(PHYSICS)

Code : 55/3

General Instruction :

(i) All questions are compulsory.

(ii) There are **29** questions in total. Questions **1** to **8** are very short answer type questions and carry **one** mark each.

(iii) Questions **9** to **16** carry **two** marks each, questions **17** to **25** carry **three** marks each and questions **27** to **29** carry **five** marks each.

(iv) There is no overall choice. However, an internal choice has been provided in one question of two marks, one questions of three marks and all three questions of five marks each. You have to attempt only one of the choices in such questions.

(v) Question **26** is a value based question carrying **four** marks.

(vi) Use of calculators is **not** permitted. However, you may use log tables if necessary.

(vii) You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

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

$\mu_0 = 4\pi \times 10^{-7}$ T mA^{-1}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

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

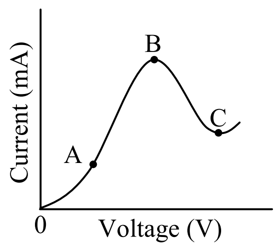
Mass of Neutrons = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

1. Write the expression for the de Broglie wavelength associated with a charged particle having charge 'q' and mass 'm', when it is accelerated by a potential V **1**

Sol. $\lambda = \frac{h}{\sqrt{2mqV}}$

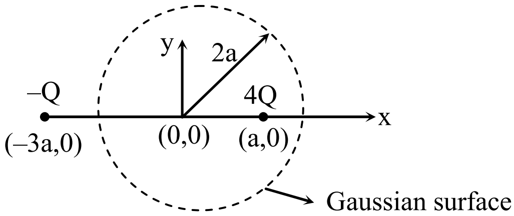
2. The graph shown in the figure represents a plot of current versus voltage for a given semiconductor. Identify the region, if any, over which the semiconductor has a negative resistance. **1**



Sol. BC

3. Two charges of magnitudes + 4Q and –Q are located at points (a, 0) and (–3a, 0) respectively. What is the electric flux due to these charges through a sphere of radius '2a' with its centre at the origin ? **1**

Sol.



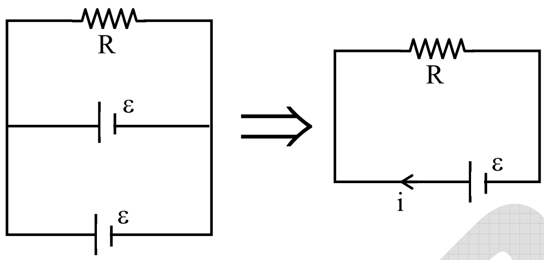
$$\phi = \frac{q_{in}}{\epsilon_0} = \frac{4Q}{\epsilon_0}$$

4. The motion of copper plates is damped when it is allowed to oscillate between the two poles of a magnet. If slots are cut in the plate, how will the damping be affected ? **1**

Sol. When slots are made in the plate, path length of induced current increases hence resistance increased so eddy current minimised and that's why it is less damped.

5. Two identical cells, each of emf E, having negligible internal resistance, are connected in parallel with each other across an external resistance R. What is the current through this resistance ? **1**

Sol.



$$i = \frac{\varepsilon}{R}$$

6. How does the mutual inductance of a pair of coils change when **1**

(i) distance between the coils is decreased and

(ii) number of turns in the coils is decreased ?

Sol. (i) Mutual inductance increased on decreasing distance.

(ii) Mutual inductance decreased on decreasing the number of turns.

7. Define the activity of a given radioactive substance. Write its S.I. units. **1**

Sol. Activity : Rate of disintegration of radiactive substance. i.e. number of radioactive nuclei disintegrating in unit time is called activity.

SI unit :-

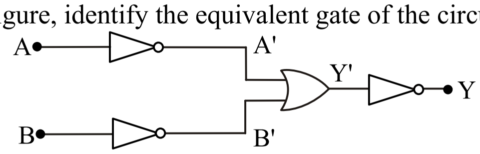
1 disintegration per second (dps) OR 1 Bq.

8. Welders wear special goggles or face masks with glass windows to protect their eyes from electromagnetic radiations. Name the radiations and write the range of their frequency. **1**

Sol. Ultraviolet rays

frequency range ($7.5 \times 10^{14} - 5 \times 10^{15}$ Hz)

9. In the circuit shown in the figure, identify the equivalent gate of the circuit and make its truth table **2**



Sol. AND GATE

Truth table

Input		Output
A	B	Y
1	0	0
0	1	0
0	0	0
1	1	1

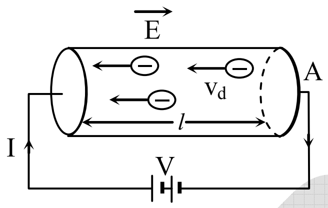
10. Explain the term 'drift velocity' of electrons in a conductor. Hence obtain the expression for the current through a conductor in terms of 'drift velocity'. **2**

OR

Describe briefly, with the help of a circuit diagram, how a potentiometer is used to determine the internal resistance of a cell.

