Charges in E Fields

① $W = q\Delta V$

$0.24 = q(150)$

$q = \boxed{0.0016\ C}$

② a) $q = 2e = 2(1.6\times10^{-19}) = 3.2\times10^{-19}\ C$

$W = \Delta E_k$

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

$(3.2\times10^{-19})(2000) = \frac{1}{2}(6.6\times10^{-27})v_f^2 - 0 \qquad (v_i = 0)$

$v_f = \sqrt{\frac{2(3.2\times10^{-19})(2000)}{(6.6\times10^{-27})}}$

$v_f = \boxed{440\ 386\ m/s}$

b) From the midpoint, the potential difference would be half as much.

$\Delta V = 1000\ V$

$W = \Delta E_k$

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

$(3.2\times10^{-19})(1000) = \frac{1}{2}(6.6\times10^{-27})v_f^2 - 0$

$v_f = \sqrt{\frac{2(3.2\times10^{-19})(1000)}{(6.6\times10^{-27})}}$

$v_f = \boxed{311\ 400\ m/s}$

3 a) $W = q\Delta V$

$= (4 \times 10^{-7})(800)$

$W = \boxed{3.2 \times 10^{-4}\ J}$

b) $W = F \cdot d$

$3.2 \times 10^{-4} = F(0.5)$

$F = \boxed{6.4 \times 10^{-4}\ N}$

c) $W = \Delta E_k$

$= E_k' - E_k$

$W = E_k'$

$E_k' = \boxed{3.2 \times 10^{-4}\ J}$

d) $E_k' = \frac{1}{2} m v_f^2$

$3.2 \times 10^{-4} = \frac{1}{2}(1 \times 10^{-5})\, v_f^2$

$v_f = \sqrt{\frac{2(3.2 \times 10^{-4})}{(1 \times 10^{-5})}}$

$v_f = \boxed{8\ m/s}$

④ $\Delta E_k = -\Delta E_e$

$$= -\left(\frac{kQq}{r_2} - \frac{kQq}{r_1}\right)$$

$$= -kQq\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$$

$$= -(9\times10^{9})(1.6\times10^{-19})(1.6\times10^{-19})\left(0 - \frac{1}{10^{-12}}\right)$$

0 because r_2 = infinity

$$= 2.304\times10^{-16}\ J \quad \text{total}$$

But, since both charges are moving, they will each have half of this.

$\therefore$ $\boxed{1.152\times10^{-16}\ J}$

$$\frac{1}{2}mv_f^2 = E_k$$

$$\frac{1}{2}(9.11\times10^{-31})v_f^2 = 1.152\times10^{-16}$$

$$v_f = \sqrt{\frac{2(1.152\times10^{-16})}{(9.11\times10^{-31})}}$$

$$v_f = \boxed{15\ 903\ 109\ m/s}$$

5 $W = \Delta E_K$

$q\Delta V = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$(1.6\times10^{-19})\,\Delta V = \frac{1}{2}(3.3\times10^{-27})\,(5\times10^{6})^2$

$\Delta V = \boxed{257\ 813\ V}$

6 a) $\Sigma F = F_e$

$ma = qE$

$a = \frac{(1.6\times10^{-19})(300)}{(9.11\times10^{-31})}$

$a = \boxed{5.27\times10^{13}\ m/s^2}$

b) $v_f = v_i + at$

$= 0 + (5.27\times10^{13})(1\times10^{-8})$

$v_f = \boxed{526\ 894\ m/s}$

7 a) $F_e = qE$

$= (1.6\times10^{-19})(2000)$

$F_e = \boxed{3.2\times10^{-16}\ N}$

b) $\Sigma F = F_e$

$ma = F_e$

$a = \frac{3.2\times10^{-16}}{1.67\times10^{-27}} = \boxed{1.92\times10^{11}\ m/s^2}$

7 c) $v_f = v_i + at$

$1 \times 10^6 = 0 + (1.92 \times 10^{11}) t$

$t = \dfrac{1 \times 10^6}{1.92 \times 10^{11}}$

$t = 5.22 \times 10^{-6}$ s

8 a) $v = 0.01c = 0.01(3 \times 10^8) = 3.0 \times 10^6$ m/s

$v_f^2 = v_i^2 + 2ad$

$(3 \times 10^6)^2 = 0^2 + 2a(0.002)$

$a = \dfrac{(3 \times 10^6)^2}{2(0.002)}$

$a = 2.25 \times 10^{15}$ m/s^2

$\Sigma F = F_e$

$ma = qE$

$(9.11 \times 10^{-31})(2.25 \times 10^{15}) = (1.6 \times 10^{-19}) E$

$E = \boxed{12\ 811 \text{ N/C}}$

b) $v_f^2 = v_i^2 + 2ad$

$v_f = \sqrt{0^2 + 2(2.25 \times 10^{15})(0.004)}$

$v_f = \boxed{4\ 242\ 641 \text{ m/s}}$

⑨ $W = \Delta E_k$

$F_e \cdot d = \Delta E_k$

$qEd = \Delta E_k$

$(1.6 \times 10^{-19})\, E\, (1.25) = 0 - 3.25 \times 10^{-15}$

$$E = \frac{-3.25 \times 10^{-15}}{(1.25)(1.6 \times 10^{-19})}$$

$$E = \boxed{-16\ 250\ \text{N/C}}$$