Chapter- 20 Electrons

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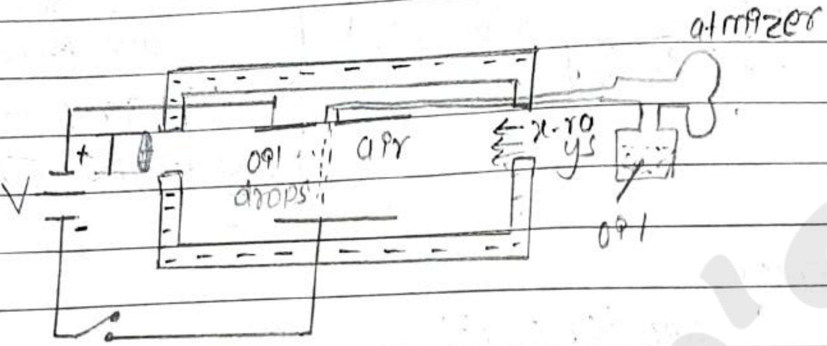
Millikans oil drop experiment: (1909 AD, Nobel Price for it in 1923 AD)

Fig (1) below shows the experimental arrangements of this experiment to determine the charges of electron.



It has two parallel metal plates A and B situated inside constant temprature chamber. Oil can be ~~seperated~~ sprayed with atomizer through the small hole in upper plate. X-rays are used to charge the balling and oil drops by ionization. A high electric field ($E = \frac{V}{d}$) can be applied between two plates with high tension battery (d being seperation between horizontal plates A and B). The fallings oil drops in air can be viewed with microscope 'M' which has scale in it. The fallings drops are with a bright light source (not shown in Fig).

Theory:- With the help of electric field, a negatively charged oil drops is taken in view, the electric field is switched off. This drop starts falling with constant terminal velocity v_1 through air under gravity. In this case, the effective

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weight of drop is equal to upward viscous force ($6\pi r\eta v_1$).
Thus,

$m'g = 6\pi r\eta v_1$ — (1)

$\therefore \frac{4}{3}\pi r^3(\rho-\sigma)g = 6\pi r\eta v_1$

$\Rightarrow r = \left[\frac{9\eta v_1}{2g(\rho-\sigma)}\right]^{1/2}$ .. (2)

{ r = radius of drop
η = viscocity of air.
m' = mass of drop − mass of air ~~dro~~ displace by drop
$= 4/3\,\pi r^3\rho - \frac{4}{3}\pi r^3\sigma$
$= \frac{4}{3}\pi r^3(\rho-\sigma)$

where,
ρ = density of oil.
σ = density of air.

Now a suitable electric feild 'E' is applied between plates and new terminal velocity v_2 of drop is found with scale in microscope and stop watch. In this case, if the drop is moving down, then

$m'g$ = upward electric force + upward viscous force

$m'g = Eq + 6\pi r\eta v_2$; q = charge on the drop .. (3)

Equating (1) and (3) we get

$6\pi r\eta v_1 = Eq + 6\pi r\eta v_2$

$Eq = 6\pi r\eta(v_1 - v_2)$

$\boxed{q = \frac{6\pi r\eta(v_1-v_2)}{E}}$ ....(4) [where $E = \frac{V}{d}$]

The radius (r) of the drop is calculated with equ. (2). Millikan repeated experiment with several drops and always found that the charge q was integral multiple of the basic charge $e = 1.6\times10^{-19}$ coulomb.

Thus,

$q = N\cdot e$; $N = 1, 2, 3 \ldots$

Thus, the electric charge is quantized.

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Note:- If the drop is moving up under electric field then v_2 in equ(4) is replaced with $-v_2$ then

$$\boxed{q = \frac{6\pi r\eta (v_1+v_2)}{E}}$$

Motion of electron in electric and magnetic field:-

If the electron is moving with velocity v in electric field E and magnetic field B then the total force on electron will be

$F = F_{ele} + F_{mag} = Ee + Bev\sin\theta$

or, $F = e[E + Bv\sin\theta]$; where θ = angle between B and v

or, $\vec{F} = e[\vec{E} + \vec{B}\times\vec{v}]$ ... (1)

Total force $\vec{F}$ is called Lorentz force.