Sol. **Drift velocity** : Drift velocity is defined as the average velocity with which free electrons in a conductor get drifted in a direction opposite to the direction of the applied electric field.

Let n be the number of free electrons per unit volume of the conductor. Then, total number of free electrons in the conductor = n × volume of the conductor = n × Al.



If e is the magnitude of charge on each electron, then the total charge in the conductor,

$Q = (nAl)e$ .....(i)

The time taken by the charge to cross the conductor length is given by

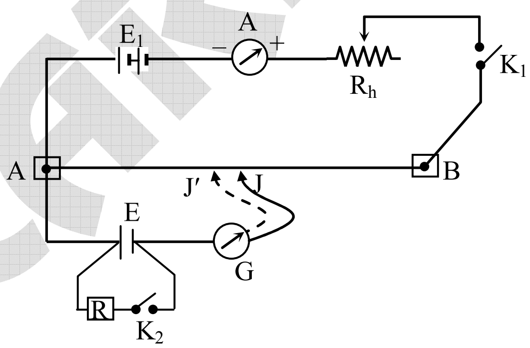
$t = \dfrac{l}{v_d}$, where v_d is drift velocity of electrons.

According to the defintion of electric current,

$I = \dfrac{Q}{t} = \dfrac{nAle}{l/v_d} = neAv_d$

$I = neA\,v_d$

OR



Close key K_1 keeping key K_2 open. Find the point (say J) on the wire AB such that on pressing the jockey on the wire at J, the galvanometer gives no deflection. At this stage, the potential difference across A and J is equal to the e.m.f. (E) of the cell.

If AJ = l_1, then, $E = V_{AJ} \propto l_1$

or $E = Kl_1$ ....(i)

Now close key K_2 so that a known resistance (R) is connected across the cell. Find the point (J′, say) such that on pressing the jockey at J′, the galvanometer gives no deflection. The terminal potential difference (V) of cell is equal to the potential difference across A and J′.

If AJ′ = l_2, then $V = V_{AJ'} \propto l_2$ or $V = Kl_2$ …(ii)

Dividing (i) by (ii), we get, $\frac{E}{V} = \frac{l_1}{l_2}$ …(iii)

We know, internal resistance of a cell is given by,

$$r = \left(\frac{E}{V} - 1\right)R \quad \text{…(iv)}$$

Using eqn. (iii), we get, $r = \left(\frac{l_1}{l_2} - 1\right)R$

11. A parallel beam of light of 450 nm falls on a narrow slit and resulting diffraction pattern is observed on a screen 1.5 m away. It is observed that the first minimum is at a distance of 3 mm from the centre of the screen. Calculate the width of the slit. **2**

Sol. $\lambda = 450 \times 10^{-9}$ m

D = 1.5 m

for I^{st} minima

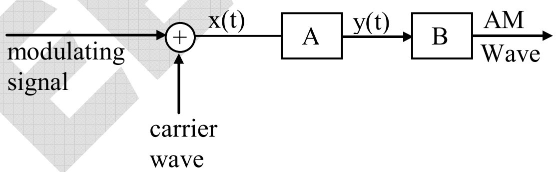
$$y = \frac{D\lambda}{a}$$

$$3 \times 10^{-3} = \frac{1.5 \times 450 \times 10^{-9}}{a}$$

$$a = \frac{1.5 \times 450 \times 10^{-9}}{3 \times 10^{-3}}$$

a = 0.225 mm

12. In the block diagram of a simple modulator for obtaining an AM signal, shown in the figure, identify the boxes A and B. Write their functions. **2**



Sol. In the given block diagram, block (A) is modulator and Block (B) is power amplifier

(A) = modulator changes the amplitude of carrier wave according to modulating signals

(B) = Power amplifier enhance the voltage and enhance power of modulated signals

13. A convex lens of focal length f_1 is kept in contact with a concave lens of focal length f_2. Find the focal length of the combination. **2**

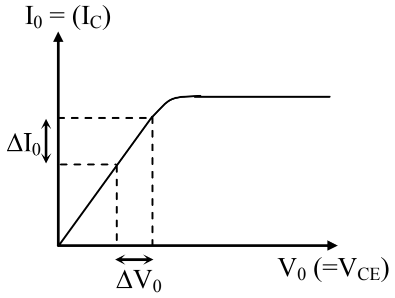
Sol.
$$\frac{1}{f} = \frac{1}{+f_1} + \frac{1}{-f_2}$$

$$\frac{1}{f} = \frac{f_2 - f_1}{f_1 f_2}$$

$$f = \frac{f_1 f_2}{f_2 - f_1}$$

14. Draw typical output characteristics of an n-p-n transistor in CE configuration. Show how these characteristics can be used to determine output resistance. **2**

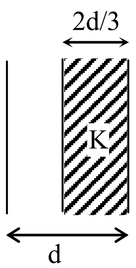
Sol.



