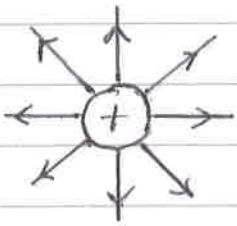
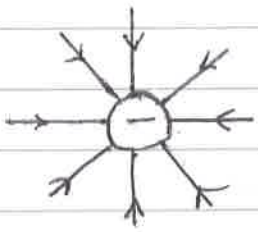
Unit 2: Particles and Waves

Forces on Charged Particles

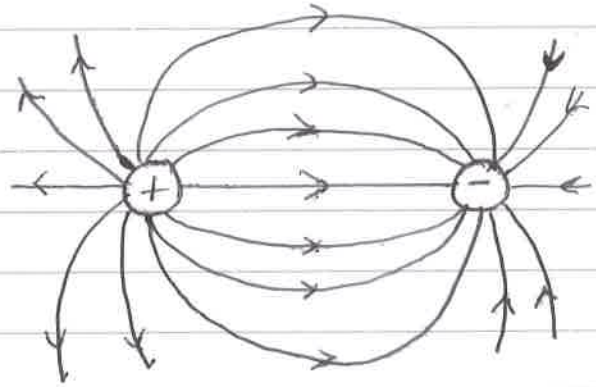
(1) a)



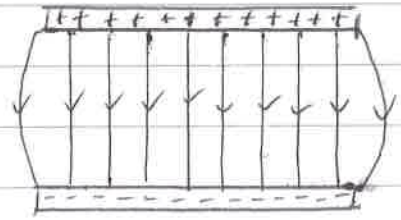
b)



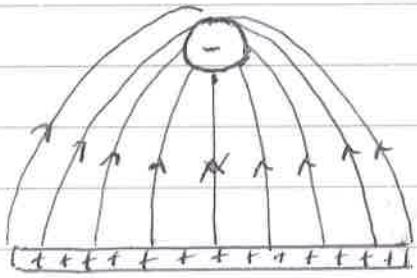
c)



d)



e)



(2) $W = QV$

$= 1.6 \times 10^{-19} \times 1$

$= 1.6 \times 10^{-19} J$

$1eV = 1.6 \times 10^{-19} J$

(3) $5 MeV = 5 \times 10^{6} \times 1.6 \times 10^{-19}$

$= 8 \times 10^{-13} J$

(4) a) $W = QV$
$= 500 \times 1.6 \times 10^{-19}$
$= 8 \times 10^{-17} J$

b) $E_K = W$
$= 8 \times 10^{-17} J$

c) $E_K = \frac{1}{2} m v^2$
$8 \times 10^{-17} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$
$v^2 = 1.76 \times 10^{14}$
$v = 1.33 \times 10^{7} ms^{-1}$

(5) a) $W = QV$
$= 1.6 \times 10^{-19} \times 2000$
$= 3.2 \times 10^{-16} J$

b) $E_K = W$
$= 3.2 \times 10^{-16}$
$= \frac{1}{2} m v^2$
$3.2 \times 10^{-16} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$
$v^2 = 7 \times 10^{14}$
$v = 2.7 \times 10^{7} ms^{-1}$

(6) $E_K = W$
$\frac{1}{2} m v^2 = QV$
$\frac{1}{2} \times 1.7 \times 10^{-27} \times v^2 = 1.6 \times 10^{-19} \times 12\,000$
$8.5 \times 10^{-28} v^2 = 1.92 \times 10^{-15}$
$v^2 = 2.26 \times 10^{12}$
$v = 1.5 \times 10^{6} ms^{-1}$

(7) $W = E_K$
$= 1.2 \times 10^{-12}$
$= QV$
$1.2 \times 10^{-12} = 1.6 \times 10^{-19} V$
$V = 7.5 \times 10^{6} V$

(8) $W = E_K$

$QV = \frac{1}{2}mv^2$

$1.6\times10^{-19}V = \frac{1}{2} \times 9.1\times10^{-31} \times 2.5\times10^{13}$