Notes: (1) If $\vec{E}$ and $\vec{B}$ are perpendicular to each other and $\theta = 90°$, such that
$F_{ele} = F_{mag}$. Then
$Ee = Bev$

$\boxed{v = \frac{E}{B}}$ ... (2) {and the field are said to be crossed fields}.

2) If $E = 0$ and $\theta = 90°$ then electron ~~moss~~ moves in circular path because B ⊥ v and F are perpendicular to each other.

$\therefore \boxed{Bev = \frac{mv^2}{r}}$ ... (3)

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3) If charge q is moving in place of electron then e is replaced by q in equations (2) and (3)

(4) The ratio of charge and mass of an electron is called Specific charge. from equ (3)

$$\boxed{\frac{e}{m} = \frac{v}{rB}} \quad -(4)$$

Deflection of electron moving in perpendicular electric field

Let an electron moving with constant velocity u along x axis mid way between two parallel metal plates having P.D of V and separation d, with upper plate +ve.

If y is the vertical deflection of electron from original path, just after coming out of the plates then as

$a_y = \left(\frac{E.e}{m}\right)$ and $u_y = 0$

$$y = u_y t + \frac{1}{2} a_y t^2 = 0 + 1/2 \left(\frac{E.e}{m}\right) t^2$$

$$\boxed{y = \frac{1}{2}\left(\frac{E.e}{m}\right) \cdot \left(\frac{L}{u}\right)^2} \quad \left[\begin{array}{l} \because u_m = u = L/t \\ \therefore t = L/u \end{array}\right]$$

Also at exit point p.

$$\boxed{\theta = \tan^{-1}\left(\frac{v_y}{u}\right)} - (2)$$

and, $\boxed{V = \sqrt{u^2 + v_y^2}}$ --(3) where, $V_y = u_y + a_y t = 0 + \frac{Ee}{m}\left(\frac{L}{u}\right)$

* Thomson's experiment for the determination of specific charge charge $\left(\frac{e}{m}\right)$ of electron

fig. (1) below shows the basic diagram of the experimental arrangement for this experiment

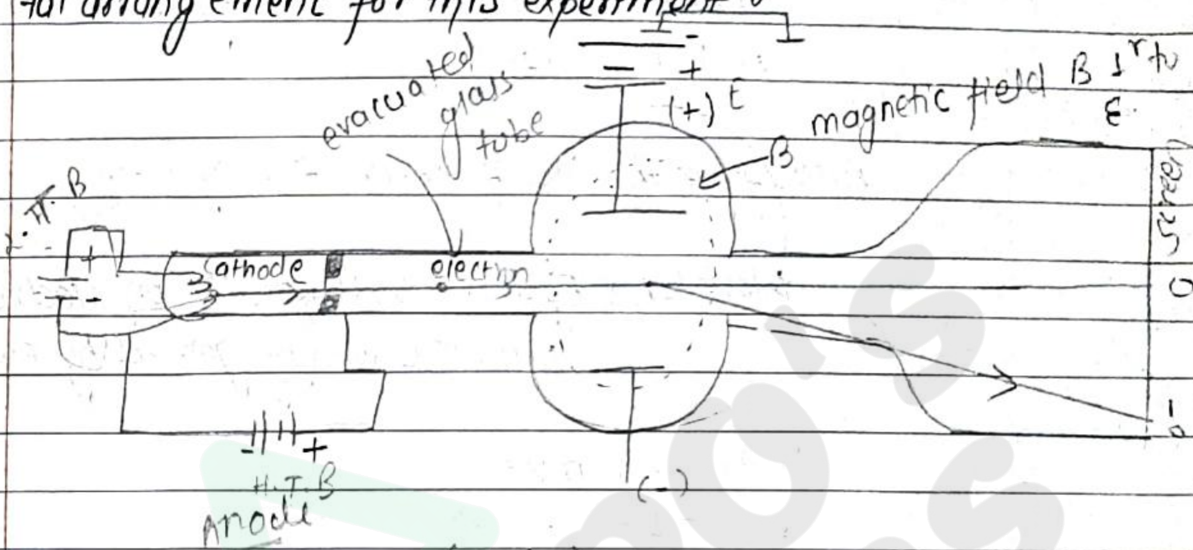

fig (1)

When electric current is passed through cathode with low tension battery (L.T.B) the cathode gets heated and electrons are emitted from cathode surface (thermionic emission). these electrons, accelerated by high voltage V of anode (with high tension battery H.T.B) move with high velocity through the narrow hole in anode and are focussed on centre 'O' of screen if both fields are switched off. A bright spot is seen at centre 'O' of screen.