Output resistance = $\dfrac{\Delta V_0}{\Delta I_0}$

15. A slab of material of dielectric constant K has the same area as that of the plates of a parallel plate capacitor but has the thickness 2d/3, where d is the separation between the plates. Find out the expression for its capacitance when the slab is inserted between the plates of the capacitor. **2**

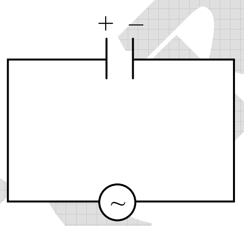
Sol.



$$C = \frac{\epsilon_0 A}{\frac{2d/3}{K} + \frac{d/3}{1}} = \frac{3\epsilon_0 AK}{d(2+K)}$$

16. A capacitor, made of two parallel plates each of the area A and separation d, is being charged by an external ac source. Show that the displacement current inside the capacitor is the same as the current charging the capacitor. **2**

Sol.



Displacement current between plates of capacitor is

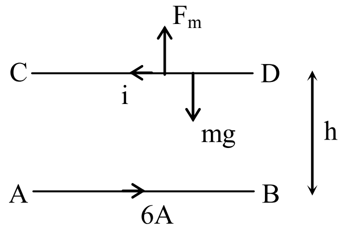
$$i_d = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 \frac{d(EA)}{dt} = \epsilon_0 A \frac{d(V/d)}{dt}$$

$$= \frac{\epsilon_0 A}{d} \frac{dV}{dt} = C\frac{dV}{dt} = \frac{d(CV)}{dt} = \frac{d}{dt}q$$

$$\therefore i_d = \frac{dq}{dt}$$

17. A wire AB is carrying a steady current of 6A and is lying on the table. Another wire CD carrying 4A is held directly above AB at a height of 1mm. Find the mass per unit length of the wire CD so that it remains suspended at its position when left free. Give the direction of the current flowing in CD with respect to that in AB. [Take the value of $g = 10\ ms^{-2}$] **3**

Sol.



($\ell \to$ length of CD)

for balance of CD

$$f_m = mg$$

$$\left(\frac{\mu_0}{2\pi}\frac{i_1 i_2}{h}\right)\ell = mg$$

$$\frac{m}{\ell} = \frac{2\times10^{-7}\times6\times4}{10^{-3}\times10} = 4.8\times10^{-4}\ kg/m$$

Direction of current in CD will be opposite to AB.

18. (a) For a given a.c., $i = i_m \sin \omega t$, show that the average power dissipated in a resistor R over a complete cycle is $\frac{1}{2} i_m^2 R$. **3**

(b) A light bulb is rated at 125 W for a 250 V a.c. supply. Calculate the resistance of the bulb.

Sol. (a) $P = i^2R = (i_m^2 \sin^2 \omega t)\ R$

$$\langle P\rangle = (i_m^2\ R) \langle \sin^2\omega t\rangle$$

$$= \frac{i_m^2 R}{2}$$

(b) $R = \frac{V^2}{P} = \frac{(250)^2}{125} = 500\ \Omega$

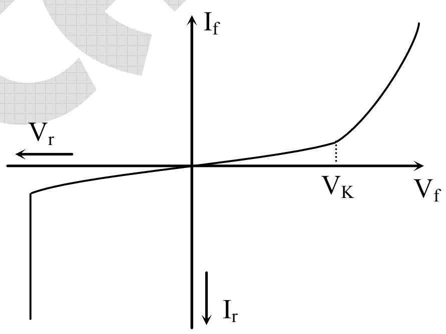
19. Draw V–I characteristics of a p-n junction diode. Answer the following questions, giving reasons : **3**

(i) Why is the current under reverse bias almost independent of the applied potential upto a critical voltage ?

(ii) Why does the reverse current show a sudden increase at the critical voltage

Name any semiconductor device which operates under the reverse bias in the breakdown region.

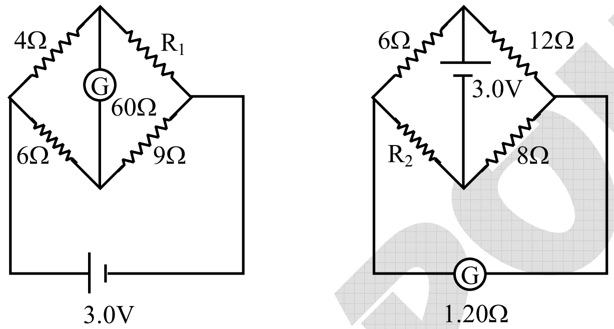
Sol.



(i) When p-n junction is reverse baised, the majority carriers in p and n region are repelled away from the junction. There is small current due to the minority carriers. This current attains its maximum or saturation value immediately and is independent of the applied reverse voltage.

(ii) As the reverse voltage is increased to a certain value, called ***break down voltage***, large amount of covalent bonds in p and n regions are broken. As a result of this, large electron-hole pairs are produced which diffuse through the junction and hence there is a sudden rise in the reverse current. Once break down voltage is reached, the high reverse current may damage the ordinary junction diode.
Device is zener diode.

