Modern physics

Chapter- The Electron.

Determination of Charge of an Electron by Millikan's Oil Drop Experiment

The experimental arrangement used by Millikan to determine the charge of an electron is shown in Fig. The apparatus consists of two horizontal circular metal plates A and B. The upper plate is connected to high tension battery and the lower plate is earthed. There is a small hole at the centre of upper plate. The nonvolatile liquid (clock oil) is sprayed by means of atomizer. These drops get charged due to friction. The arrangement of plates is enclosed by a double walled chamber in which cold water is circulating to keep the constant temperature.

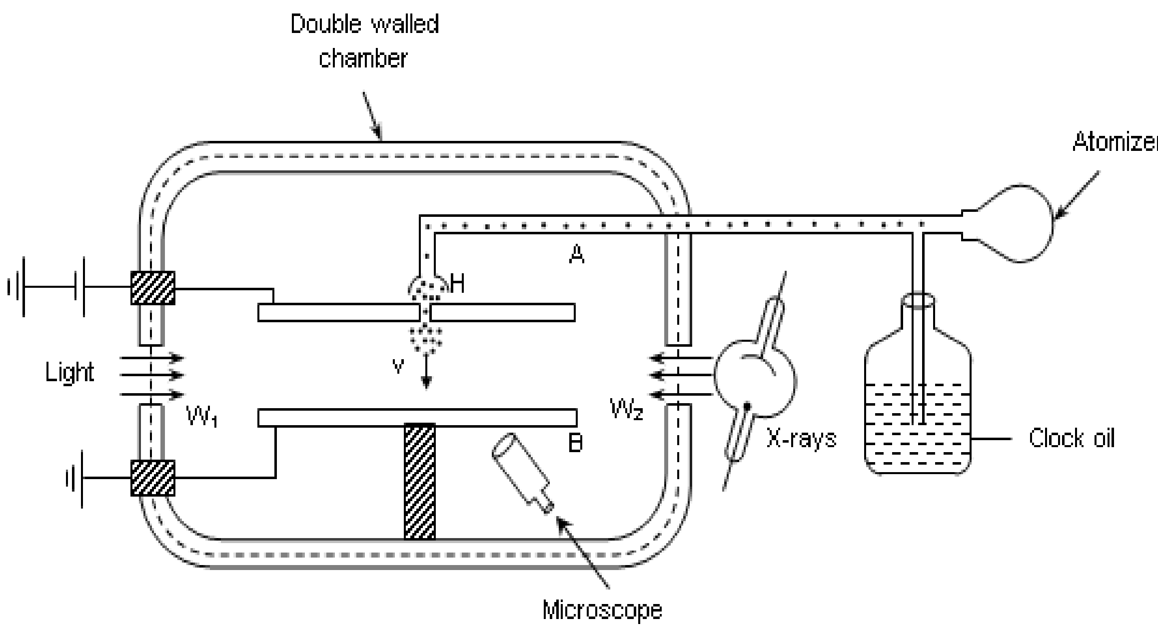


Fig. Millikan's experiment

The oil drops falling between two plates are illuminated by light through the window W_1 and ionized by passing x-rays through the window W_2. The windows W_2 is used to let X-rays pass in to the space between the plates in order to ionize the oil drop in case the oil drop are not ionized by friction.The motion of an oil drop can be observed by using microscope.

Motion of the oil drop under gravity

Let the electric field is not applied. As the oil drop falls under gravity its velocity goes on increasing.A stage comes when the viscus force on the oil drop becomes equal to its resultant weight. The oil drop now moves with a constant velocity,called terminal velocity.

Let, r= radius of the oil drop

ρ = density of oil
σ = density of air
η = coefficient of viscosity of air and
v_1 = terminal velocity of an oil drop

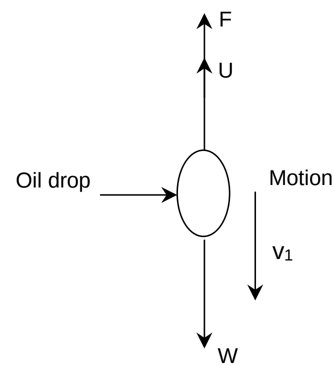


Fig. Motion of oil drop under gravity

Then,

Weight of the oil drop (W) = mg

$$= \frac{4}{3}\pi r^3 \rho g$$

Where, g is acceleration due to gravity.

Upthrust on the oil drop due to air is,

U = Weight of air displaced by the oil drop

$$\text{or, } U = \frac{4}{3}\pi r^3 \sigma g$$

From Stoke's law,

Viscous force on the oil drop in upward direction is

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

When the oil drop attains terminal velocity, then

$$F + U = W$$

$$\text{or, } F = W - U$$

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

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

Knowing the values of η, v_1, g, ρ and σ, the radius of an oil drop can be calculated.

