p465 1, 2, 3, 6, 7, 10, 12, 14, 18, 21, 23, 25, 27, 30, 31, 35, 41

① $F = k\frac{q_1 q_2}{r^2} = \frac{(8.99\times10^9\,Nm^2C^{-2})(3.6\times10^{-6}\,C)(3.6\times10^{-6}\,C)}{(0.093\,m)^2}$

$= \underline{13\,N}$

② $\frac{30\times10^{-6}\,C}{1.6\times10^{-19}\,C} = \underline{1.88\times10^{14}\text{ electrons}}$

③ $F = k\frac{q_1 q_2}{r^2} = \frac{(8.99\times10^9\,Nm^2C^{-2})(26\times1.6\times10^{-19}\,C)(1.6\times10^{-19}\,C)}{(1.5\times10^{-12}\,m)^2}$

$= \underline{2.7\times10^{-3}\,m}$

⑥ $F \propto \frac{1}{r^2}$ so if $r' = \frac{r}{8}$ the force is $\underline{64 \text{ times}}$ larger

⑦ $F_2 = 3F_1$

$\frac{\cancel{kq_1q_2}}{r_2^2} = 3\frac{\cancel{kq_1q_2}}{r_1^2}$

$r_2 = \frac{r_1}{\sqrt{3}} = \frac{(0.0845\,m)}{\sqrt{3}} = 0.0488\,m$

⑩ $F_E = k\frac{q_1 q_2}{r^2} = \frac{(8.99\times10^9\,Nm^2C^{-2})(1.6\times10^{-19}\,C)(1.6\times10^{-19}\,C)}{(0.53\times10^{-10}\,m)^2}$

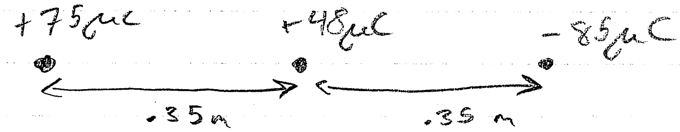
$= 8.2\times10^{-8}\,N$

$F_G = \frac{Gm_1m_2}{r^2} = \frac{(6.67\times10^{-11}\,Nm^2kg^{-2})(9.11\times10^{-31}\,kg)(1.67\times10^{-27}\,kg)}{(0.53\times10^{-10}\,m)^2}$

$= 3.6\times10^{-47}\,N$

$\frac{F_E}{F_G} = \frac{8.2\times10^{-8}\,N}{3.6\times10^{-47}\,N} = \underline{2.3\times10^{39}}$

12



F on +75μC

$$F = \frac{(8.99\times10^9\ Nm^2c^{-2})(75\times10^{-6}C)(48\times10^{-6}C)}{(.35m)^2} = -264.2N$$

$$F = \frac{(8.99\times10^9\ Nm^2c^{-2})(75\times10^{-6}C)(85\times10^{-6}C)}{(.70m)^2} = 116.96N$$

F_{net} = 150 N left

F on +48μC

$$F = \frac{(8.99\times10^9\ Nm^2c^{-2})(48\times10^{-6}c)(75\times10^{-6})}{(.35m)^2} = 264.2N$$

$$F = \frac{(8.99\times10^9\ Nm^2c^{-2})(48\times10^{-6}c)(85\times10^{-6}c)}{(.35m)^2} = 299.4N$$

F_{net} = 560 N right

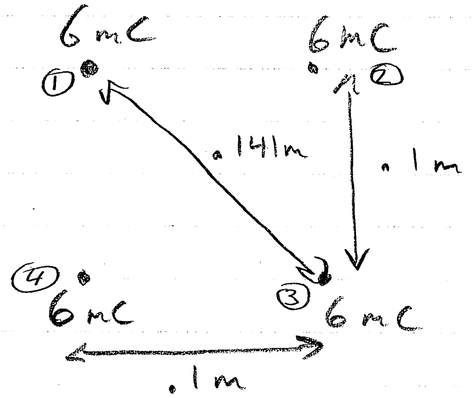
F on −85μC

$$F = \frac{(8.99\times10^9\ Nm^2c^{-2})(85\times10^{-6}c)(75\times10^{-6}c)}{(.70m)^2} = -116.96N$$

$$F = \frac{(8.99\times10^9\ Nm^2c^{-2})(85\times10^{-6}c)(48\times10^{-6}c)}{(.35m)^2} = -299.4N$$

F_{net} = 420 N left

14



The magnitude of the force on each charge will be the same (it is a square and all the charges are identical)

(Calculation done for force on ①)

$$F_{12} = F_{14} = \frac{k q_1 q_2}{r^2} = \frac{(8.99\times10^9\ Nm^2C^{-2})(6\times10^{-3}C)(6\times10^{-3}C)}{(.1m)^2}$$
$$= 3.24\times10^7\ N$$