20. Define the current sensitivity of a galvanometer. Write its S.I. unit. Figure shows two circuits each having a galvanometer and a battery of 3V. **3**
When the galvanometers in each arrangement do not show any deflection, obtain the ratio R_1/R_2.



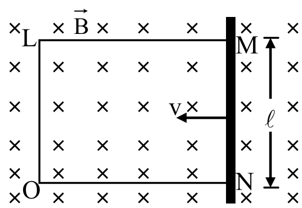
Sol. Current sensitivity : It is deflection produced in the galvanometer per unit current flowing through it.
S.I. unit -

In first fig. $\frac{4}{R_1} = \frac{6}{9} \Rightarrow R_1 = 6\ \Omega$

In second fig. $\frac{12}{8} = \frac{6}{R_2} \Rightarrow R_2 = 4\Omega$

$\therefore \frac{R_1}{R_2} = \frac{6}{4} = \frac{3}{2}$

21. A rectangular conductor LMNO is placed in a uniform magnetic field of 0.5 T. The field is directed perpendicular to the plane of the conductor. When the arm MN of length of 20 cm is moved towards left with a velocity of 10 ms^{-1}, calculate the emf induced in the arm. Given the resistance of the arm to be 5 Ω (assuming that other arms are of negligible resistance) find the value of the current in the arm. **3**



OR

A wheel with 8 metallic spokes each 50 cm long is rotated with a speed of 120 rev/min in a plane normal to the horizontal component of the Earth's magnetic field. The Earth's magnetic field at the place is 0.4 G and the angle of dip is 60°. Calculate the emf induced between the axle and the rim of the wheel. How will the value of emf be affected if the number of spokes were increased ?

Sol. $\varepsilon = vB\ell = 10 \times 0.5 \times 0.2 = 1$ volt

$i = \frac{\varepsilon}{R} = \frac{1}{5} = 0.2$ Amp.

OR

$B_H = B_e\cos\theta = 0.4 \times 10^{-4} \cos 60^o = 2 \times 10^{-5}$ T

$\varepsilon = \frac{B_H \omega R^2}{2}$

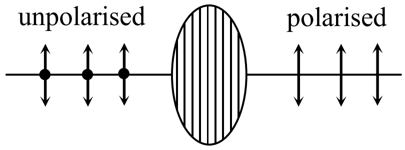
$= \frac{2 \times 10^{-5} \times 4\pi (0.5)^2}{2}$

$= 3.14 \times 10^{-5}$ V $\qquad \omega = 2\pi \times \frac{120}{60} = 4\pi$

On increasing the number of spokes, emf will remain same because they form parallel combination.

22. (a) What is linearly polarized light ? Describe briefly using a diagram how sunlight is polarised.
(b) Unpolarised light is incident on a polaroid. How would the intensity of transmitted light change when the polaroid is rotated ? **3**

Sol. (a) When vibrations of light wave are confined to only one direction then light is called linearly polarised.

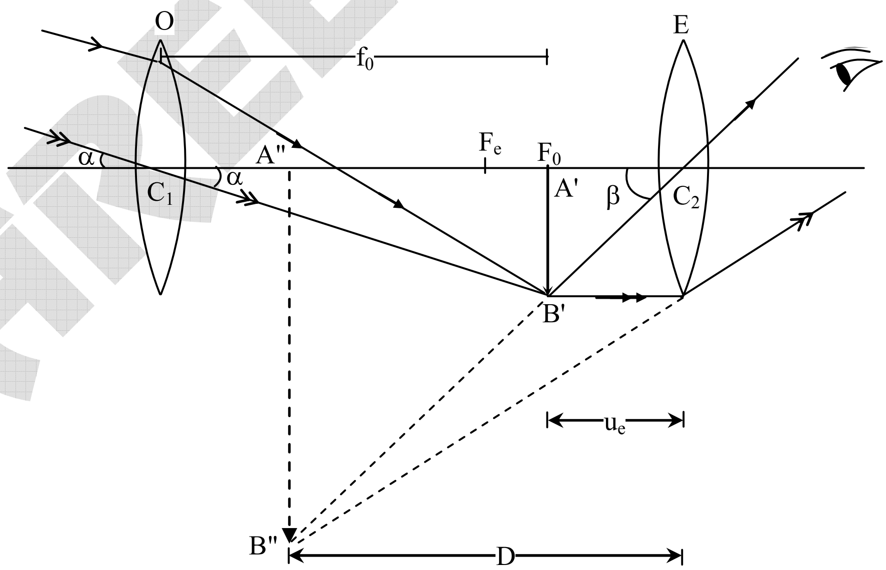


When sunlight passes through polaroid then components parallel to axis passes in unaffected way and components perpendicular to axis are absorbed so transmitted light is polarised.

(b) On rotating the polaroid, intensity remains unchanged as half of the incident intensity.

23. Draw a labelled ray diagram of a refracting telescope. Define its magnifying power and write the expression for it.
Write two important limitations of a refractive telescope over a reflecting type telescope. **3**

Sol.



