# S AQ'S (4 MARKS)

## RAY OPTICS

**1. Define focal length of a concave mirror prove that the radius of curvature of concave mirror is double its focal length?**

**A.** When a light ray incident parallel to the principal axis of a concave mirror gets reflected through a principle focus 'F' if 'C' is the centre of curvature and CP is the normal to the mirror at 'P'

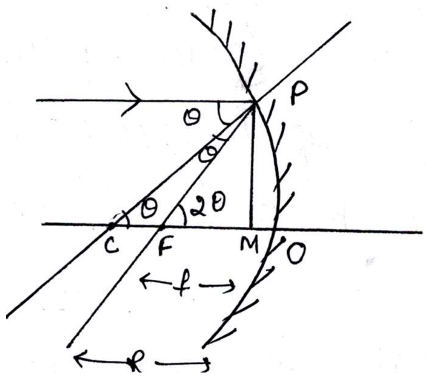
$\angle CPO = \theta$

$\angle OPF = 2\theta$

From $\Delta FPO$

$$\text{Tan } 2\theta = \frac{PM}{FM}$$

From $\Delta CPO$ $\tan\theta = \dfrac{PM}{CM}$




If $\theta$ is small

$\tan\theta \approx \theta$ and $\tan 2\theta \approx 2\theta$

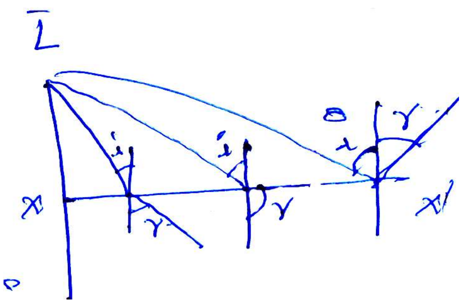
$$2Q = \frac{PM}{FM} \Rightarrow 2\left(\frac{\cancel{PM}}{CM}\right) = \frac{\cancel{PM}}{FM} \Rightarrow \frac{2}{R} = \frac{1}{F} \Rightarrow F = \frac{R}{2}$$

**2. Define critical angle. explain total internal refelction using a neat diagram?**

**A.** **<u>Critical angle</u>** :- When a light ray is refracted from denser medium to rarer medium at particular angle of incidence. If the angle of refraction is $90^0$. Then the angle of incidence is called critical angle.

$$n_{12} = \frac{1}{\sin i_c}$$

**<u>Total Internal refelction</u>** :- When the light is propagated from denser medium to rarer medium. If the angle of incidence is greater than critical angle. Then the right ray is completely reflected in the same medium is called total internal reflection.




**<u>Explanation</u>** :- Consider a light ray passing from denser mediun to a rarer medium. The light ray after refraction bends away from the normal. If the angle of incidence increases then angle of refraction increases as sin r $\alpha$ sin i. If the angle of incidence equal to critical angle at 'A' " then the refracted ray just grazes the surface xx' and angle of fraction becomes $90^0$. If the angle of incidence (i) increases further greater than critical angle then it reflects into the same denser medium. This is known as total internal reflection.

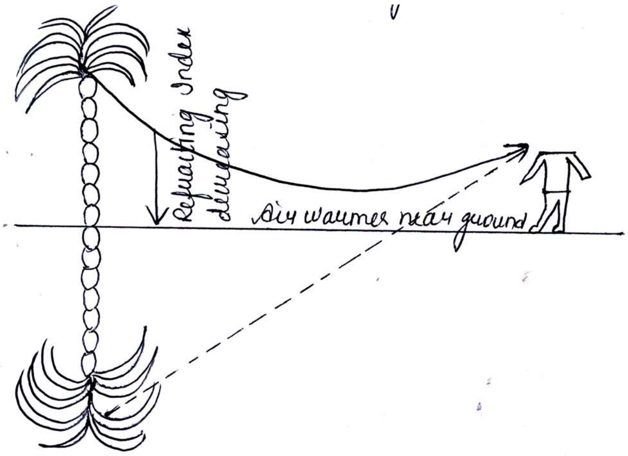
**Condition for total internal reflection :**

1. The Light ray must travel from denser to rarer medium.
2. The angle of incidence in the denser medium must be greater than the critical angle.

**3. Explain the formation of mirage ?**

**A.** **Mirage** :- It is an optical illusion observed in deserts and coal tarred roads on a hot day. The object such as a true appears inverted and the observer gets the impression as if the inverted image has been formed by a pool of water. This phenomenon is known as mirage.

**Explanation** :- In summer, the layers of air near the gorund are hotter that the air at higher levels Hotter air is less density, and has smaller refractive index than the cold air. In still air, The optical density at different layers of air increases with hight As a result, light from a tall object such as tree, passes the medium whose refractive index decreases towards the ground. Then a ray of light from the object successively bends away from the normal. If the angle of Incidence for the air near the ground exceeds the critical angle. total internal reflection takes place. tp a distant observer, the light appears to be coming from somewhere below the ground such inverted images of distant tall objects causes an optical illusion to the observer. This phenomenon is called mirage.




