EM Fields Review

① $F_e = k\frac{q_1 q_2}{r^2}$

$\therefore F_e \propto \frac{1}{r^2}$

If r is doubled, then F is multiplied by $\frac{1}{2^2}$

$\therefore$ The new force would be $\boxed{\frac{F}{4}}$.

② $F_e \propto q$

If q is doubled, F is doubled

Since <u>both</u> charges are doubled, F is doubled <u>twice</u>.

$\therefore$ The new force would be $\boxed{4F}$.

③ $F_e \propto \frac{1}{r^2}$ ($r \times 2 \rightarrow F \times \frac{1}{4}$, see #1 above)

$\therefore 4 \times 10^{-5}\ N \times \frac{1}{4} = \boxed{1 \times 10^{-5}\ N}$

④ $F_e \propto q$ ($q \times 2 \rightarrow F \times 2$, see #2 above)

$F_e \propto \frac{1}{r^2}$ ($r \times 2.5 \rightarrow F \times \frac{1}{(2.5)^2}$)

$\therefore 2.5 \times 10^{-4} \times 2 \times \frac{1}{(2.5)^2} = \boxed{8 \times 10^{-5}\ N}$

(5) $F_e = \frac{kQq}{r^2}$

$$4 \times 10^{-7} = \frac{9 \times 10^{9}\, Q^2}{(0.03)^2}$$

$$Q = \sqrt{\frac{(4 \times 10^{-7})(0.03)^2}{9 \times 10^{9}}}$$

$$Q = \boxed{\pm 2 \times 10^{-10}\ C}$$

(6) $F_e = \frac{kQq}{r^2}$

$$-350 = \frac{(9 \times 10^{9})(4 \times 10^{-5})\, q}{(0.1)^2}$$

$$q = -\frac{(350)(0.1)^2}{(9 \times 10^{9})(4 \times 10^{-5})} = \boxed{-9.7 \times 10^{-6}\ C}$$

Note: F_e was negative b/c the force is attractive.

(7)

(A) — 12 cm — (B) —— 24 cm —— (C)

+4.6   −2.3   −2.3

$$F_A = \frac{kQ_AQ_B}{r^2} = \frac{(9 \times 10^{9})(4.6 \times 10^{-6})(2.3 \times 10^{-6})}{(0.12)^2}$$

$F_A = 6.6125$ N [Left] (b/c A attracts B)

(7) continued

$$F_C = \frac{kQ_BQ_C}{r^2} = \frac{(9\times10^9)(2.3\times10^{-6})(2.3\times10^{-6})}{(0.24)^2}$$

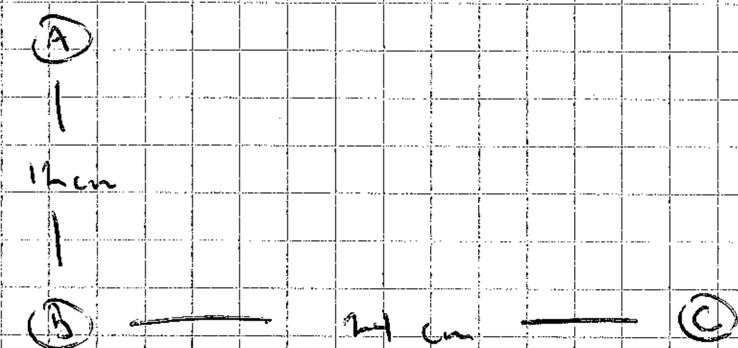
$F_C = 0.8266$ N [Left] (b/c C repels B)

$\Sigma F = F_A + F_C$

$= 6.6125$ N [L] $+ 0.8266$ N [L]

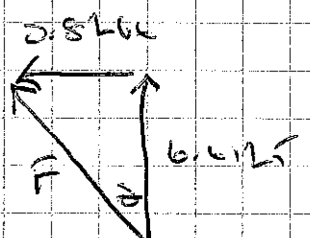
$\Sigma F = 7.4$ N [Left]

(8)



$F_A = 6.6125$ N [North] (b/c A attracts B)

$F_C = 0.8266$ N [West] (b/c C repels B)



$F^2 = 0.8266^2 + 6.6125^2$

$F = 6.7$ N [$7.1°$ W of N]

$$\theta = \tan^{-1}\left(\frac{0.8266}{6.6125}\right)$$

$\theta = 7.1°$

(9) $E = \frac{F_e}{q} = \frac{4.5 \times 10^{-5}}{6.5 \times 10^{-6}} = \boxed{6.9 \ N/C}$

(10) $W = q\Delta V$

$8 \times 10^{-3} = 4 \times 10^{-6} \ \Delta V$

$\Delta V = \boxed{2000 \ V}$

(11) $W = q\Delta V$

$= (2.5 \times 10^{-6})(60)$

$W = \boxed{1.5 \times 10^{-4} \ J}$

(12) $W = q\Delta V$

$= (100)(900\,000\,000)$

$W = \boxed{9 \times 10^{10} \ J}$

(13) $E = \frac{V}{d}$

$V = E \cdot d = (750)(0.015) = \boxed{11.25 \ V}$

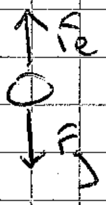
(14) $E = \frac{V}{d} = \frac{450}{0.02} = \boxed{22\,500 \ V/m}$