Now only magnetic field B is switched ON, and it is observed that bright spot shifts to point 'O'' on screen (because electron moves in circular path in ⊥r magnetic field)

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Then with the help of variable voltage V', the electric field E is so adjusted that the bright spot again comes to point 'O' of screen. Thus

$$F_{ele} = F_{mag}$$

$$E \cdot e = Bev \text{ ; where } v = \text{velocity of electron}$$

$$\therefore v = \frac{E}{B} \quad \text{---} (1)$$

Also, from the law of conservation of energy

Workdone by anode voltage V on electron = kinetic energy gained by electron.

$$\therefore eV = 1/2\ mv^2$$

$$\therefore \frac{e}{m} = \frac{v^2}{2V} \quad \text{---} (2)$$

With equ (1) equ (2) gives

$$\frac{e}{m} = \frac{1}{2V}\left(\frac{E}{B}\right)^2$$

or, $\frac{e}{m} = \frac{1}{2V}\left(\frac{V'}{d \cdot B}\right)^2$ [where $E = V'/d$ and d = separation between two plates of electric field].

Thus with equ (3) $\frac{e}{m}$ of electron can be calculated.

The value of $\frac{e}{m}$ for electron is found to be 1.76×10^{11} coulomb kg^{-1}

Note:-

From the value of $\frac{e}{m}$, the mass of electron is calculated and its value is $m = 9.1 \times 10^{-31}$ kg.

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* Mass of proton and electron is different.

$M_e = 9.1 \times 10^{-31}$ kg

$M_p = 1836$ times of M_e

$= 1836 \times m_e$

$\therefore m_p \Rightarrow 1.7 \times 10^{-27}$ kg

* charge of electron and proton is same

$e = 1.6 \times 10^{-19}$ C.

* 1 electron volt $= 1.6 \times 10^{-19}$ J.

* In $\perp^r$ mag field

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

* angular velocity (v) = ~~1.6×10~~ $r\omega$ (ω = omega)

* Omega (ω) = $2\pi f$ (f = frequency)

* K.E = $1/2\ mv^2$. * Momentum = $m \times v$ (Newton sec)

* Numerical:-

① An electron having energy 500 eV moves at right angles to the uniform ~~velocity of~~ magnetic field of 20×10^{-3} Tesla. Find the radius of the circular path $\left(\frac{e}{m} = 1.76\times10^{11}\ Ckg^{-1}\right)$

⇒ soln;

here; for electron moving in ⊥r magnetic field.

$KE = 500\,eV$

$= 500\times 1.6\times10^{-19}\,J \quad (\because 1\,eV = 1.6\times10^{-19}\,J)$

$= 8\times10^{-17}\,J$

radius $(r) = ?$ $\quad B = 20\times10^{-3}$ Tesla.

we know,

$KE = 1/2\, mv^2$

$v = \sqrt{\frac{2KE}{m}}$

$= \sqrt{\frac{2\times8\times10^{-17}}{9.1\times10^{-31}}} \quad (\because m_e = 9.1\times10^{-31}\,kg)$

$= 1.325\times10^{-24}\,ms^{-1}$

Now,

$Bev = \frac{mv^{\cancel{2}}}{r}$

or, $r = \frac{mv}{Be}$

or, $r = \frac{v}{B\cdot\left(\frac{e}{m}\right)} = \frac{1.325\times10^{-24}}{20\times10^{-3}\times1.76\times10^{11}}$

$= \frac{1.325\times10^{-24-8}}{35.2}$

$\therefore r = 3.76\times10^{-34}\,m$ Ans

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(2) An electron of k.E 10 eV is moving in circular path of radius 11 cm in 1r mag. field. find the magnetic flux density i.e. magnetic field 'B'?