Magnifying power of an astronomical telescope is defined as the ratio of the angle subtended by the final image at the eye to the angle subtended by the object at the eye.

If α and β, be the angles subtended by the object and image with the eye respectively, then

M.P. = $\frac{\beta}{\alpha}$

(a) For distinct vision

M.P. = $\frac{-f_0}{f_e}\left(1+\frac{f_e}{D}\right)$

(b) For normal vision, $u_e = f_e$

M.P. = $-\left(\frac{f_0}{f_e}\right)$

Limitations of refracting telescope :-

(i) The refracting telescope suffers from spherical & chromatic aberrations.

(ii) Objective lens of refracting telescope of very large aparture are very difficult to manufacture.

24. Write Einstein's photoelectric equation and point out any two characteristic properties of photons on which this equation is based. **3**

Briefly explain the three observed features which can be explained by this equation.

Sol. If energy of photon = E (= hν) work function of metallic surface = ϕ = ($h\nu_0$)

kinetic energy of emitted electron = $\frac{1}{2}mv^2$

$E = \phi + \frac{1}{2}mv^2$

$\frac{1}{2}mv^2 = h(\nu - \nu_0)$

Einstein's equation

Two charactristics of photons

(i) This equation is based on particle nature of light

(ii) Total energy of photon is transffered completly to single electron.

(iii) If incident frequency ν < threshold frequency (ν_0), then kinetic energy $\left(\frac{1}{2}mv^2\right)$ will be negative which is not possible because kinetic energy can not be negative. This shows that photoelectric emission is not possible if frequency (ν) of incident light is less than the threshold frequency (ν_0) of the metal.

(iv) One photon can emit only one electron from the metal surface, so the number of photoelectrons emitted per second is directly proportional to the intensity of incident light which depends upon number of photons present in the incident light.

(v) From eqn. it is clear that kinetic energy, $\frac{1}{2}mv^2$ increases with the increase in the frequency (ν) of the incident light.

25. Name the type of waves which are used for line of sight (LOS) communication. What is the range of their frequencies ? **3**

A transmitting antenna at the top of a tower has a height of 45 m and the receiving antenna is on the ground. Calculate the maximum distance between them for satisfactory communication in LOS mode. (Radius of the Earth = 6.4×10^6m)

Sol. High frequency waves (above 40 MHz) called space waves can be transmitted from transmitting to receiving antenna and the mode for travelling of these waves through space is known as space wave propagation.

$d = \sqrt{2hR_e}$

$d = \sqrt{2\times 45\times 6.4\times 10^6}$

d = 24000 m, d = 24 km

26. One day Chetan's mother developed a severe stomach ache all of a sudden. She was rushed to the doctor who suggested for an immediate endoscopy test and gave an estimate of expenditure for the same. Chetan immediately contacted his class teacher and shared the information with her. The class teacher arranged for the money and rushed to the hospital. On realising that Chetan belonged to a below average income group family, even the doctor offered concession for test fee. The test was conducted successfully.

Answer the following questions based on the above information **4**

(a) Which principle in optics is made use of in endoscopy ?

(b) Briefly explain the values reflected in the action taken by the teacher.

(c) In what way do you appreciate the response of the doctor on the given situation ?

Sol. (a) Total internal reflection.

(b) Teacher plays a good role to teach a moral in a perfect way to student how to support for humanity by presenting him as an example for students

(c) As chetan belongs to below average income group family. Keeping this in his/her mind, doctor offred consession for the test fee and served his oath for huminity as a doctor in a best possible way.

27. (a) Define electric dipole moment. Is it a scalar or a vector ? Derive the expression for the electric field of a dipole at a point on the equatorial plane of the dipole. **5**

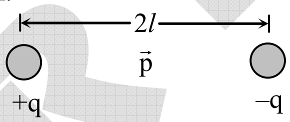
(b) Draw the equipotential surfaces due to an electric dipole. Locate the points where the potential due to the dipole is zero.

OR

Using Gauss' law deduce the expression for the electric field due to a uniformly charged spherical conducting shell of radius R at a point (i) outside and (ii) inside the shell.

Plot a graph showing variation of electric field as a function of r > R and r < R (r being the distance from the centre of the shell)

Sol. (a) Electric dipole moment of an electric dipole is defined as the product of the magnitude of either charge of the electric dipole and the dipole length.



i.e., $\vec{p} = q\,(2\,\vec{l}\,)$

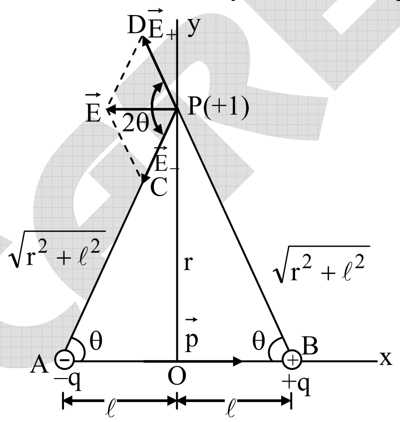
The magnitude of dipole moment is

$$p = q \times 2l$$

Dipole moment is a vector quantity

SI Unit of dipole moment ($\vec{p}$) is coulomb metre (Cm)