**4. Explain the formation of a rainbow?**

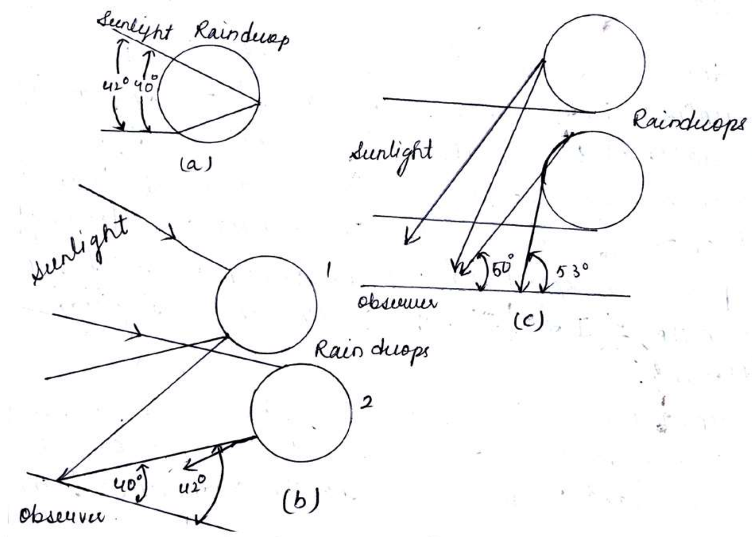
**A.** **Formation of Rainbow** :-

1) The rainbow is an example of the dispersion of sunlight by the water drops in the atmosphere. This sunlight by the water drops in the atmosphere. This is due to combined effect of dispersion, refraction and reflection of sunlight by spherical rain droplets.

2) An observer can see a rainbow only when his back is towards the sun In order to understand the formation of rainbow, consider figure (a) sunlight is first refracted as it entires a raindrops. This causes the different wavelengths of white light to separate longer wavelength of light are bent the least while the shorter wavelength are bent the most. These component rays strike the inner suface of the water drop and get internally reflected. if the angle between the refracted ray and normal to the drop surface is greater than the critical angle the reflected light is refracted again as it comes out of the drop as shown in the figure. It is found that the violet light emerges at an angle of $40^0$ related to the incoming sunlight and red light emerges at an angle of $42^0$ - for other colours angles lie in between these two values.

3) Figure (b) explains the formation of primary rainbow Red light from drop 1, and violet light from drop 2 reach the observers eye. The violet from drop 1 and red light from drop 2 are directed level above or below the observer. Thus the observer sees a rainbow with red colour on the top and violet on the bottom thus, the primary rainbow is a result of reflection and refraction.

4) When light rays undergoes two internal reflections inside a raindrop, instead of one as in the primary rainbow, secondary rianbow as shown in figure (c). The intensity of light i is reduced at the second reflection and hence the secondary rainbow is fainter than the primary rainbow. Also the order of the colours is reversed.

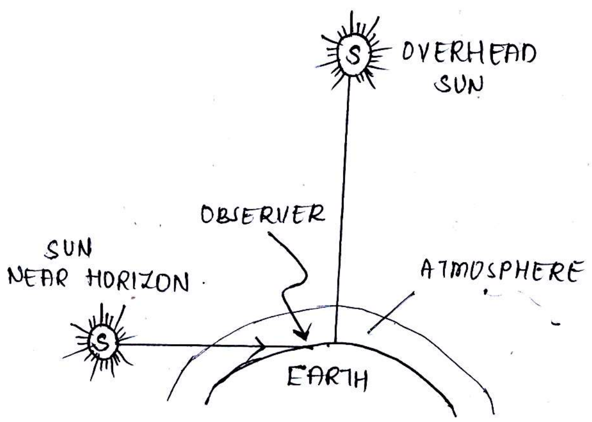



**5. Why does the setting sun appear red?**

**A.** As sunlight travels through the earths atmosphere, it gets scattered by the atmospheric particles. light of shorter wavelengths is scattered much more than light of longer wave lengths the amount of scattering is inversely proportional to the fourth power of the wavelength $\left(I\alpha\frac{1}{\lambda^4}\right)^T$. This is known as Rayleigh scattering.

At sunrise or sunset the sun looks almost reddish the reason is that at the time of sun set or sun rise, The light from the sun has to transverse larger thickness of atmosphere than what it covers when the sun is overhead as shown in figure.

Due to this, more of the blue and shorter wave length of sun light is removed by scattering and the least scattered light i.e., red reaches our eye. so the sun looks reddish.