⇒ Given,

$k.E = 10 eV$ $r = 11 cm$

$= 10 \times 1.6 \times 10^{-19} J$ $= 0.11 m$

$= 1.6 \times 10^{-18} J$

Here,

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

or, $1.6 \times 10^{-18} = 1/2 \times 9.1 \times 10^{-31} \times v^2$

or, $\frac{3.2 \times 10^{-18}}{9.1 \times 10^{-31}} = v^2$

or, $v = \sqrt{3.516 \times 10^{-1-18+31}}$

or, $v = \sqrt{3.516 \times 10^{12}}$

$\therefore v = 1.87 \times 10^{12} ms^{-1}$

Now,

$B = ?$

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

or, $B = \frac{mv}{r.e}$

or, $B = \frac{9.1 \times 10^{-31} \times 1.87 \times 10^{12}}{0.11 \times 1.6 \times 10^{-19}}$

$= \frac{1.7017 \times 10^{-18}}{0.176 \times 10^{-19}}$

$= 96.6875$

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(8) If the P.D betn anode and cathode in an electric gun is 500 volt. find

(i) energy gained by electron.
(ii) Velocity of electron (v).
(iii) Momentum of electron.

⇒ Given.

$P.D(V) = 500$ volt

(i) K.E gained by electron = Voltage x charge

$= 500 \times 1.6 \times 10^{-19}$ Joule

$= 800 \times 10^{-19}$ J.

(ii) velocity (v) = ?

$KE = 1/2\ mv^2$

or, $V = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \times 800 \times 10^{-19}}{9.1 \times 10^{-31}}}$

$= \sqrt{175.8241758 \times 10^{12}}$

$= \sqrt{1.758241758 \times 10^{14}}$

$= 13259870.88$

$= 1.32 \times 10^{7}\ ms^{-1}$ Ans.

(iii) Momentum of electron = $m \times v$

$= 9 \times 10^{-31} \times 1.32 \times 10^{7}$.

$= 12.012 \times 10^{-24}$

$= 1.2 \times 10^{-23}$ Newton-sec

(4) A proton beam accelerated by 2000 volt enters a magnetic field of 0.2 Tesla. Calculate the radius of circular path.

⇒ Given,

Mass of proton $(m_p) = 1.7 \times 10^{-27}$ kg

$B = 0.2$ Tesla

Here,

K.E gained by proton is:

$K.E = \text{voltage} \times \text{charge } (e.v)$

$\Rightarrow 1000 \times 1.6 \times 10^{-19}$ Joule.

$\Rightarrow 3200 \times 10^{-19}$ J #.

Now,

$KE = 1/2 \, mv^2$

$\Rightarrow v = \sqrt{\dfrac{2KE}{m_p}}$

$= \sqrt{\dfrac{2 \times 3200 \times 10^{-19}}{1.7 \times 10^{-27}}}$

$\Rightarrow \sqrt{3764.70588 2 \times 10^{8}}$

$= 6.13 \times 10^{5}\ ms^{-1}$ #.

Again,

$Bev = \dfrac{mv^2}{r}$

or, $r = \dfrac{mv}{B.e} = \dfrac{1.7 \times 10^{-27} \times 6.13 \times 10^{5}}{0.2 \times 1.6 \times 10^{-19}}$

$= \dfrac{10.421 \times 10^{-22}}{0.32 \times 10^{-19}}$

$= \cancel{82.565625 \times 10^{-3}}$ $32.565625 \times 10^{-}$

$= 32.565625 \times 10^{-1} \times 10^{-2}$

$= 3.25 \times 10^{-2}$ meter #.

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(5) Proton with charge mass ratio $1 \times 10^6 C kg^{-1}$ are rotated in a circular orbit of radius r, in the uniform $\perp^r$ mag. field of 0.5 Tesla(B). Show that the number of revolutions per sec i.e frequency is independent of radius and also find frequency.

⇒ Given,

for proton moving in $\perp^r$ mag. field, B = 0.5 Tesla

charge mass ratio $\left(\frac{e}{m}\right) = 1 \times 10^6 \, C kg^{-1}$

(i) To prove that frequency 'f' is independent of radius 'r'

(ii) frequency (f) = ?