Electric field intensity at P due to +q charge is given by



$$E_+ = \frac{1}{4\pi\varepsilon_0}\,\frac{q}{BP^2} \text{ along PD}$$

$$= \frac{1}{4\pi\varepsilon_0}\,\frac{q}{(r^2+\ell^2)} \text{ along PD} \qquad \ldots\ldots \text{(i)}$$

Elecric field intensity at P due to –q charge is given by

$E_- = \frac{1}{4\pi\varepsilon_0}\frac{q}{AP^2}$ along PC $= \frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+\ell^2)}$ along PC ….. (ii)

From (i) and (ii), $E_+ = E_- = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+\ell^2)}$ …… (iii)

The net electric field intensity due to the electric dipole at point P.

$\therefore\ E = \sqrt{E_+^2 + E_-^2 + 2E_+E_-\cos 2\theta}$

$= \sqrt{E_+^2 + E_+^2 + 2E_+^2\cos 2\theta}$ ($\because$ $E_- = E_+$)

$= \sqrt{2E_+^2 + 2E_+^2\cos 2\theta} = \sqrt{2E_+^2(1+\cos 2\theta)}$

$= \sqrt{2E_+^2 \times 2\cos^2\theta}$

($\because$ $1 + \cos 2\theta = 2\cos^2\theta$)

$\therefore\ E = 2E_+\cos\theta = 2 \times \frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+\ell^2)}\cos\theta$ [Using equation (iii)]

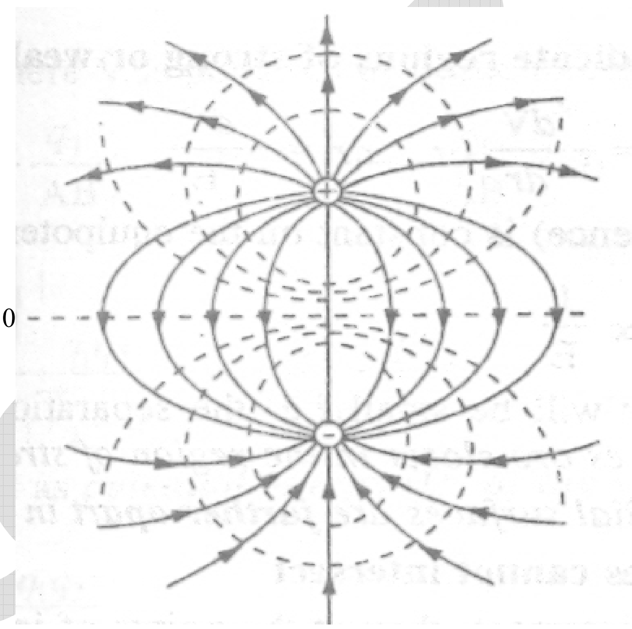
$\cos\theta = \frac{\ell}{\sqrt{r^2+\ell^2}}$

$E = \frac{p}{4\pi\varepsilon_0(r^2+\ell^2)^{3/2}}$

If $\ell << r$, $E = \frac{p}{4\pi\varepsilon_0 r^3}$

(b)

V = 0

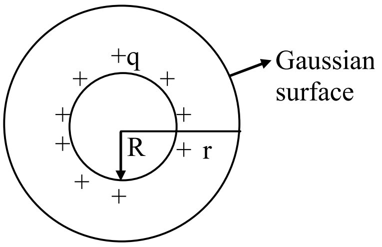


OR

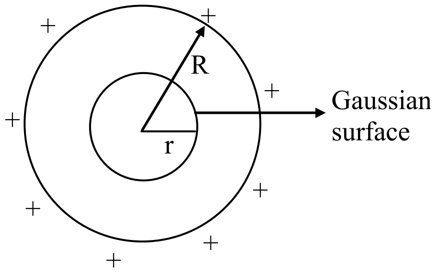
(i) $\oint \vec{E}.\vec{ds} = \frac{q_{in}}{\epsilon_0}$

$E.4\pi r^2 = \frac{q}{\epsilon_0}$

$E = \dfrac{q}{4\pi \in_0 r^2}$

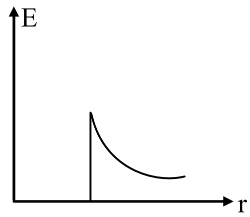


(ii) $\oint \vec{E}.\vec{ds} = \dfrac{q_{in}}{\in_0}$



$E.\ 4\pi r^2 = \dfrac{0}{\in_0}$

$E = 0$



28. Using Bohr's postulates, derive the expression for the frequency of radiation emitted when electron in hydrogen atom undergoes transition from higher energy state (quantum number n_i) to the lower state, (n_f). **5**

When electron in hydrogen atom jumps from energy state $n_i = 4$ to $n_f = 3,2,1$, identify the spectral series to which the emission lines belong.