Motion of the oil drop under electric field

The electric field is applied between two plates and the Coulomb force is acting vertically upward direction. As a result, the oil drop moves upward and attains terminal velocity v_2, as showing in fig.

E = strength of electric field
q = charge on the oil drop and
v_2 = terminal velocity of the oil drop

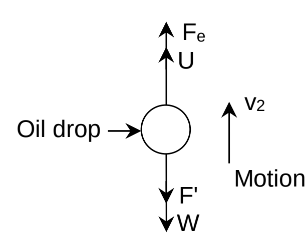


Fig. Upward motion of oil drop under electric field

Then,

Coulomb's force acting on the oil drop in upward direction (F_e) = qE

Viscous force acting on the drop in down ward direction is

$$F' = 6\pi\eta r v_2$$

When the oil drop attains terminal velocity v_2, then

$$F_e + U = W + F'$$

or, $F_e = W - U + F'$

or, $F_e = F + F'$

or, $qE = 6\pi\eta r v_1 + 6\pi\eta r v_2$

or, $q = \dfrac{6\pi\eta r(v_1 + v_2)}{E}$

Substituting the value of r in above equation, we have

$$\text{So,}q = \frac{6\pi\eta}{E}\sqrt{\frac{9\eta v_1}{2(\rho - \sigma)\, g}}\quad (v_1 + v_2)$$

Knowing the values of η, E, ρ, σ, g, v_1 and v_2; the value of charge q on the oil drop can be determined.

Special Cases

Case I

When the oil drop moves downwards and attains terminal velocity v_2, after applying electric field, then,

$$F' + F_e + U = W$$

or, $F_e = W - U - F'$

or, $F_e = F - F'$

or, $qE = 6\pi\eta r\,(v_1 - v_2)$

or, $q = \dfrac{6\pi\eta r\,(v_1 - v_2)}{E}$

or, $q = \dfrac{6\pi\eta}{E}\sqrt{\dfrac{9\eta v_1}{2(\rho - \sigma)\, g}}\ (v_1 - v_2)$

Case II

When the oil dro remains stationary between two plates after applying electric field. then

$$F_e + U = W$$

$$F_e = W - U$$

or, $qE = \dfrac{4}{3}\pi\, r^3\,(\rho - \sigma)\, g$

or, $q = \dfrac{4\pi r^3(\rho - \sigma)g}{3E}$

or, $q = \dfrac{4\pi r^3(\rho - \sigma)gd}{3V}$

Where, V is potential diffeence and d is distance between two plates.

Since the density of air (σ) is very small. So the upthrust on the oil drop can be neglected, i.e. $U \approx 0$ as Here,

$$F_e = W$$

or, $qE = mg$

or, $q = \frac{mg}{E} = \frac{mgd}{V} = \frac{4\pi r^3 \rho gd}{3V}$.

Importance of Millikan's oil drop experiments

1. This experiment shows that the smallest possible charge is the charge of an electron which is ,e = -1.6×10^{-19}C.
2. This experiment proves the quantization of charge, i.e. q = ne
   where, n = 1, 2, 3 … is integer
   e = -1.6×10^{-19}C charge of an electron.
3. Millikan's oil drop experiment along with Thomson's e/m experiment can be used to calculate the mass of an electron.

Cathode rays

The invisible rays, emerging normally from the cathode of a discharge tube, kept at a pressure of 0.01 mm of Hg and (10-15) KV potential difference.

Properties of Cathode Rays:

1. Cathode rays are stream of negatively charged electrons.
2. They are deflected by electric and magnetic fields.
3. They travel in a straight line with 1/10 of velocity of light in vacuum.
4. They can penetrate thin sheets of metal foil.
5. They affect on photographic plate.
6. When they strike on the metal target of high atomic weight, x - rays are produced.
7. They produce heat when they strike on matter.

Motion of electron in electric field

Let us suppose that a horizontal beam of electrons moving with velocity v,passes between two parallel plate as shown in figure.