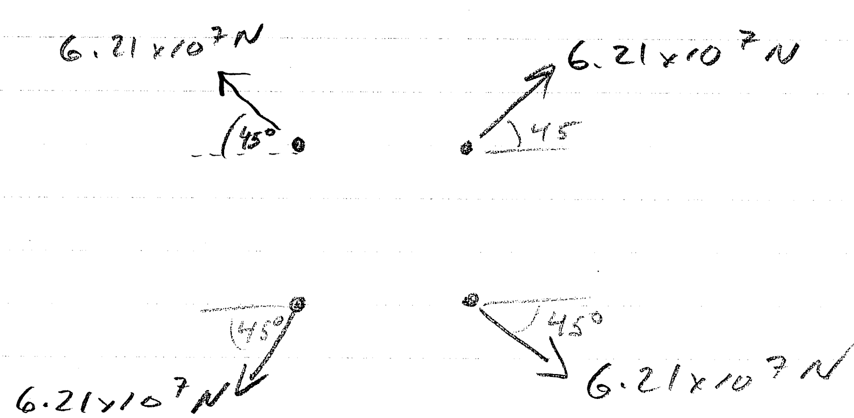
$$F_{13} = \frac{k q_1 q_3}{r^2} = \frac{(8.99\times10^9\ Nm^2C^{-2})(6\times10^{-3}C)(6\times10^{-3}C)}{(.141m)^2}$$
$$= 1.63\times10^7\ N$$

$$F_x = -F_{12} + -F_{13}\cos 45 = -3.24\times10^7 N - 1.63\times10^7 N \cos 45$$
$$= -4.39\times10^7\ N$$

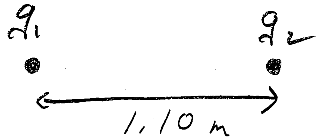
$$F_y = F_{14} + F_{13}\sin 45 = 3.24\times10^7 N + 1.63\times10^7 N \sin 45$$
$$= 4.39\times10^7\ N$$

$$F_{net} = \sqrt{(-4.39\times10^7 N)^2 + (4.39\times10^7 N)^2} = 6.21\times10^7\ N$$

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{4.39\times10^7 N}{4.39\times10^7 N}\right) = 45^\circ$$



(18)



$q_1 + q_2 = 560\,\mu C$

$q_2 = 560 \times 10^{-6} - q_1$

$F = 22.8\,N$ repulsive

$F = k\dfrac{q_1 q_2}{r^2}$

$22.8\,N = \dfrac{(8.99 \times 10^{9}\ Nm^2C^{-2})\, q_1\,(560 \times 10^{-6} - q_1)}{(1.10\,m)^2}$

$3.07 \times 10^{-9} = q_1\, 560 \times 10^{-6} - q_1^{\,2}$

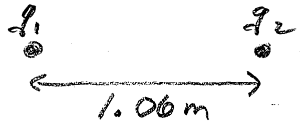
$q_1^{\,2} - 560 \times 10^{-6} q_1 + 3.07 \times 10^{-9} = 0$

$q_1 = \dfrac{560 \times 10^{-6} \pm \sqrt{(560 \times 10^{-6})^2 - 4(1)(3.07 \times 10^{-9})}}{2(1)}$

$q_1 = \underline{5.54 \times 10^{-4}\,C}\,,\ 5.55 \times 10^{-6}\,C$

$q_2 = \underline{6.00 \times 10^{-6}\,C}\,,\ 5.54 \times 10^{-4}\,C$

(21)



$q_1 + q_2 = 90.0\,\mu C$

(a) $F = 12.0\,N$ repulsive

$q_2 = 90.0 \times 10^{-6}\,C - q_1$

$F = k\dfrac{q_1 q_2}{r^2}$

$12\,N = \dfrac{(8.99 \times 10^{9}\ Nm^2C^{-2})\, q_1\,(90 \times 10^{-6} - q_1)}{(1.06\,m)^2}$

$1.5 \times 10^{-9} = 90 \times 10^{-6} q_1 - q_1^{\,2}$

$q_1^{\,2} - 90 \times 10^{-6} q_1 + 1.5 \times 10^{-9} = 0$

$q_1 = \dfrac{90 \times 10^{-6} \pm \sqrt{(90 \times 10^{-6})^2 - 4(1)(1.5 \times 10^{-9})}}{2(1)}$