OR

(a) Draw the plot of binding energy per nucleon (BE/A) as a function of mass number A. Write two important conclusions that can be drawn regarding the nature of nuclear force.

(b) Use this graph to explain the release of energy in both the processes of nuclear fusion and fission.

(c) Write the basic nuclear process of neutron undergoing β-decay. Why is the detection of neutrinos found very difficult

Sol. According to Bohr, energy is radiated in the form of a photon when the electron of an excited hydrogen atom returns from higher energy state to the lower energy state. In other words, energy is radiated in the form of a photon when electron in hydrogen atom jumps from higher energy orbit ($n = n_i$) where $n_i > n_f$. The energy of the emitted radiation or photon is given by

$h\nu = E_{n_i} - E_{n_f}$

we know $E_n = \dfrac{-me^4}{8h^2 \in_0^2 n^2}$

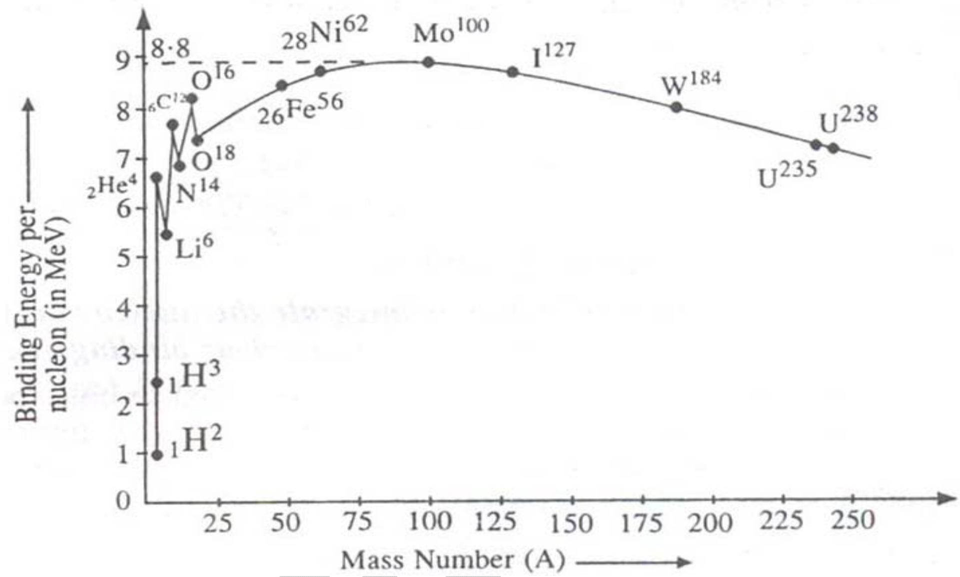
$$\therefore h\nu = \frac{me^4}{8\epsilon_0^2 n_i^2 h^2} - \frac{me^4}{8\epsilon_0^2 n_f^2 h^2} \text{ i.e., } h\nu = \frac{me^4}{8\epsilon_0^2 h^2}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\text{or } \nu = \frac{me^4}{8\epsilon_0^2 h^3}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

	Name of series
n = 4 to n = 3	Paschan
n = 4 to n = 2	Balmer
n = 4 to n = 1	Lyman

OR

(a)



Conculsions :-

(i) The intermediate nuclei have large value of BE/A so they are more stable.

(ii) BE/A has low value for both of light and heavy nuclei so they are unstable nuclei.

(b) In nuclear fission, unstable heavy nuclei splits into two stable intermediate nuclei and in Nuclear fusion, 2 ustable light nuclei combines to form stable intermediate nuclei so in both processes energy liberates as stability increases

(c) $n \longrightarrow P + {}_{-1}\beta^0 + \overline{\nu}$

Neutrinos are difficult to detect as they go through all object by penetrating them.

29. (a) Using Biot-Savart's law, derive the expression for the magnetic field in the vector form at a point on the axis of a circular current loop. **5**

(b) What does a toroid consist of ? Find out the expression for the magnetic field inside a toroid for N turns of the coil having the average radius r and carrying a current I. Show that the magnetic field in the open space inside exterior to the toroid is zero.

OR

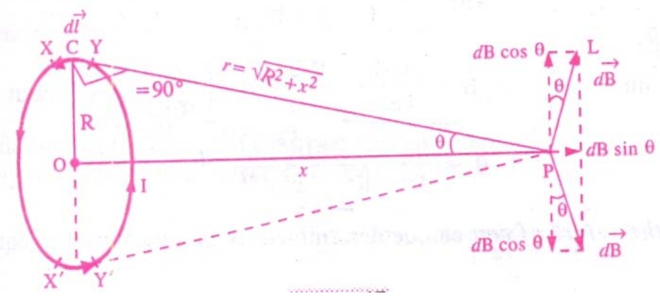
(a) Draw a schematic sketch of a cyclotron. Explain clearly the role of crossed electric and magnetic field in accelerating the charge. Hence derive the expression for the kinetic energy acquired by the particles.