Here,

(i) In $\perp^r$ Mag. field

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

or, $$Be = \frac{mv}{r}$$

or, $$Be = \frac{m(r\omega)}{r} \quad (\because v = r\omega)$$

or, $$Be = m(2\pi F) \quad (\because \omega = 2\pi f)$$

$$\therefore f = \frac{Be}{2\pi m} \longleftarrow (i)$$

From eqn (3), frequency (f) is independent of radius 'r'

(iii) From eqn (?)

$$f = \frac{Be}{2\pi m} = \frac{B}{2\pi} \times \frac{e}{m}$$

$$= \frac{0.5}{2 \times 3.14} \times 1 \times 10^6 \quad \left(\frac{e}{m} = 1 \times 10^6 \text{ c kg}^{-1}\right)$$

$$= 8 \times 10^{-2} \times 10^6$$

$$= 8 \times 10^4 \text{ rev/sec}$$

(6) In Ionosphere, electrons execute 14×10^{6} rev/sec on circular plate. Find magnetic field.

⇒ Soln;

In ⊥r mag. field.

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

$$or,\ B = \frac{mv}{er}$$

$$or,\ B = \frac{m(r\omega)}{er}$$

$$or,\ B = \frac{m \times 2\pi f}{e}$$

$$or,\ B = \frac{9.1 \times 10^{-31} \times 2 \times 3.14 \times 14 \times 10^6}{1.6 \times 10^{-19}}$$

$$= 500.045 \times 10^{-6}$$

$$\Rightarrow 0.0005 \text{ Tesla}$$

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(7) An electron is moving at $10^7\ ms^{-1}$ normal to magnetic field of 0.1 Tesla. Find the radius of circular path. What would be the radius of circular path if the magnetic field is dobuled.

⇒ given,

$$\text{Velocity } (v) = 10^7\ ms^{-1}$$

$$B = 0.1 \text{ Tesla}$$

we know,

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

$$\text{or, } r = \frac{mv}{Be} = \frac{9 \times 10^{-31} \times 10^7}{0.1 \times 1.6 \times 10^{-19}}$$

$$= 56.25 \times 10^{-5}$$

$$= 5.625 \times 10^{-4} \text{ meter}$$

when mag. field i.e 'B' is double, new mag. field

$$B' = 2 \times 0.1 = 0.2 \text{ Tesla}$$

then,

$$\text{New radius } (r') = \frac{mv}{B'e}$$

$$= \frac{mv}{2Be}$$

$$= \frac{1}{2} \times 5.625 \times 10^{-4} \quad \left[\because r = \frac{mv}{Be}\right]$$

$$= 2.81 \times 10^{-4} \text{ meter}$$

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(i) In Millikan's oil drop experiment, a charge oil drop of density 880 kgm-3 is held stationary between two horizontal parallel metal plates separated by 6 mm and having PD of 103 volts. when the electric field is switched off, the drop falls 2mm in 357 sec. what is the radius of drop?

Given: viscosity of air $= 1.8 \times 10^{-5}$ Nsm^{-2}

density of air may be neglected

⇒ soln;

Here In Millikan's oil drop experiment,

$$E = \frac{V}{d} = \frac{1000}{0.006} \frac{\text{volt}}{\text{meter}} \quad [d = 6mm = 0.006\,m]$$

when the electric field is switched off,

$$\text{Terminal velocity } (v_1) = \frac{\text{distance}}{\text{time taken}}$$

$$= \frac{0.002}{357\,sec}$$

$$= 5.6 \times 10^{-6}\,ms^{-1}$$

→ As 'E' is switched off

$$mg = 6\pi r \eta v_1$$

$$\text{i.e } r = \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}$$

or, ρ = density of oil drop = 880 kgm^{-3}

σ = density of medius (air) = neglected) = 0

$g = 9.8\,ms^{-2}$

viscosity (η) $= 1.8 \times 10^{-5}$ Nsm^{-2} of air

so,

$$r = \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}$$

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$$= \sqrt{\frac{9 \times 1.8 \times 10^{-5} \times 5.6 \times 10^{-6}}{2 \times 9.8 \times 880}}$$