$q_1 = \underline{6.79 \times 10^{-5}\,C}\,,\ 2.21 \times 10^{-5}\,C$

$q_2 = \underline{2.21 \times 10^{-5}\,C}\,,\ 6.79 \times 10^{-5}\,C$

(21) (b) $q_1 + q_2 = 90.0\,\mu C$, $F = 12.0N$ attractive

$q_1 = 90\times10^{-6} - q_2$

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

$$-12 = \frac{(8.99\times10^{9})(90\times10^{-6} - q_2)q_2}{(1.06\,m)^2}$$

$$-1.5\times10^{-9} = 90\times10^{-6} q_2 - q_2^2$$

$$q_2^2 - 90\times10^{-6} q_2 - 1.5\times10^{-9} = 0$$

$$q_2 = \frac{90\times10^{-6} \pm \sqrt{(-90\times10^{-6})^2 - 4(1)(-1.5\times10^{-9})}}{2(1)}$$

$q_2 = \underline{-1.44\times10^{-5}\,C}$, $1.04\times10^{-4}C$

$q_1 = \underline{-1.04\times10^{-4}\,C}$

(23) $E = \dfrac{F}{q}$ $\quad + \xrightarrow{E} -$

$F = qE = (1.6\times10^{-19}\,C)(2360\,NC^{-1}) = \underline{3.78\times10^{-16}N}$ towards West

(25) $q = -8.8\,\mu C$, F

$E = \dfrac{F}{q} = \dfrac{8.4N}{8.8\times10^{-6}C} = \underline{9.5\times10^{5}\,NC^{-1}\text{ up}}$

(27) $E = \dfrac{F}{q}$

$F = qE$

$ma = qE$

$$a = \frac{qE}{m} = \frac{(1.6\times10^{-19}C)(750\,NC^{-1})}{(9.11\times10^{-31}kg)} = \underline{1.3\times10^{14}\,ms^{-2}}$$

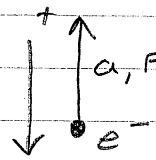
the acceleration is in the direction opposite to the electric field at that point

(30) $a = 1\times10^{6}g$

$$E = \frac{F}{q} = \frac{ma}{q} = \frac{(1.67\times10^{-27}kg)(1\times10^{6})(9.81ms^{-2})}{1.6\times10^{-19}C}$$

$$E = 0.1 \ NC^{-1}$$

(31)



$$E = \frac{F}{q} = \frac{ma}{q} = \frac{(9.11\times10^{-31}kg)(115ms^{-2})}{(1.6\times10^{-19}C)}$$

$$E = 6.55\times10^{-10} \ NC^{-1} \text{ south.}$$

(35)

$$E = \frac{F}{q} = \frac{k\cancel{q_1}q_2}{\cancel{q}r^2}$$

$$E = \frac{kQ}{(x+a)^2} - \frac{kQ}{(x-a)^2}$$

$$= \frac{kQ(x-a)^2 - kQ(x+a)^2}{(x+a)^2(x-a)^2}$$

$$= \frac{kQ\left((x^2-2ax+a^2)-(x^2+2ax+a^2)\right)}{(x^2+2ax+a^2)(x^2-2ax+a^2)}$$

$$= \frac{kQ(\cancel{x^2}-2ax\cancel{+a^2}\cancel{-x^2}-2ax\cancel{-a^2})}{(x^4\cancel{-2ax^3}+a^2x^2\cancel{+2ax^3}-4a^2x^2\cancel{+2a^3x}+a^2x^2\cancel{-2a^3x}+a^4)}$$

$$= \frac{-kQ4ax}{(x^4-2a^2x^2+a^4)}$$

$$= \frac{kQ4ax}{(x^2-a^2)^2} \text{ to the left}$$

(41) (a) $F = qE$

$ma = qE$

$a = \frac{qE}{m}$

$$v^2 = \cancel{u^2} + 2as = \sqrt{\frac{2qEs}{m}} = \sqrt{\frac{2(1.6\times10^{-19}C)(1.45\times10^{4}NC^{-1})(.011m)}{9.11\times10^{-31}kg}}$$

$$\underline{V = 7.49\times10^{6} \ ms^{-1}}$$

41(b) time to cross gap

$$v = \cancel{u} + at$$

$$\sqrt{\frac{2qEs}{m}} = \frac{qE}{m} t$$

$$t = \sqrt{\frac{2ms}{qE}} = \sqrt{\frac{2(9.11 \times 10^{-31}\,kg)(0.011\,m)}{(1.6 \times 10^{-19}\,C)(1.45 \times 10^{4}\,NC^{-1})}} = 2.94 \times 10^{-9}\,s$$

distance electron will fall in that time

$$s = \cancel{ut} + \frac{1}{2}at^2 = \frac{1}{2}(9.81\,ms^{-2})(2.94 \times 10^{-9}\,s)^2$$

$$= 4.24 \times 10^{-17}\,m$$

The electron will drop 4.24×10^{-17} m in the time it takes to cross the gap, this is small enough to safely ignore the gravitational force.