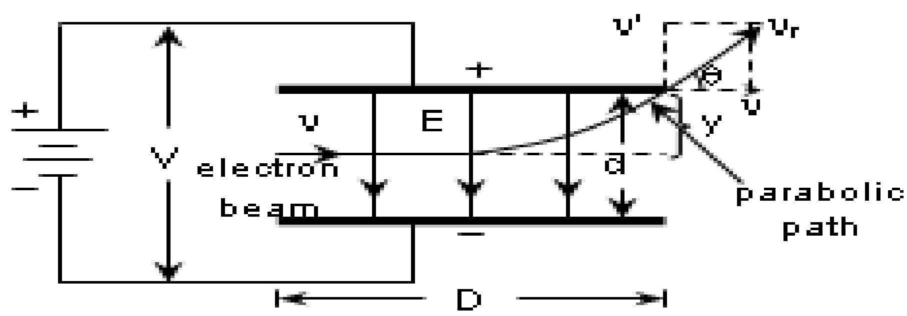


Fig Deflection of electron beam in electric field

If V be thepotential difference between the plates and are separated by a distance d apart, then The electric field intensity between two plates is

$$E = \frac{V}{d}$$

Vertical force on electron (F) = eE

Vertical acceleration (a) $= \frac{eE}{m}$

Vertical deflection of electron beam (y) $= \frac{1}{2}at^2$

$$= \frac{1}{2}\frac{eE}{m}t^2$$

Where, t is time taken by an electron to pass the plate.

Again, horizontal displacement (x) = $\nu t \Rightarrow t = \frac{x}{\nu}$

$$y = \frac{1}{2}\frac{eE\,x^2}{m\nu^2} = \left(\frac{eV}{2mdv^2}\right)x^2$$

The term $\left(\frac{eV}{2mdv^2}\right)$ is a constant. So, this equation is similar to the equation of parabola, $y = kx^2$. Hence, the path followed by an electron in electric field which is parabolic.

If x = D, length of the plate then,

$$y = \frac{eVD^2}{2mdv^2}$$

The vertical velocity of electron is

$$\nu' = at = \frac{eE}{m}t = \frac{eED}{m\nu} = \frac{eVD}{mdv}$$

The magnitude of resultant velocity of electron when it emerges out of the electric field is

$$\nu_r = \sqrt{\nu^2 + v'^2} = \sqrt{v^2 + \left(\frac{eVD}{mdv}\right)^2}$$

Let θ be the angle made by resultant velocity with horizontal. Then,

$$\tan\theta = \frac{\nu'}{\nu} \Rightarrow \theta = \tan^{-1}\left(\frac{\nu'}{\nu}\right)$$

$$\text{or, } \theta = \tan^{1}\left(\frac{eVD}{mdv^2}\right)$$

Motion of electron beam in Magnetic Field

Let us consider an electron beam moving with speed v horizontally which enters a uniform magnetic field of magnitude B acting perpendicular to the direction of motion as shown in figure.

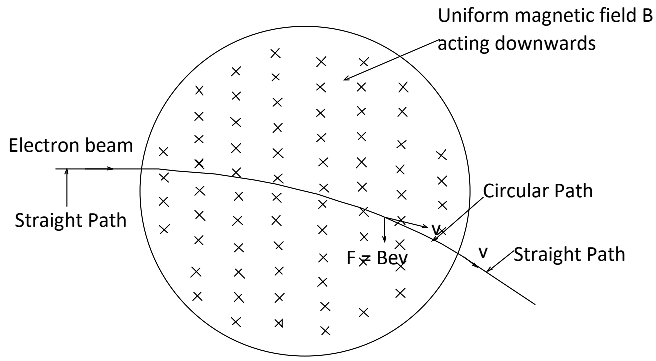


Fig. Circular motion in uniform magnetic field.

The force acting on the electron in magnetic field is,

$$\vec{F} = e(\vec{v} \times \vec{B})$$

Or, $\vec{F} = Bev \sin\theta$

Where, θ is the angle between $\vec{B}$ and $\vec{v}$.

The direction of force is given by Fleming's left hand rule. Here, the angle between B and v is 90^0.

$$\therefore \vec{F} = Bev$$

The magnitude of force is,

$$F = Bev \text{ ....i}$$

This force is constant in uniform magnetic field and its direction is perpendicular to both B and v. So this force does not change the velocity but it deflects the electron beam in a circular path inside the uniform magnetic field.

The centripetal force is required to move the electron in circular path. This force is provided by magnetic force.

Here, Centripetal force = magnetic force $\Rightarrow \dfrac{mv^2}{r} = Bev$

$$\text{or, } r = \frac{mv}{Be} \text{ ....ii}$$

Where, m is mass of an electron.

This equation ii. represents the radius of the circular path.

Since, $v = \omega.r. = 2\pi fr$, where, f is frequency of electron.