$$= \sqrt{\frac{90.72 \times 10^{-11}}{17248}}$$

$$= \sqrt{5.25 \times 10^{-3} \times 10^{-11}}$$

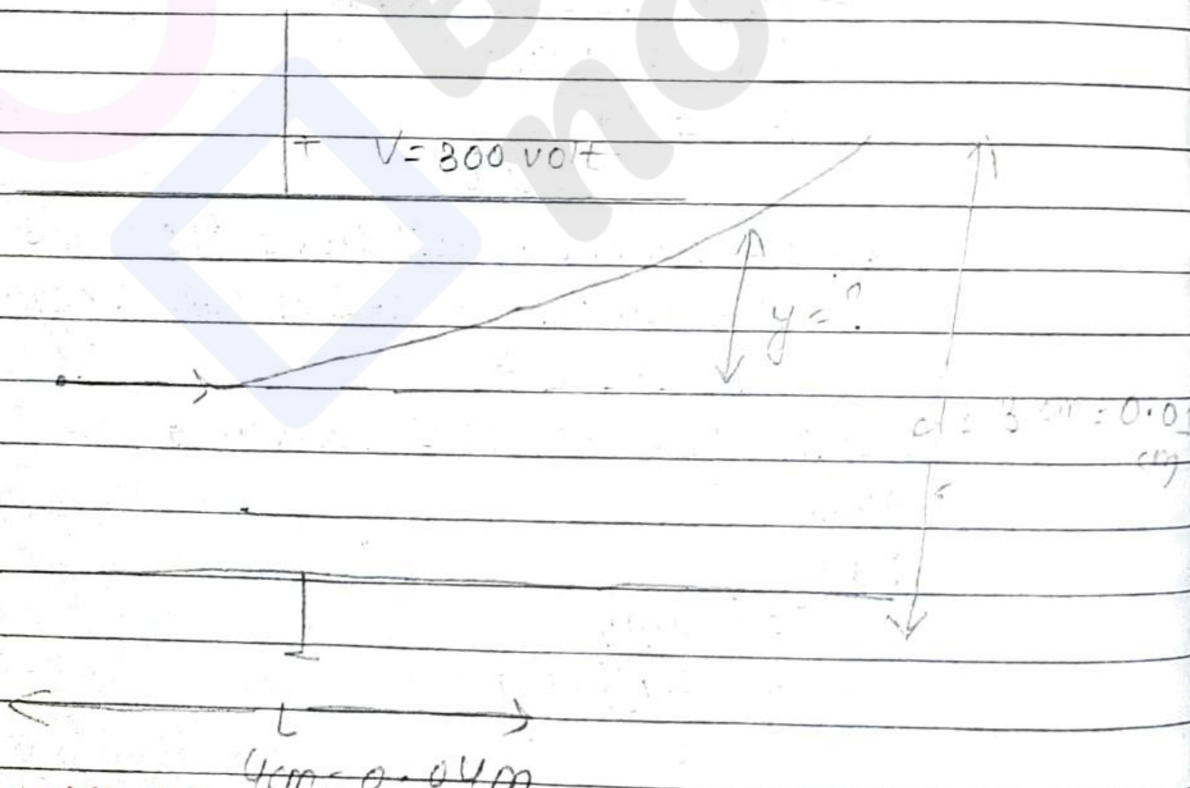
$$= \sqrt{5.25 \times 10^{-14}}$$

$= 2.29 \times 10^{-7}$ meter 1/2.

(9) Eq (based on: deflection)

An electron moving with horizontal constant velocity 10^7 ms^{-1} enters midway between two parallel, horizontal metal plate separated by distance 3 cm and having length 4cm with P.D of 300 volt. Find the vertical deflection of electron if $\frac{e}{m} = 1.8 \times 10^{11}$ Ckg^{-1}

⇒ Given,



PD = 300 volt

initial velocity (u) = 10 ms^{-1}

distance betn plates (d) = 3 cm = 0.03 m

length (l) = 4 cm = 0.04 m

$\frac{e}{m} = 1.8 \times 10^{11}$ ckg^{-1}

vertical deflection (y) = ?

we know,

$y = \frac{1}{2}\left(\frac{E \cdot e}{m}\right)\left(\frac{l}{u}\right)^2$

$\Rightarrow \frac{1}{2}\left(\frac{V}{d}\right)\left(\frac{e}{m}\right)\left(\frac{l}{u}\right)^2$ (∵ E = V/d)