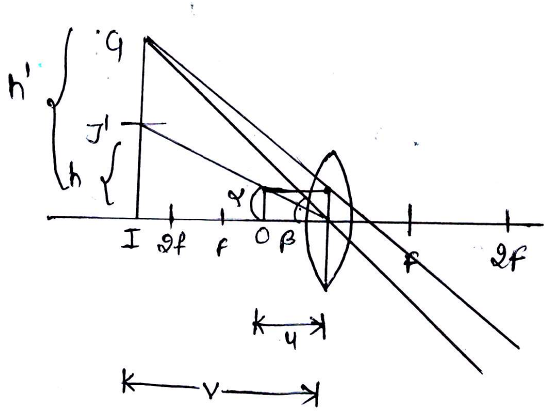

**6. With a neat labelled diagram explain the formation of image in a simple microscope?**

**A.** **<u>Simple microscope</u>** :- A convex lens of short focal length is used as a simple microscope The lens is arranged in a circular metallic frame.

**<u>Formation of image</u>** :- An object OJ is placed within the principle focus F of the convex lens. The image is virtual and magnified.

$$\text{Magnifying power} = M = \frac{\text{vitual angle with instrument}}{\text{Maximum vitual angle extended by } \angle i}$$

$$\therefore M = \frac{D}{u}$$



we know that $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$

f is +ve But v & u are -ve

$$\frac{1}{f}=-\frac{1}{v}-\left(-\frac{1}{u}\right)$$

$$\frac{1}{u}=\frac{1}{f}+\frac{1}{v}$$

But $M=\frac{D}{u}=D\left(\frac{1}{f}+\frac{1}{v}\right)$

Image is at near point v=D

$$M=D\left(\frac{1}{f}+\frac{1}{D}\right)=\frac{D}{f}+1$$

At far point $v = \alpha$

$$M=D\left(\frac{1}{f}+\frac{1}{\alpha}\right) \qquad \Rightarrow M=\frac{D}{f}$$

**7. A light ray passes through a prism of angle A in a position of minimum deviation Obtain an expression for (a) The angle of incident in terms of the angle of the prism and the angle of the manimum deviation (b) The angle of refraction in terms of the refraction index of the prism ?**

**A.** Let us consider a prism ABC of angle of incidence $i_1$ and angle of emergent $i_2$ as shown in the figure. from fig

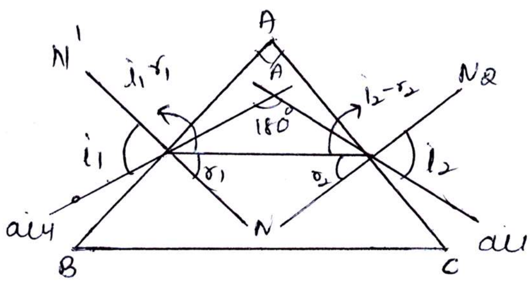
Angle of prism :- From Quadrilateral

$\Delta$ PQNA

$r_1+r_2+\angle N = \angle N + A$

$r_1+r_2 = A$

If $r_1 = r_2 = r \Rightarrow r=\frac{A}{2}$



from $\Delta$ PQ.A

$i_1-r_1+i_2-r_2+\cancel{180}-\delta=\cancel{180}$

$i_1+i_2 = \delta+(r_1+r_2)$

$i_1+i_2 = \delta + A$

if $i1 = i_2 = i$

$i = \frac{\delta + A}{2}$

But from snell's law $\mu = \frac{\sin i}{\sin r}$

$$\mu = \frac{\sin\left(\frac{A+\delta}{2}\right)}{\sin\left(A/2\right)}$$

* For small angle prism :-

$$\sin\left(\frac{A+\delta}{2}\right) \approx \left(\frac{A+\delta}{2}\right)$$

sin A/2 = A/2

$$\mu = \frac{\frac{A+\delta}{\not{2}}}{A/\not{2}} \quad \Rightarrow \mu = \frac{A+\delta}{A}$$

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# WAVE OPTICS

**8. Explain Doppler effect in light Distinguish between red shift and bllue shift.**

**A. <u>Doppler Effect in light</u>** :-

1. The apparent change in frequency (or) wave length of light is called doppler effect in light.
2. If '$\vartheta$' is the actual frequency and '$\Delta\vartheta$ is the apparent frequency, then the relative change in frequency.
3. $\frac{\Delta\vartheta}{\vartheta} = \frac{-V}{C}$ or $\frac{\Delta\lambda}{\lambda} = \frac{V}{C}$
4. Here 'C' is the speed of light and 'V' is the velocity of the source which is small compared to that of light Doppler effect in light is symmetric

| 5. Red shift | Blue shift |
|---|---|
| 1. The spectrum of Radiation from the source of light shif towards red end of the spectrum. this is called red shift | 1. The spectrum of radiation from the source of light shifts towards the blue end of the Spectrum. this is called blue shift |
| 2. When the source is moving away from observer the wave length emitted increases | 2. When the source is moving towards the observer the wavelength emitted decreases |
| 3. $\Delta\lambda = +\frac{\vartheta}{C}\lambda$ | 3. $\Delta\lambda = -\frac{\vartheta}{C}\lambda$ |
| 4. This confirms the expanding nature of the universe | 4. This confirms the universe is not expanding |

**9. Does the principle of conversation of energy hold for interference and diffraction phenomenon? explain briefly.**

**A.** Yes, the principle of conservation of energy hold good for both the inference and diffraction phenomenon.

Explanation :

1. In the case of interference the energy will be disappear at the position of bright bands thus energy remains constant so principle of conservation of energy holds good for interference.