From above equations, we have

$$r = \frac{2\pi fr\, m}{Be}$$

$$\text{or, } f = \frac{Be}{2\pi m}$$

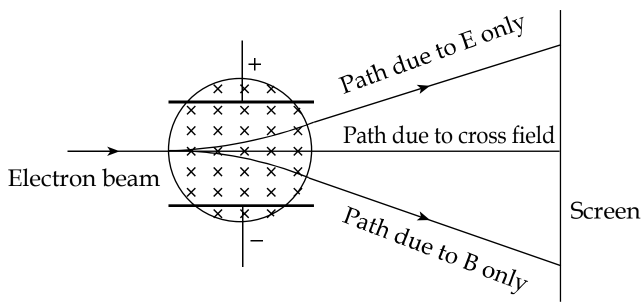
i.e. the frequency is independent of the radius of the path and velocity of electron beam.
The time period of electron is given by

$$T = \frac{1}{f} = \frac{2\pi m}{Be}$$

The time period is also independent of the radius of the path and velocity of electron beam.

Motion of Electron Beam in Cross Field

The uniform electric and magnetic fields acting mutually perpendicular to each other is called cross field. The magnitude and direction of both fields are so adjusted that the deflection produced by one field on charged particle is cancelled by the deflection produced by the other. Thus the beam is undeflected while passing through the cross field as shown in Fig.



Consider a beam of electron is moving with the velocity v in the electric field E and magnetic field B.
The force on electron due to electric field is

$$F_e = eE$$

The force on electron due to magnetic field is

$$F_m = Bev$$

When the beam is undeflected , then

$$\text{magnetic force } (F_m) = \text{electric force } (F_e)$$

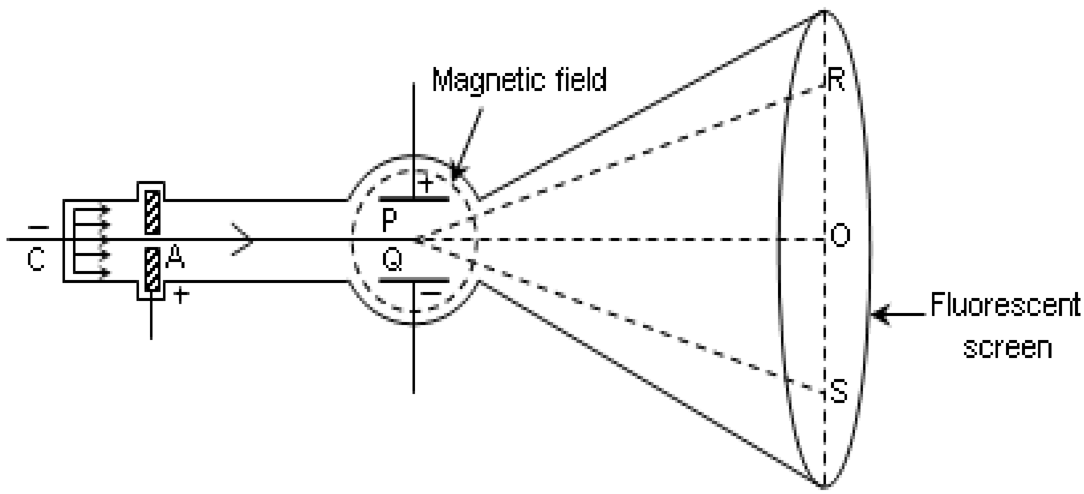
$$Bev = eE$$

$$\text{or, } v = \frac{E}{B}$$

The motion of beam of electrons in cross field is used in electronic devices like television, computer etc.

Determination of Specific Charge (e/m) of an Electron by Thomson's Experiment

The experimental arrangement for determination of specific charge of an electron is shown in Fig. The apparatus consists of a discharge tube with fluorescent screen. There are two electrodes, one is cathode C and another is anode A. A uniform electric field E is applied in down ward direction through the two horizontal metal plates P and Q. However, a uniform magnetic field B is applied in inward direction and is perpendicular to the electric field.



When the high voltage is applied between cathode and anode, a narrow beam of cathode rays is emitted from cathode to anode. This beam is allowed to pass between two plates P and Q and then strikes the fluorescent screen and luminous spot is seen. When both electric and magnetic fields are not applied, the beam of cathode rays moves straight and strikes at the centre 'O' of the screen.

When a uniform electric field E is applied between two plates P and Q, the beam is deflected upwards, towards the positive plate and strikes on the screen at 'R'.

The force acting on the electron in electric field is

$$F_e = eE, \text{ where e is charge of an electron}$$

When a uniform magnetic field B is applied perpendicular to the beam then it is deflected down ward in a circular path and then strikes the screen at 'S'.

The force acting on the electron in magnetic field is

$$F_m = Bev$$

Where v is velocity of electron in a magnetic field. The beam of electron is undeflected in the cross field if the resultant force acting on the electron is zero.

For this condition, magnetic force on electrons (F_m) = electric force on electron (F_e)

$$\text{or,} \quad Bev = eE$$

$$\text{or,} \quad v = \frac{E}{B} \text{ ....i}$$

Let m be the mass and V be the potential difference between cathode and anode.