$\Rightarrow \frac{1}{2}\left(\frac{300}{0.03}\right)(1.8 \times 10^{11})\left(\frac{0.04}{10^7}\right)^2$

$\Rightarrow \frac{1}{2}\left(\frac{300}{0.03}\right) \times 1.8 \times 10^{11} \times 1.6 \times 10^{-17}$

$\Rightarrow 5000 \times 1.8 \times 1.6 \times 10^{-6}$

$\Rightarrow 14400 \times 10^{-6}$

$\Rightarrow 0.0144$ meter

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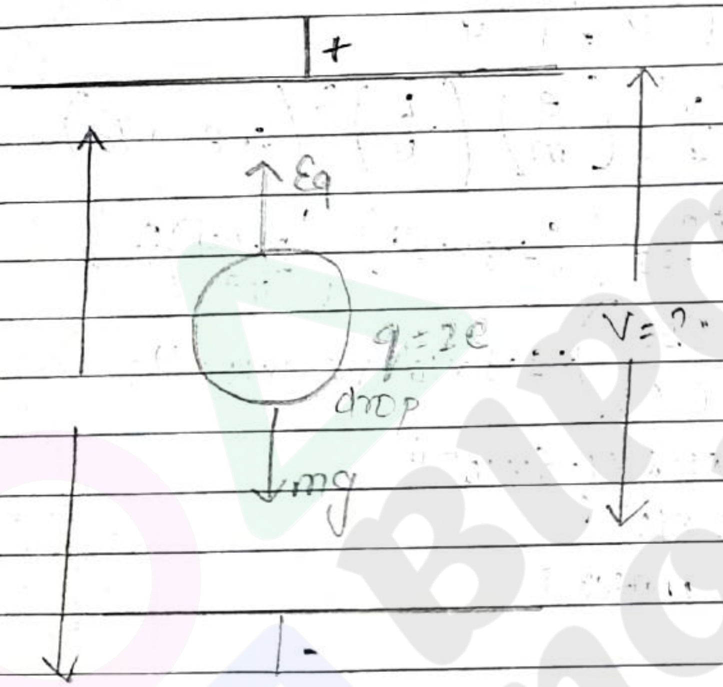
(10) calculate the potential differences in volts to be maintained between two parallel horizontal metals plates 5 mm apart so that a small drop with two electrons attached on it is in drop with two electrons attached on it is in equilibrium [$g = 9.8 ms^{-2}$] [mass of drop (m) = 1.31×10^{-14} kg]

⇒



As the charge drops in equilibrium,

$mg = Eq$

or, $mg = \frac{V}{d} \cdot (2e)$ [∴ $q = Ne$
$= 2e$ (N = no. of electron)

or, $V = \frac{mg \cdot d}{2e}$

or, $V = \frac{1.81 \times 10^{-14} \times 9.8 \times 0.05}{2 \times 1.6 \times 10^{-19}}$

$\therefore V = \frac{0.06419 \times 10^{-14}}{3.2 \times 10^{-19}}$

$\Rightarrow 2005.93$ volt.

* Multiple choice questions (MCQs):-

(1) When an electron moves through uniform magnetic field, it speed:-

(a) increase (b) decreases (c) remains constant (d) depends on field.

(2) The kinetic energy of a proton accelerated by 1V is:-

(a) 1/184 ev (b) 1840.3 V (c) 1 ev (d) $(1840)^{1/2}$ ev

(3) An electron of mass 'm' and charge 'e' is accelerated from rest through a potential difference of V volts in a vacuum. The speed of electrons will be:-

(a) $\left[\frac{eV}{m}\right]^{1/2}$ (b) $\left[\frac{mV}{e}\right]^{1/2}$ (c) $\left[\frac{m}{eV}\right]^{1/2}$ (d) $\left[\frac{2eV}{m}\right]^{1/2}$

$\because eV = \frac{1}{2}mv^2$ $\therefore$

(4) Work done in carrying an electron across a pd of 10 V is

(a) 0.1 ev (b) 1 ev (c) 10 ev (d) 100 ev

Work = voltage x exchange = 10 volt x e $\Rightarrow$ 10 ev.

(5) In Millikan's oil drop experiment, an oil drops is held stationary by a Pd of 400 V. If another drop of double the radius, but carry the same charge is to be held stationary, the Pd required is:-

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(a) 800 V (b) 1600 V (c) 3200 V (d) 1400 V.