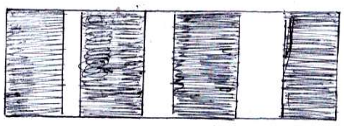
2. In diffraction phenomenon, the interference of secondary wavelets takes place. therefore principle of conservation of energy holds good for diffraction.

3. In both the interference and diffraction, redistribution of energy takes place. The energy is average energy of waves remains same. There is no loss or gain of energy due to formation of dark and bright bands in interference and diffraction of light. Thus they do not violate law of conservation of energy.

**10. How do you determine the resolving power of your eye?**

**A.** **Resolving power** :- The ability of an optical instrument to produce distinctly separate image of two objects located very close to each other is called resolving power.

**Resolving power of eye** :- make black stripes of equal width sparated by white strepes all the white stripes should be of equal width, while that of white stripes should increase from left to right for example let the black stripes have a width of 5mm. let the width of two which stripes be 0.5 mm each, the next two white stripes be 1mm each, the next 1.5 mm each, etc. paste this pattern on a wall in the room at the height of your eye.



Now watch the pattern with one eye. by moving away or closer to the wall, find the position where you can just see some black stripes as separate stripes. All the black stripes to the right of this would be more clearly visible. If 'd' is the width of the white stripe and 'D' is the distance of the wall from two crossed eye.Then d/D is the resolution of the eye.

**11. Derive the expression for the intensity at a point where interference of light occurs. Arive at the condition for maximum and zero intensity.**

**A.** **Interference**:- The redistribution of energy due to super imposition of two or more waves is called interference

**Theory** :- Let $y_1$ and $Y_2$ are the displacements produced by the coherent waves at any 'P' on the screen. The waves can be represented by

y1 = a cos $\omega t$ and $y_2 = a \cos(\omega t + \theta)$

Here a = amplitude , and w = Angular frequency and the resultant displacement 'y' is given by

$y = y_1 + y_2 \Rightarrow y = a \cos wt + a \cos(wt + \theta)$ or

$y = 2a \cos(\theta/2) \cos(wt + \theta/2)$

The amplitude of the resultant displacement is $2a \cos(\theta/2)$ and hence the intensity at that point will be $I = 4 I_0 \cos^2 . \theta/2$

Condition for maximum intensity :-

$\theta = 0, \pm 2\pi, \pm 4\pi$ ....leads maximum intensity or constructive interference.

Condition for zero intensity :- $\theta = \pm \pi, \pm 3\pi, \pm 5\pi$ ....leads minimum or zero intensity or destructive interference.

**12. Discuss the intensity of transmitted light when a polaroid sheet is rotated between crossed, polaroids.**

**A.** Let $I_0$ be the intensity of polarised light after passing through the first polariser $P_1$, then the intensity of light after passing through second polariser $p_2$ will be

$$I = I_0 \cos^2 \theta$$

Where q is the angle between pass axes of $p_1$ and $p_2$ since $p_1$ and $p_3$ are crossed the angle between the axes of $p_2$ and $p_3$ will be $(\pi/2-\theta)$. hence the intensity of light emerging from $p_3$ will be

$$I = I_0 \cos^2 \theta \cos^2\left(\frac{\pi}{2} - \theta\right)$$

$$= I_0 \cos^2 \theta \sin^2 \theta = (I_0/4) \sin^2 2\theta$$

therefore, the transmitted intensity will be maximum when $\theta = \pi/4$

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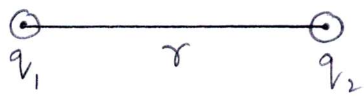
# ELECTRIC CHARGES AND FIELDS

**13. State and explain coulomb's inverse law in electricity.**

**A.** The force of attraction or repulsion between the charges is directly proportional to the product of their changes and inversely proportional to the square of the distance between them.

$F \alpha q_1 q_2$

$F \alpha \frac{1}{r^2}$




$F \alpha \frac{q_1 q_2}{r^2}$

$$F_a = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

$$\therefore \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$$

$\therefore E_0$ - permitivity of free space.