(b) An α-particle and a proton are released from the centre of the cyclotron and made to accelerate.

(i) Can both be accelerated at the same cyclotron frequency ? Give reason to justify your answer.

(ii) When they are accelerated in turn, which of the two will have higher velocity at the exit slit of the dees ?

Sol. (a)



According to Biot-Savart's law, magnetic field due to a small element XY at point P is

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\phi}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\frac{Id\ell\sin 90^\circ}{r^2} = \frac{\mu_0 Id\ell}{r^2} \quad (\because \sin 90^\circ = 1)$$

Resolving dB into two components :

(i) dB cos θ, which is perpendicular to the axis of the coil

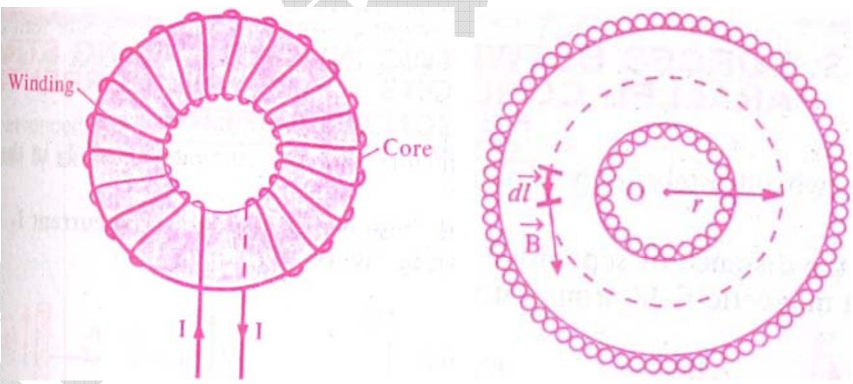
(ii) dB sin θ which is along the axis of the coil and away from the centre of the coil.

$$B = \int dB\sin\theta \text{ or } B = \frac{\mu_0 I\sin\theta}{4\pi r^2}\int dl$$

$$\therefore \quad B = \frac{\mu_0 I\sin\theta \times 2\pi R}{4\pi r^2}$$

$$\therefore \quad B = \frac{\mu_0}{4\pi}\frac{2\pi IR^2}{(R^2+x^2)^{3/2}}$$

(b)



$$\oint \vec{B}.d\vec{l} = B \times 2\pi r \qquad \ldots(i)$$

According to Ampere's circuital law,

$$\oint \vec{B}.d\vec{l} = \mu_0 \times \text{net current enclosed by the circle of radius r}$$

$$= \mu_0 \times \text{total number of turns} \times I$$

$$= \mu_0 (n \times 2\pi r) I \qquad \ldots(ii)$$

Comparing equation (i) and (ii), we get

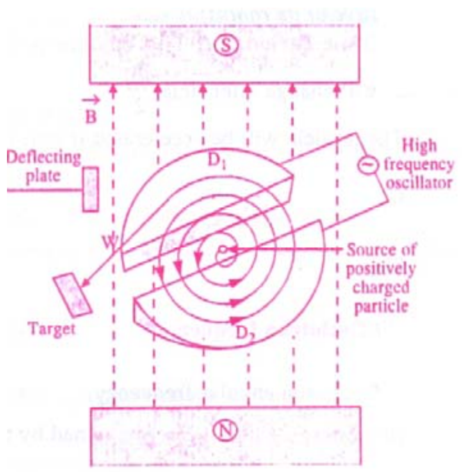
$$B \times 2\pi r = \mu_0(n \times 2\pi r) I$$

$$B = \mu_0 nI$$

For any point inside the empty space surrounded by toroid and outside the toroid, magnetic field B is zero because the net current enclosed in these spaces is zero. But magnetic field is not exactly zero.

OR

(a)



Electric field accelerate the charged particle where as magnetic field makes its path circular.

$$\text{K.E.} = \frac{1}{2}mv^2 \qquad , \qquad r = \frac{mv}{qB}$$

$$= \frac{1}{2}m\left(\frac{qBr}{m}\right)^2$$

$$\text{K.E.} = \frac{q^2B^2r^2}{2m}$$

(b) (i) $f_\alpha = \dfrac{qB}{2\pi m} = \dfrac{(2e)B}{2\pi(4m_p)} = \dfrac{eB}{4\pi m_p}$

$$f_p = \frac{eB}{2\pi m_p}$$

$\therefore f_\alpha \propto f_p$

So both can't be accelerated by same frequency.

(ii) $r = \dfrac{mv}{qB}$

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

$$v \propto \frac{q}{m}$$

$$\frac{v_p}{v_\alpha} = \frac{q_p}{q_\alpha}\frac{m_\alpha}{m_p}$$

$$= \left(\frac{e}{2e}\right)\left(\frac{4m_p}{m_p}\right)$$

$$\frac{v_p}{v_\alpha} = 2$$

$\therefore v_p = 2v_\alpha$

$\therefore v_p > v_\alpha$