$1.6\times10^{-19}V = 1.14\times10^{-17}$

$V = 71V$

(9) a) $W = QV$

$= 1.6\times10^{-19} \times 25\,000$

$= 4\times10^{-15}J$

$E_K = W$

$= 4\times10^{-15}J$

b) $E_K = \frac{1}{2}mv^2$

$4\times10^{-15} = \frac{1}{2}\times9.1\times10^{-31}\times v^2$

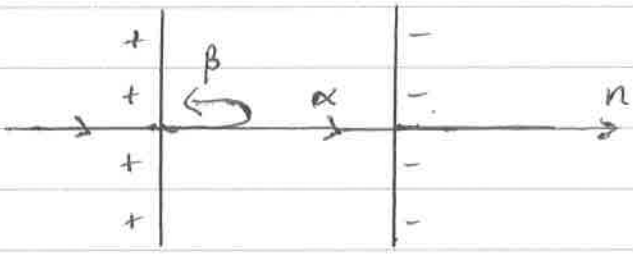
$v^2 = 8.8\times10^{15}$

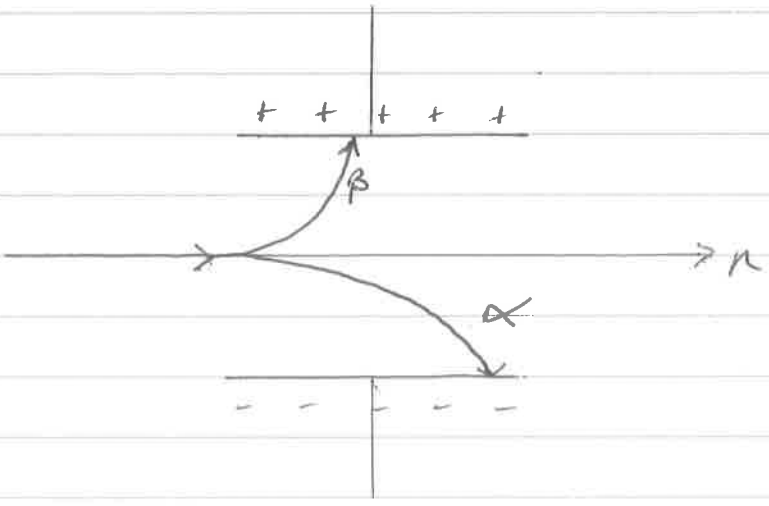
$v = 9.4\times10^{7}ms^{-1}$

c) no. of electrons $= \frac{3\times10^{-3}C/s}{1.6\times10^{-19}C} = 1.88\times10^{16}$

d) The kinetic energy is converted into heat energy and x-rays are produced.

(10)





(11) This information tells us the electron is moving parallel to the magnetic field.

(12) D

(13) a) No change b) Out of the paper

c) Into the paper d) No change

e) Up f) Left

g) Left h) Down

(14) The energy which does not change is the kinetic energy of the electron which is determined by the mass of the electron and the speed of the electron. Neither of these quantities changes in the field. However the electron accelerates which means there must be a change in velocity per unit time. Velocity (unlike speed) is a vector quantity - determined by magnitude and direction. The magnitude does not change but the direction does in the magnetic field. Hence the electron accelerates.

(15) a) $W = QV$

$= 1.6 \times 10^{-19} \times 2500$

$= 4 \times 10^{-16} J$

b) $E_K = W$

$= 4 \times 10^{-16}$

$E_K = \frac{1}{2} m v^2$

$4 \times 10^{-16} = \frac{1}{2} \times 9.1 \times 10^{-31} v^2$

$v^2 = 8.8 \times 10^{14}$

$v = 2.96 \times 10^7 ms^{-1}$

c) no. of electrons $= \frac{3m C/s}{1.6 \times 10^{-19}} = 1.88 \times 10^{16}$

d) The collisions which occur as a result of particles travelling to a target at a high speed allow scientists to see their sub atomic structure.

(16) a) $I = \frac{P}{V}$

$= \frac{30}{15000}$

$= 2 \times 10^{-3} A$

$= 2 \times 10^{-3} C/s$

no. of electrons

$= \frac{2 \times 10^{-3}}{16 \times 10^{-19}}$

$= 1.25 \times 10^{16}$

(16) b) $E_K = W$

$\frac{1}{2} m v^2 = QV$

$\frac{1}{2} \times 9.1 \times 10^{-31} \times v^2 = 1.6 \times 10^{-19} \times 15\,000$

$v^2 = 5.27 \times 10^{15}$

$v = 7.26 \times 10^7 \text{ ms}^{-1}$

(17) a) $W = QV$

$= 1.6 \times 10^{-19} \times 25\,000$

$= 4 \times 10^{-15} \text{ J}$

$E_K = W$

$= 4 \times 10^{15} \text{ J}$

b) $E_K = \frac{1}{2} m v^2$

$4 \times 10^{15} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$

$v^2 = 8.8 \times 10^{15}$

$v = 9.37 \times 10^7 \text{ ms}^{-1}$

c) no. of electrons $= \frac{5 \times 10^{-3} \text{ C/s}}{1.6 \times 10^{-19} \text{ C}} = 3.12 \times 10^{16}$

d) Changes to heat energy and x-rays are produced.

(18) a) i) $W = QV$

$= 1.6 \times 10^{-19} \times 1000$

$= 1.6 \times 10^{-16} \text{ J}$

ii) $E_W = F d$

$1.6 \times 10^{-16} = F \times 5 \times 10^{-4}$

$F = 3.2 \times 10^{-13} \text{ N}$

iii) $F = ma$

$3.2 \times 10^{-13} = 9.1 \times 10^{-31} a$

$a = 3.52 \times 10^{19} \text{ ms}^{-2}$

(18) a) iv) $u = 0\ ms^{-1}$ $\quad v = ?$ $\quad a = 3.52 \times 10^{15}\ ms^{-2}$ $\quad s = 5 \times 10^{-4}\ m$

$v^2 = u^2 + 2as$

$v^2 = 0 + 2 \times 3.52 \times 10^{15} \times 5 \times 10^{-4}$

$= 3.52 \times 10^{12}$

$v = 1.88 \times 10^{6}\ ms^{-1}$

$v = u + at$

$1.88 \times 10^{6} = 0 + 3.52 \times 10^{15} t$

$t = 5.3 \times 10^{-10} s$

v) $t = \frac{d}{v} = \frac{0.12 \times 10^{-2}}{1.88 \times 10^{6}} = 6.4 \times 10^{-10} s$

b) i) The speed would be the same as Q and V have remained the same.

ii) The time would be greater as the acceleration is smaller.

(19) a) Negative b) Positive

c) Positive d) Negative

(20)

A = alternating electric fields; B = fixed-target; C = alternating electric fields; D = spiral of increasing radius; E = constant magnetic field; F = perpendicular; G = increases; H = physical size; I = relativistic effects; J = fixed-target; K = circular path of fixed radius; L = can be varied; M = alternating magnetic fields; N = increased; O = relativistic effects; P = the same; Q = opposite; R = colliding beam.