$\varepsilon_0 = 8.85 \times 10^{-12}$ Fery/meter

It opposes the flow of charge

$$F_m = \frac{1}{4\pi\varepsilon} \frac{q_1 q_2}{r^2}$$

$\varepsilon$ - permitivity of medium

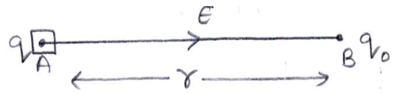
$$\frac{F_a}{F_m} = \frac{\frac{1}{\varepsilon_0}}{\frac{1}{\varepsilon}} = \frac{\varepsilon}{\varepsilon_0} = \varepsilon_r \Rightarrow k \quad \text{(Relative permitivity)}$$

**14. Define intensity of electric field at a point derive an expression for the intensity due to a point charge.**

**A.** Let us consider a charge q be placed at a point A.
We can find out the intensity of electric field at a point B as shown in figure.

* From coulomb's law $F = \frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r^2}$

But $E = F/q_0 = \frac{\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r^2}}{q_0}$

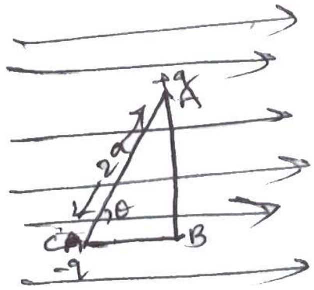



$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^3}\vec{r}$

**15. Derive the equation for the couple acting on a electric dipole in a uniform electric field.**

**A.** Let us consider on electric dipole placed in uniform electric field. There are two equal and opposite forces acting on a dipole constitutes couple on it.
Couple acting on the dipole
C = one of the force x perpendicular distance
= Eq (AB)




From ΔABC $\sin\theta = \frac{AB}{2a}$

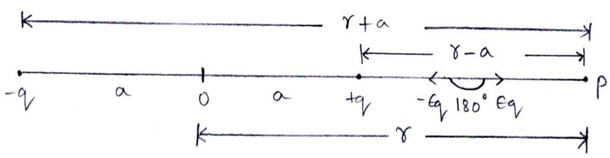
$AB = 2a\sin\theta$
$C = Eq(2a\sin\theta)$
$C = Ep\sin\theta$ [ $\because p = 2aq$ ]

$\vec{C} = \vec{P} \times \vec{E}$

$C_{max} = PE$, $\theta = 90^0$, $\sin 90^0 = 1$
$C_{min} = 0$. $\theta = 0^0$, $\sin 0^0 = 0$

**16. Derive an expression for the electric intensity of the electric field at a point on the axial line of an electric dipole.**

**A.** __Axial line__ :- The line which is passig through the charges of dipole is called axial line the resultant intensity at p is




$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

$Eq = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}$

$-Eq = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$

*Resultant intensity :- $E = {}_{+}Eq - {}_{-}Eq$

$E_A = \frac{1}{4\pi\varepsilon_0} q\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]$

$$E_A = \frac{1}{4\pi\varepsilon_0} q\left[\frac{(r+a)^2-(r-a)^2}{(r-a)^2(r+a)^2}\right]$$

$$E_A = \frac{1}{4\pi\varepsilon_0} q\left[\frac{\cancel{r^2}+\cancel{a^2}+2ar-\cancel{r^2}-\cancel{a^2}+2ar}{(r^2-a^2)^2}\right]$$

$$E_A = \frac{1}{4\pi\varepsilon_0} q\left[\frac{4ar}{(r^2-a^2)^2}\right]$$

$$E_A = \frac{1}{4\pi\varepsilon_0} \frac{(2aq)2r}{(r^2-a^2)^2} \quad [\because \text{but} = 2aq]$$

$$E_A = \frac{1}{4\pi\varepsilon_0} \frac{(2p)\cancel{r}}{r^{\cancel{4}}} \quad [\because \text{if } r>> a \text{ we can neglect } a^2]$$

$$E_A = \frac{1}{4\pi\varepsilon_0} \frac{(2p)}{r^3}$$

**17. Derive an expression for the electric intensity of the electric field at a point on the equatorial plane of an electric dipole.**

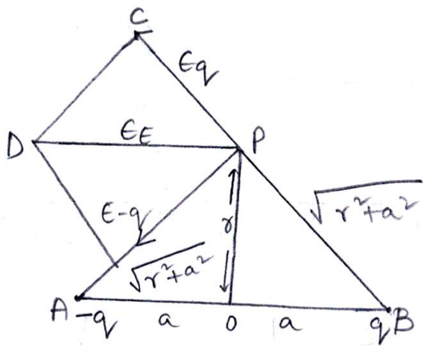
**A.** **Equatorial line** :- The line which is passing through the perpendicular bisector of the electric dipole is called equatorial line.