6) The ratio of chare-to-mass ratio of a proton to an α-particle equals:-

(a) 2 (b) 1/2 (c) 4 (d) 1/4

9, 10, 13, 14, 15, 28 : repeated
17, 18, 20, 22 : Not in course.

* Note:→ cathode rays are the beams of fast moving electrons ($\simeq 10^7 ms^{-}$)
→ cathode rays are produced in discharged tube at low pressure (10^{-2} mm of Hg to 10^{-3} mm of Hg)
→ cathode rays are deflected in electric and magnetic field (which shows particle nature of electron).

(7) Cathode rays are:-
(a) stream of fast moving electrons (b) neutral particles.
(c) stream of positive ions (d) positron.

(8) which of the following statements is true for cathode

(a) It emits X-rays on striking a metal
(b) It is an electro magnetic
(c) It is a stream of positively charged parallel.
(d)

(11) An electron is moving with a velocity 'v' and enters a uniform electric field perpendicularly, its trajectory within the field will be:
(a) circular (b) parabolic (c) elliptical (d) hyperbolic

(18) An electron of charge (e) and mass 'm' is accelerated from rest through a p.d of V in a vaccum. The speed of electron
(a) ~~circular~~ $\sqrt{\frac{ev}{m}}$ (b) $\sqrt{\frac{mv}{e}}$ (c) $\sqrt{\frac{m}{ev}}$ (d) $\sqrt{\frac{2ev}{m}}$

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(12) An electron of charge is at rest in a electric field betn 2 plates seperated by a distance (d) with pd (V). What will be the force experienced by the electron?

(a) $\frac{eV}{d}$ (b) $\frac{e}{Vd}$ (c) $\frac{V}{d}$ (d) $\frac{d}{eV}$

Electric force $(F) = E \cdot e = \frac{V}{d} \cdot e \Rightarrow \frac{eV}{d}$.

(16) cathod rays are produce when the pressure in the air charge tube is

(a) 1 cm of Hg (b) 76 mm Hg (c) 10^{-2} to 10^{-3} mm Hg.

(25) (~~49~~) An oil drop of mass 50 mg and charge -5 μC is ~~what~~ just balanced in the air against the force of gravity. Calculate the strength of the electric field required to balance.

(a) 98 NC^{-1} upwards (b) 98 NC^{-1} downwards.
(c) 9.8 NC^{-1} towards the earth (d) 0.8 NC^{-1} towards the North.

Not more imp (21) A proton and α-particle is moved into a magnetic field having the same K.E. What is the ratio of their radius?

(a) 1:2 (b) 1 : $\sqrt{2}$ (c) $\sqrt{2}$: 1 (d) 1:1

(23) Hydrogen ion and doubly ionized helium atom are accelerated from rest through the same pd. The ratio of their final velocities of hydrogen and helium is:-

(a) 1:2 (b) 2:1 (c) $\sqrt{2}$: 1 (d) 1 : $\sqrt{2}$

(24) An electron is accelerated through a pd of 200 V. If e/m for the electron be 1.6×10^{11} C/kg, the velocity will be:

(a) 8×10^{-5} m/s (b) 8×10^{6} m/s (c) 8×10^{7} m/s (d) 8×10^{4} m/s

Formula: $eV = \frac{1}{2} mv^2$; $v = \sqrt{\frac{2eV}{m}}$

(26) An oil drop carrying a charge 'q' has a mass 'm'. It is falling freely in the air with the terminal velocity 'v'. The electric field required to make the drop move upwards with the same speed is:

(a) $\frac{2mg}{q}$ (b) $\frac{mg}{q}$ (c) $\frac{mgv}{q}$ (d) $\frac{mgv}{q^2}$

(27) In Millikan's oil drop experiment, a charge drop of mass 1.8×10^{-14} kg is stationary betn its plates. The distance betn two plates is 0.90 cm and Pd is 2K watt. The number of electrons on the drop is:

(a) 5 (b) 10 (c) 50 (d) 100.

(29) If a p.d of 1V is applied across an electron, the energy gained by it will be.

(a) 1 J (b) 1 eV (c) 1 Nm (d) 1 WS