The kinetic energy gained by each electron is $E_k = \frac{1}{2}mv^2$

The potential energy of an electron is $E_p = eV$

Since the potential energy at the cathode is converted into gain in kinetic energy at the anode.

$$\therefore\ E_p = E_K$$

$$\text{or, } eV = \frac{1}{2}mv^2$$

$$\text{or, } \frac{e}{m} = \frac{v^2}{2V} \text{ ....ii}$$

Form equations (i) and (ii), we have

$$\frac{e}{m} = \frac{(E/B)^2}{2V}$$

$$\text{or, } \frac{e}{m} = \frac{E^2}{2VB^2} \text{ ....iii}$$

It V' be the potential difference between two plates and d be the distance between them, then

$$E = \frac{V'}{d}$$

$$\therefore \frac{e}{m} = \frac{V'^2}{2VB^2d^2} \text{ ....iv}$$

Knowing the values of V,V', B and d, the value of specific charge $\left(\frac{e}{m}\right)$ of an electron can be determine. Experimentally it is found that the value of $\frac{e}{m}$ for electron is 1.76×10^{11} C kg^{-1}.

NUMERICAL PROBLEMS

1. In a Millikan's oil drop experiment, a drop is observed to fall with a terminal speed 1.4 mm/s in the absence of electric field. When a vertical electric field of 4.9×10^5 V/m is applied, the droplet is observed to continue to move downward at lower terminal speed 1.21 mm/s. Calculate the charge on the drop. [Density of oil = 750 kg/m^3, viscosity of air = 1.81×10^{-5} kg/ms, density of air = 1.29 kg/m^3]
2. An electron moves a circular path of radius 20 cm in uniform magnetic field of 2×10^{-3} T. Find the speed of the electron and period of revolution. Mass of electron = 9.1×10^{-31} kg.
3. A beam of electrons moving with velocity of 10^7m/s, enters midway between two horizontal parallel plates in the direction parallel to the plates which are 5 cm long and 2 cm apart and have a p.d of V volts between them. Calculate V if the beam is deflected so that it just grages the edge of the plate. (Assume e/m = 1.76×10^{11} C/kg)
4. Specific charge of a particle is 4.4×10^7 Ckg^{-1}. It is moving in a circular orbit with a velocity 3.52×10^5 ms^{-1} in a magnetic flux density 0.4T. Find the radius of its orbit.
5. In a Thomson's experiment voltage across the plates is 50V and the distance between them is 3 cm. The magnetic field applied to make the beam undeflected is 10^{-4} T. What is the velocity of the electron passing between the plates.
6. Electron is accelerated through a potential difference of 2kV and then it enters a uniform magnetic field of 0.02T, in a direction perpendicular to it. Find the radius of the path of the electron in the magnetic field. (Mass of electron = 9.1×10^{-31} kg)
7. An electron having 450 eV of energy moves at right angles to a uniform magnetic field of flux density 1.50×10^{-3} T. Find the radius of its circular orbit. Assume that the specific charge of the electron is 1.76×10^{11} C kg^{-1}.