* From figure :-

$$E_{-q} = E_q = \frac{1}{4\pi\varepsilon_0} \frac{q}{\left(\sqrt{r^2+a^2}\right)^{\cancel{2}}}$$

$\Delta ABP$ and $\Delta PCD$ are similar triangles

$$\frac{E_E}{2a} = \frac{Eq}{\sqrt{r^2+a^2}}$$




$$\frac{E_E}{2a} = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2+a^2}}{\sqrt{r^2+a^2}}$$

$$\frac{1}{4\pi\varepsilon_0} \frac{2aq}{(r^2+a^2)^1(r^2+a^2)^{1/2}}$$

$$E_E = \frac{1}{4\pi\varepsilon_0} \frac{p}{(r^2+a^2)^{3/2}}$$

If r >>a, we can neglect a2

$$E_E = \frac{1}{4\pi\varepsilon_0} \frac{p}{r^3}$$

**18. State Gauss's law in electrostatics and explain its importance?**

**A.** **GAUSS'S LAW** :- " The electric flux $(\phi)$ through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the net charge enclosed by the surface ".

$$\phi = \oint \vec{E}.\vec{ds} = \frac{1}{\varepsilon_0} q$$

$\rightarrow$ This is the integral from of gauss's law
$\rightarrow$ q = charge, E = electric field
$\rightarrow$ $\varepsilon_0$ is the permitivity of free space.

* Importance :- Symmetrically consideration in many problems make application of good for any closed surface of any shape.
2. Gauss theorem holds good for any closed surface of any shape.
3. Gauss theorem gives relation between electric field at the charge
4. Gauss theorem is valid for stationery charges as well as for rapidly moving charge.

# ELECTROSTATIC POTENTIAL AND CAPACITANCE

**19. Derive an expression for the electric potential due to a point charge.**

**A.** Let us consider a point charge 'q' fixed at a point 'o' in freeze phase. Let us find electric potential at point 'b' due to charge 'q' -

dw = -F.dx

Where [ F= $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{x^2}$ ]

$$dw = \int_{\infty}^{r} -\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{x^2}dx$$

$$w = -\frac{1}{4\pi\varepsilon_0} qq_0 \int_{\infty}^{r} \frac{1}{x^2}dx$$

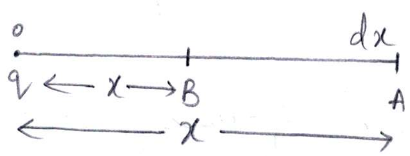
$$w = -\frac{1}{4\pi\varepsilon_0} qq_0 \left[-\frac{1}{x}\right]_{\infty}^{r}$$

$$w = -\frac{1}{4\pi\varepsilon_0} qq_0 \left[\frac{1}{r} - \frac{1}{\infty}\right]$$

$$w = -\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r}$$

[ $\because$ but V = $\frac{w}{q_0}$ ]

$$V = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$



**20. Derive an expression for the potential energy of an electric dipole placed in a uniform electric.**

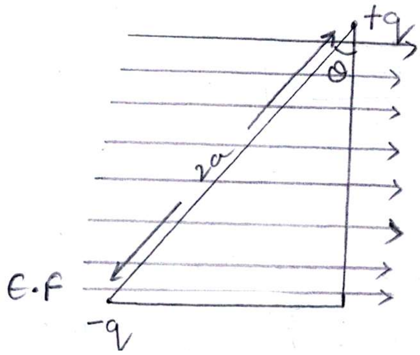
**A. Electric dipole** :- Two equal and opposite charges separated by a small distance is called an "electric dipolle".

Let 'q' be the charge, 2a be the length and it makes an angle $\theta$ with electric field as shown in figure.

$\rightarrow T = PE \sin\theta$

$\rightarrow dw = Tdq$

[where $w = \int dw$ ]




* $W = \int PE \sin\theta \, d\theta$

$W = PE \int \sin\theta \, d\theta$

[where $\int \sin\theta \, d\theta = -\cos\theta$]

$W = PE(-\cos\theta)$

$W = -PE \cos\theta$

$\rightarrow$ If $\theta = 0^0$ , $\cos\theta = 1$

$W = -PE$

$\rightarrow$ If $\theta = 180$ , $\cos 180 = -1$

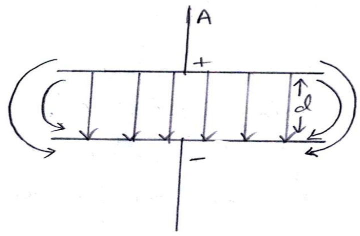
$W = PE$

**21. Derive an expression for the capacitance of a parallel plate capacitor.**

**A.** Let us consider a parallel plate capacitor which consists of to plates each with area (A) and separated by a distance (d) as shown in figure.

$\rightarrow$ Intensity of electric field between thee plates

$$E = \frac{\sigma}{\varepsilon_0}$$




$\because$ where $\left[E = \frac{v}{d}, \sigma = \frac{q}{A}\right]$

$$\frac{v}{d} = \frac{q}{A\varepsilon_0}$$

$$\frac{q}{v} = \frac{A\varepsilon_0}{d} \quad [\because \text{ where } \frac{q}{v} = c]$$

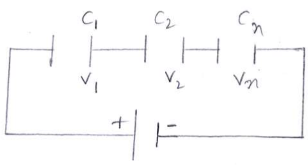
$$C = \frac{A\varepsilon_0}{d}$$

**22. Explain series and parallel combination of capacitors. Derive the formula for equivalent capacitance in each combination.**

**A.** **<u>Series combination</u>** :- In series combination the capcitors are first arranged in series order such that the 2nd plate of 1st capcitor is connected to 1st plate of third capacitor and so on. Finally the 1st plate of 1st capacitor and 2nd plate of last capacitor are connected to the battery.