(15) $V = E \cdot d = (2.5 \times 10^{3})(0.08) = \boxed{200 \ V}$

(16) $E = \frac{V}{d}$

$d = \frac{V}{E} = \frac{600}{1.2\times10^{4}} = \boxed{0.05\ m}$

(17)



$F_e = F_g$

$qE = mg$

$q\frac{V}{d} = mg$

$q = \frac{mgd}{V}$

$= \frac{(2.6\times10^{-15})(9.8)(0.005)}{270}$

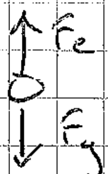
$q = \boxed{4.7\times10^{-19}\ C}$

$q = \pm Ne$

$4.7\times10^{-19} = \pm N(1.6\times10^{-19})$

$N = \boxed{\pm 3}$

(18)



$$F_e = F_g$$

$$qE = mg$$

$$q\frac{V}{d} = mg$$

$$V = \frac{mgd}{q}$$

$$= \frac{(1\times10^{-4})(9.8)(0.25)}{(5\times10^{-6})}$$

$$V = \boxed{49\ V}$$

(19) $W = q\Delta V$ $\quad W = \Delta E_K$

$$q\Delta V = \Delta E_K$$

$$(1.6\times10^{-19})(500) = \tfrac{1}{2}(9.1\times10^{-31})v^2 - 0$$

$$v = \sqrt{\frac{2(1.6\times10^{-19})(500)}{(9.11\times10^{-31})}}$$

$$v = \boxed{1.33\times10^{7}\ m/s}$$

(20) $q\Delta V = \Delta E_K$

$(1.6\times10^{-19})\Delta V = \frac{1}{2}(9.1\times10^{-31})(1\times10^6)^2 = \frac{1}{2}(9.1\times10^{-31})(5\times10^6)^2$

$(1.6\times10^{-19})\Delta V = -1.092\times10^{-17}$

$\Delta V = \boxed{-68\ V}$

(the negative indicates polarity)

(21) Out of the page.

(22) Down

(23) $F = qvB$

$= (1.6\times10^{-19})(3\times10^7)(2\times10^{-4})$

$F = \boxed{9.6\times10^{-16}\ N\ [\text{into the page}]}$

(24) $v = \frac{E}{B}$

$B = \frac{E}{v} = \frac{4\times10^4}{8.5\times10^7} = \boxed{4.7\times10^{-4}\ T}$

(25) $\Sigma F = F_B$

$\frac{mv^2}{r} = qvB$

$B = \frac{mv}{rq} = \frac{(9.1\times10^{-31})(2\times10^8)}{(0.5)(1.6\times10^{-19})} = \boxed{0.0023\ T}$

(26) $\frac{mv^2}{r} = qvB$

$r = \frac{mv}{qB}$

$= \frac{(9.1\times10^{-31})(2\times10^{5})}{(1.6\times10^{-19})(41\times10^{-3})}$

$r = \boxed{0.028 \text{ m}}$

(27) Part 1 Accelerated

$W = q\Delta V \qquad W = \Delta E_k$

$q\Delta V = \frac{1}{2}mv_f^2 - 0$

$v_f = \sqrt{\frac{2q\Delta V}{m}}$

Part 2 Curved Path

$\frac{mv^2}{r} = qvB$

$v = \frac{qBr}{m}$

Continued on Next Page

(27) Equate the 2 velocity expressions

$$\sqrt{\frac{2q\Delta V}{m}} = \frac{qBr}{m}$$

$$\frac{2q\Delta V}{m} = \frac{q^2B^2r^2}{m^2}$$

$$2\Delta V = \frac{qB^2r^2}{m}$$

$$\frac{2\Delta V}{B^2r^2} = \frac{q}{m}$$

$$\frac{q}{m} = \frac{2(150)}{(50\times10^{-3})^2(0.098)^2} = \boxed{1.25\times10^7\ C/Kg}$$

(28) Doubly ionized means $q = 2e = 2(1.6\times10^{-19})$

The work for this is identical to question 27, so see above for the setup.

$$\frac{2\Delta V}{B^2r^2} = \frac{q}{m}$$

$$m = \frac{qB^2r^2}{2\Delta V}$$

$$= \frac{2(1.6\times10^{-19})(75\times10^{-3})^2(0.083)^2}{2(232)}$$

$$m = \boxed{2.67\times10^{-26}\ Kg}$$

(29) H^+ ; $q = +1.6 \times 10^{-19}$ C

Same setup as in question 27.

$$\frac{2 \Delta V}{B^2 r^2} = \frac{q}{m}$$

$$r = \sqrt{\frac{2 m \Delta V}{q B^2}}$$

$$= \sqrt{\frac{2(1.67 \times 10^{-27})(100)}{(1.6 \times 10^{-19})(50 \times 10^{-3})^2}}$$

$$r = \boxed{0.029 \text{ m}}$$