8. A beam of protons is accelerated form rest through a potential difference of 2000 V and then enters a uniform magnetic field which is perpendicular to the direction of the proton beam. If the flux density is 0.4 T calculate the radius of the path which the beam describes. (Proton mass = 1.7×10^{-27} kg., Electronic charge = -1.6×10^{-19}C)
9. Two plane metal plates 4.0 cm long are held horizontally 3.0 cm apart in a vacuum, one being vertically above the other. The upper plate is at a potential of 300V and the lower is earthed. Electrons having a velocity of 1.0×10^7 m s^{-1} are injected horizontally midway between the plates and in a direction parallel to the 4.0 cm edge. Calculated the vertical deflection of the electron beam as it emerges from the plates. (e/m for electron 1.8×10^{11} C kg^{-1})
10. An oil drop of mass 3.25×10^{-15} kg falls vertically with uniform velocity, through the air between vertical parallel plates which are 2 cm apart. When a p. d. of 1000V is applied to the plates the drop moves towards the negatively charged plate, its path being inclined at 45° to the vertical. Calculate the charge on the drop.
11. In Millikan-type apparatus, the horizontal plates are 1.5cm apart. With the electric field switched off an oil drop is observed to fall with the steady velocity 2.5×10^{-2} cm/s. When the electric field is switched on the upper plate being positive, the drop just remains stationary when the p.d. between plates is 1500V. a) calculate the radius of the drop b) How many electronic charges does it carry?
12. A beam of electrons, moving with a velocity of 10^7 m/s, enters midway between two horizontal parallel plates in a direction parallel to the plates. Each plate is 5 cm long. These plates are kept 2 cm apart and a potential difference of 90 V is applied between them. Calculate the velocity of the electron-beam with which it just grazes the edge of the positive plate. (e/m = 1.8×10^{11} C/kg).
13. An electron is accelerated through a potential difference of 2000V and then it enters a uniform magnetic field of 0.02 Tesla in a direction perpendicular to it. Find the radius of the path of the electron in the magnetic field. Mass of an electron is 9.1×10^{-31} kg, charge of an electron is 1.6×10^{-19} C.
14. Calculate the radius of a water drop which would just remain suspended in an electric field of 300 V/cm and charged with one electron.
15. Calculate the p.d. in volt necessary to be maintained between two horizontal conducting plates, one 5 mm above the other, so that a small oil drop of mass 1.31×10^{-14} kg with two electrons attached to it remains in equilibrium. (g = 9.8ms^{-2}, charge of electron = -1.6×10^{-19} c).
16. A beam of electrons is under potential difference of 1.36×10^4V applied across two parallel plates 4 cm apart and a magnetic field 2×10^{-3} T at right angles to each other. If two fields produce no deflection in the electronic beam, calculate (i) The velocity of electrons (ii) the radius of the orbit in which the beam will move, if the electric field is made zero. [Given; mass of electron = 9.1×10^{-31} kg.].
17. An electron beam after being accelerated from rest through a potential difference of 5 KV in vacuum is allowed to impinge normally on a fixed surface. If the incident current is 50μ A. Determine the fore exerted on the surface assuming that it bring the electrons to rest. Take mass of electron is 9.1×10^{-13}kg.
18. Find the electric field required to keep a water drop of radius 10^{-5} cm just suspended in vacuum when charge with one electron. (charge of electron = 1.6×10^{-19} c and density of water=1000kg/m^3.)
19. A beam of electrons, moving with a velocity of 10^6 m/s enters midway between two horizontal parallel plates in a direction parallel to the plates. Each plate is 4cm long. These plates are kept 2cm apart and a potential difference V is applied between them. Calculate V if the beam is deflected so that it just grazes the edge of positive plate. (Given e/m for the electron is 1.8×10^{11}c kg^{-1}.)

20. An electron having 500eV energy enters at right angle to a uniform magnetic field of 10^{-4} Tesla. If its specific charge is 1.75×10^{11} Ckg^{-1} calculates the radius of its circular orbit.

SHORT QUESTION.

1. Cathode rays cannot be regarded as electromagnetic waves. Why?
2. Compare the specific charge of an electron with that of a proton.
3. What is the importance of Millikan's oil drop experiment?
4. The value of e/m is constant for cathode rays but not for positive rays. Why?
5. Write down expressions for acceleration of a moving charge Q in parallel and perpendicular magnetic fields.
6. An electron and a proton move with same the same speed in a uniform magnetic field of equal magnitude. Compare the radii of their circular path.
7. A charged particle is fired into a cubical region of space where there is uniform magnetic field. Outside this region, there is no magnetic field, is it possible that the particle will remain inside the cubical region? Explain.
8. A charged particle moves through a region of space with constant velocity. If the external magnetic field is zero in this region, can conclude that the external field in the region is also zero? Explain.
9. Beams of electrons and protons having the same initial K.E. enter normally into an electric field, which beam will be more curved? Justify.

1. Cathode rays cannot be regarded as electromagnetic waves. Why?

Cathode rays are beams of negatively charged particles which are deflected by electric and magnetic fields where as electromagnetic waves are chargeless and they are not deflected by electric and magnetic fields. The cathode ray is emitted from cathode to anode and its speed depends on the potential difference between cathode and anode of the discharge tube. But the electromagnetic waves are emitted in all direction and its speed is constant in a medium. Hence cathode rays are not electromagnetic waves.

2. Compare the specific charge of an electron with that of a proton.

The specific charge of an electron of mass me and charge e is e/m_e.

Where as the specific charge of a proton of mass m_p and charge e is e/m_p.

$$\text{Then, } \frac{e/m_e}{e/m_p} = \frac{e}{m_e} \times \frac{m_p}{e} = \frac{1.67\times10^{-27}}{9.1\times10^{-31}} \approx 1840$$

So, specific charge of electron is nearly 1840 times the specific charge of proton.