$\rightarrow$ Where 'q' is constant and 'v' is variable.

$$v = \frac{q}{c}, \; v_1 = \frac{q}{c_1}, \; v_2 = \frac{q}{c_2}, \; v_3 = \frac{q}{c_3} \ldots\ldots\ldots, v_n = \frac{q}{c_n}$$



$$\frac{q}{c} = q\left[\frac{1}{c_1}+\frac{1}{c_2}+\frac{1}{c_3}.....+\frac{1}{c_n}\right]$$

$$\frac{1}{C} = \left[\frac{1}{c_1}+\frac{1}{c_2}+\frac{1}{c_3}.....+\frac{1}{c_n}\right]$$

* Parallel combination 1st plate of all the capacitors are giving to one terminal of the battery and all 2nd plates are giving to opposite terminals of the battery. This combination is called parallel combination.

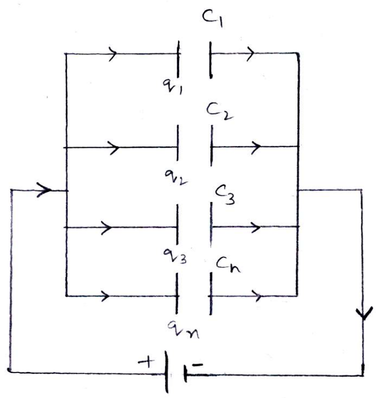
'v' is constant but 'q' is variable

$q = cv$, $q_1 = C_1v$, $q_2 = C_2 V$, $q_3 = C_3 V$........$q_n = C_nV$

$q = q_1+q_2+q_3$.......$+q_n$

$C\cancel{V} = \cancel{V}\,[C_1+C_2+C_3+.....Cn]$

$C = C_1+C_2+C_3.......C_n$




**23. Derive an expression for the energy stored in a capacitor. what is the enrgy stored when the space between the plates is filled with a dieletric.**
**a) With charging battery disconnected?**
**b) With charging battery connected in the circuit ?**

**A.** Energy stored in a capacitor :- Let us consider a capacitor of capacity (c) is charged to a potential (v) by giving a charge (q) on it.

$dw = vdq$

$\because$ but $v = \frac{q}{c}$

$dw = \frac{q}{c}dq$

$\rightarrow$ The work require to increase the charge from O to Q

$$w = \int_0^Q \frac{q}{c}dq$$

$$w = \frac{1}{c}\int_0^Q \frac{q}{c}dq$$

$$u = \frac{1}{c}\left[\frac{q^2}{2}\right]_0^Q$$

$$u = \frac{q^2}{2c} \text{ (or) } u = \frac{c^{\cancel{2}}v^2}{2\cancel{c}} = \frac{1}{2}cv^2$$

formula $\left[\int x^n dx = \frac{x^{n+1}}{n+1}\right]$

$$u = \frac{Q^{\cancel{2}}}{2\frac{\cancel{Q}}{V}} = \frac{1}{2}QV$$

$C = \frac{Q}{V} \Rightarrow Q = CV \Rightarrow V = \frac{Q}{C}$

(a)* With chaging battery disconnected :-

$V^1 = \frac{V}{K}, \quad C^1 = \frac{Q}{\frac{V}{K}} = KC$

$V1 = \frac{1}{2}C^1V^{1^2} = \frac{1}{2}KC\left(\frac{V^2}{K^2}\right) = \frac{1}{2}\frac{CV^2}{K}$

$U^1 = \frac{u}{k}$

(b)* With charging battery connected in the circuit :-

$q^1 = kq, \; v^1 = v$

$c^1 = \frac{Kq}{v} = KC, \quad u = = \frac{1}{2}CV^2$

$u^1 = \frac{1}{2}CV^2, \; R = \frac{1}{2}KCV^2$

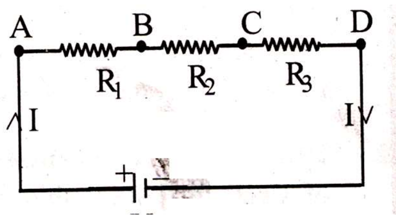
$u^1 = KV$

**24. Derive an expression for the effective resistance when three resistors are connected in (i) Series (ii) Parallel.**

**A.i. Series Combination:** Consider three resistors $R_1$, $R_2$ and $R_3$ are conneccted in series to a call of emf V. Since the three resitances are in series, same current flows through all the resistances. Let $V_1$, $V_2$ and $V_3$ be the potential difference across the three resistors respectively.

