ C}}{(0.040 \text{ m})^2} + \frac{9.5 \times 10^{-6} \text{ C}}{(0.100 \text{ m} - 0.040 \text{ m})^2}\right]\hat{\mathbf{x}} \\ &= \boxed{(5.9 \times 10^7 \text{ N/C})\hat{\mathbf{x}}} \end{aligned}$$

31. (a) The forces balance. So, the force due to the electric field must be opposite to that due to gravity. And, since the charge is negative, the electric field must be directed downward.

$$qE = mg$$

$$E = \frac{mg}{q}$$

$$\mathbf{E} = \frac{mg}{q}(-\hat{\mathbf{y}}) = -\frac{(0.012 \text{ kg})(9.81 \frac{\text{m}}{\text{s}^2})}{3.6 \times 10^{-6} \text{ C}}\hat{\mathbf{y}} = \boxed{(-3.3 \times 10^4 \text{ N/C})\hat{\mathbf{y}}}$$

- (b) Since the downward force due to gravity was balanced by the upward force due to the electric field, and since the charge on the object has now increased, the acceleration will be upward.

$$F_q - F_g = ma$$

$$2qE - mg = ma$$

$$2q\left(\frac{mg}{q}\right) - mg = ma$$

$$mg = ma$$

$$a = g$$

So, the acceleration is $\boxed{(9.81 \text{ m/s}^2)\hat{y}}$.

$$51. \text{ (a) } E = \frac{kq}{r^2} = \frac{(8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2})(4.2 \times 10^{-6} \text{ C})}{(1.5 \text{ m})^2} = \boxed{1.7 \times 10^4 \text{ N/C}}$$

$$\text{(b) } \Sigma F_y = T + F_q - mg = 0$$

$$T = mg - F_q$$

$$= mg - \frac{kq_1q_2}{r^2}$$

$$= (0.025 \text{ kg})(9.81 \frac{\text{m}}{\text{s}^2}) - \frac{(8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2})(3.1 \times 10^{-6} \text{ C})(4.2 \times 10^{-6} \text{ C})}{(1.5 \text{ m})^2}$$

$$= \boxed{0.19 \text{ N}}$$