3. What is the importance of Millikan's oil drop experiment?

Importance of Millikan's Experiment

i. Millikan's experiment shows that electronic charge is the smallest possible charge on a charged particle .

ii. Millikan's experiment has proved the quantization of charge i.e. a body can carry an integral multiple of minimum charge e.

i.e. $Q = \pm n e$, where n = 1, 2, 3…

iii. There is no direct method to find the mass of an electron. Knowing the charge of an electron and specific charge, the mass of the electron can be determined which is as

$$\therefore \quad \frac{e}{e/m} = \frac{1.6\times10^{-19}}{1.75\times10^{11}} = 9.11 \times 10^{-31}\text{ kg}$$

4. **The value of specific charge (e/m) is constant for cathode (negative) rays but not for positive (canal) rays, Why?**

   Cathode rays are the stream of fast moving electrons. The value of charge and mass of an electron are constant. Therefore, the specific charge (e/m) of cathode rays is constant. However, the positive rays consist of positive ions which have different masses for different gases. Therefore, the value of e/m of positive rays is not constant.

5. **A charged particle is fired into a cubical region of space where there is uniform magnetic field outside this region, there is no magnetic field. Is it possible that the particle will remain inside the cubical region? Explain.**

   Yes, it is possible that the particle will remain inside the cubical region if it enters perpendicularly to the magnetic field and the diameter of circular path is less than the side of the cube.

6. **An electron and a proton move with the same speed in a uniform magnetic field of equal magnitude. Compare the radii of their circular path.**

   The radius of circular path covered by a charged particle moving in a magnetic field of flux density B is given by

   $r = \frac{mv}{Bq}$, where m is the mass of charged particle, v be velocity and q be the charge of particle. Since mass of proton is greater than mass of electron, the radius of proton is greater than the radius of electron for same speed and charge in a magnetic field.

7. **Write down expressions for acceleration of a moving charge Q in parallel and perpendicular magnetic fields.**

   The acceleration of a moving charge Q in a magnetic field is given by

$$a = \frac{BQv \sin\theta}{m}$$

   Where, B is magnetic flux density, v is velocity of charged particle, m is mass of charged particle and θ is angle between B and v

   When a charge is moving parallel to the direction of magnetic field, then $\theta = 0^0$

$$\therefore \quad a = \frac{BQv \sin 0}{m} = 0$$

   When a charge is moving perpendicular to the direction of magnetic field, then $\theta = 90^0$

$$\therefore \quad a = \frac{BQv \sin 90}{m} = \frac{BQv}{m}$$

8. **A charged particle moves through a region of space with constant velocity. If the external magnetic field is zero in this region, can we conclude that the external field in the region is also zero? Explain.**

   Yes, the velocity is constant only in the region of zero electric field because the velocity of charged particle will be constant in a field free space and in cross field space. Here, magnetic field is zero and hence for constant velocity electric field also be zero.

9.Beams of electrons and protons having the same initial K.E. enter normally into an electric field, which beam will be more curved? Justify.

Initial kinetic energy(K.E)=1/2 mv^2

So, v^2=2 K.E/m…………………..i

Also we have the vertical deflection as,

$$Y=\frac{1}{2}\frac{eVD^2}{mdv^2}$$

Replacing the value of v we get,

$$Y=\frac{1eVD^2}{2md.2K.E/m}$$

$$\text{So, } Y=\frac{1}{4}\frac{eVD^2}{d.K.E}$$

From this relation it is observed that,both have same vertical deflection .hence both have same curved.

Multiple choice question

21. In Millikan-type apparatus, the horizontal plates are 1.5cm apart. With the electric field switched off an oil drop is observed to fall with the steady velocity 10^{-2} cm/s. When the electric field is switched on the upper plate being positive, the drop just remains stationary when the p.d. between plates is 1500V. How many electronic charges does it carry? (Density of oil = 900 kg/m^3, viscosity of air = 1.8 × 10^{-5} kg/ms. g=9.8 m/s)

    a. 3 b. 5 c. 8 d. 11

22. A beam of electrons moving with velocity of 10^7m/s, enters midway between two horizontal parallel plates in the direction parallel to the plates which are 0.05m long and 0.02m apart and have a p.d of V volts between them. Calculate V if the beam is deflected so that it just grages the edge of the plate. (Assume e/m = 1.76 × 10^{11} C/kg)

    a. 100 v b. 120 v c. 140 v d. 160 v

23. An electron and proton move with the same speed in a uniform magnetic field of equal magnitude.Then,
    a. Radius of proton is greater than radius of electron.
    b. Radius of electron is greater than radius of proton.
    c. Both have equal radius.
    d. Path of electron and proton will be parabolic in nature.

24. An electrons enters in a magnetic field of 10^{-3}T normally with velocity of 10^6m/s. The radius of path of electron is (e/m = 1.76 × 10^{11} C/kg)

    a. 11.4 cm b. 11.4 mm c. 5.7 cm d. 5.7 mm

25. If electron, proton,Neutron and alpha particle are deflected in the same electric field with same velocity. What will be the deflection in them?
    a. Proton less than electron.
    b. Electron more than alpha particle.
    c. Proton more than alpha particle.
    d. All of above.

26. In millikan's oil drop experiment, an oildrop is held stationary by a potential difference of 400 v. If another drop of double the radius,but carry the same charge is to be held stationary, the potential difference required is

    a. 800 V b. 1600 V c. 3200 V d. 400 V

27. An electron is moving with a velocity v and enters a uniform electric field perpendicularly.It's trajectory within the field will be,
    a. Parabolic b. circular c. hyperbolic d. elliptic.
    b. A charge particle enters in a magnetic field perpendicular to the magnetic lines of force.tThe path of particle is
    c. Straight line b. circular c. spiral d. elliptic.

28. An electron of mass m and charge e is accelerated from rest through a potential difference of V volt in vacuum. The speed of electron will be,

a. $\sqrt{\frac{eV}{m}}$ b. $\sqrt{\frac{mV}{e}}$ c. $\sqrt{\frac{m}{eV}}$ d. $\sqrt{\frac{2eV}{m}}$

29. A positron has the same mass as

a. Neutron b. neutrino c. an electron d. a proton.

30. The ratio of specific charge of a proton to that of an α- particle is ,

a. 4:1 b. 1:2 c. 1:4 d. 2:1

20. Specific charge of a particle is 4.4×10^7 Ckg^{-1}. It is moving in a circular orbit with a velocity 10^5 ms^{-1} in a magnetic flux density 0.7 T. Then the radius of its orbit will be

a. 0.0032m b. 0.02 m c. 0.2 m d. 0.01 m

21. **Cathode rays cannot be regarded as electromagnetic waves**

a. Cathode rays are beams of negatively charged particles.

b. Cathode rays are deflected by electric and magnetic fields

c. The cathode ray is emitted from cathode to anode.

d. all of above.

22. An electron and proton are projected in electric field at right angle to field with the same velocity.then,

a. Electron's trajectory will be more curved.

b. proton's trajectory will be more curved.

c. both will have same curved.

d. None of the above.

23. A beam of electron is moving with a constant velocity in a region having electric and magnetic field of strength 20V/m and 0.5 T at right angle to the direction of motion of electrons. Then the velocity of electron will be,

a. 40m/s

b. 8 m/s

c. 20 m/s

d. 5.5 m/s

24. The kinetic energy of an electron which is accelerated through a p.d. of 100 V is

a. 1.16×10^4k wh

b. 418.6 calories

c. 1.6×10^{-17}j

d. 6.2×10^{-34}watt second.

25. when a proton is accelerated through a potential difference of 1 V,then it's K.E. is,

a. 1 ev

b. 1/1840 eV

c. 1840 eV

d. 1840 c eV

26. **Compare the specific charge of an electron with that of a proton.**

a. 1840:1 nearly

b. 1 :1840 nearly

c. 1.76×10^{11}:1

d. $1 : 1.76 \times 10^{11}$

27. The importance of Millikan's oil drop experiment is

a. Millikan's experiment shows that electronic charge is the smallest possible charge on a charged particle .

b. Millikan's experiment has proved the quantization of charge

c. Knowing the charge of an electron and specific charge, the mass of the electron can be determined

d. All of above

28. **Write down expressions for acceleration of a moving charge Q in parallel with magnetic fields.**

a. $\frac{BQv}{m}$

b. 0

c. **m/BQV**

d. **ev/BE**

29 Write down expressions for acceleration of a moving charge Q in perpendicular with magnetic fields.

e. $\frac{BQv}{m}$

f. 0

g. **m/BQV**

h. **ev/BE**

30. When the electron beam enters in the cross field, then the velocity of the electron beam will be

a. v= 2E/m

b. v=B/E

c. v=0

d. E/B

31. Beams of electrons and protons having the same initial K.E. enter normally into an electric field, which beam will be more curved?

a. Beam of proton will be more curved.

b. Beam of electron will be more curved.

c. Both are equally curved.

d. path of both will be straight line.

32. The radius of oil drop in millikan's oil drop experiment is

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

b. r= mv/BE

c. $r = \sqrt{\frac{9nv}{2(\rho-\sigma)}}$

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

34. In the ionosphere electron execute 1.4×10^6 revolution in a second. Then the strength of the magnetic flux density in this region will be,(mass of electron = 9.1×10^{-31} kg, charge of electron = 1.6×10^{-19} c).

a. 9.1×10^{-3}

b. 6.1×10^{-3}

c. 1.1×10^{-3}

d 0.5×10^{-4}