$V_1 = IR_1 \;\; V_2 = IR_2$ and $V_3 = IR_3$. But $V = V_1 + V_2 + V_3$

$\Rightarrow V = IR_1 + IR_2 + IR_3$




If equivalent resistance of the series combination is R, then

$V = IR = I(R_1 + R_2 + R_3)$ or $R = R_1 + R_2 + R_3$

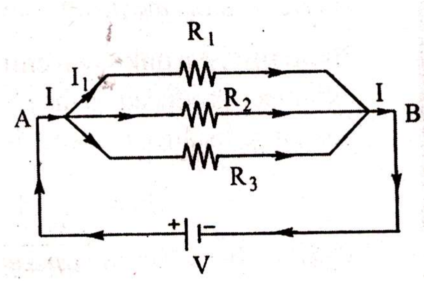
Thus, equivalent resistance of a series combination of ersistors is equal to sum of resistances of all resistors.

**ii. Parallel Combination:** Consider three resistors $R_1$, $R_2$ and $R_3$ connected in parallel to a potential source (cell) V. Since the three resistors are parallel, the potential difference across cell resistor is same series V. Let $i_1$, $i_2$ and $i_3$ be the current through the resistors respectively.

$I_1 = \frac{V}{R_1}, \; I_2 = \frac{V}{R_2}$ and $I_3 = \frac{V}{R_3}$

But $I = I_1 + I_2 + I_3$ or $I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

$\therefore \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ or $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$




Thus the reciprocal of effective resistance is equal to the sum of reciprocals of individual resistances.

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# MOVING CHARGES AND MAGNETISM

**25. State and explain Biot-Savart Law.**

**A.** **Biot-Savart Law :** Biot - Savart Law gives the magnetic field induction at any point around the current carrying conductor of any shape.

**Explaination :** Consider a conductor 'QR' through which a current 'i' is passing the magnetic induction (dB) at any point due to small element is :

i. Directly proportional to the current i passing through the conductor.

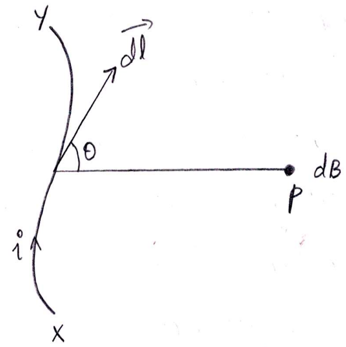
ii. Length of the small element ($d\ell$).

iii. Sine of the angle between the element and the line joining small element and the point ($\sin\theta$) and

iv. inversely proportional to the square of the distance ($r^2$) between the small element and the point.

→ The magnetic induction at 'p' is dB.

$$dB \propto i$$
$$dB \propto d\ell$$
$$dB \propto \sin\theta$$
$$dB \propto \frac{1}{r^2}$$




$$dB \propto \frac{i(d\ell)\sin\theta}{r^2}$$
$$dB = \frac{\mu_0}{4\pi}\frac{i\,d\ell\sin\theta}{r^2}$$

For induction $B = \int dB$

$$B = \frac{\mu_0}{4\pi}\int\frac{i\,d\ell\sin\theta}{r^2}$$

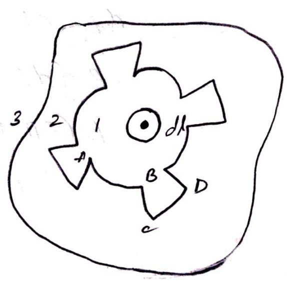
**26. State and explain Ampere's Law.**

**A.** **Statement :** The line integral of $\vec{B}.\vec{d\ell}$ taken over the entire closed path of induction in a given perpendicular plane is equal to $\mu_0$ times, the total current enclosed in the closed path . $\oint \vec{B}.\vec{d\ell} = \mu_0\, i$.

**Explanation :** Consider a long straight current carrying conductor emerging out perpendicular to the plane of the paper. The magnetic lines are in the form of concentric circles centred on the wire.

Consider some closed paths around the conductor as shown path 1 is circular and path 2 and 3 are of general shape. $d\ell$ is an elementry path 1 of radius 'r'. Let I be the current.

$$\bar{B}.\overline{d\ell} = \frac{\mu_0 I}{2\pi}\,d\theta$$




for path 1,

$$\therefore \oint \bar{B}.\overline{d\ell} = \oint \frac{\mu_0 I}{2\pi}d\theta = \frac{\mu_0 I}{2\pi}\oint d\theta = \mu_0 I.$$

$(\because \oint d\theta$ for path 1 is $2\pi)$

$$\therefore \oint \bar{B}.\overline{d\ell} = \mu_0 I.$$

Similarly for the path 2,

$$\bar{B}.\overline{d\ell} = \frac{\mu_0 I}{2\pi}\theta_{AB}$$

$$\bar{B}.\overline{d\ell} = \frac{\mu_0 I}{2\pi}\theta_{CD} \text{ and so on.}$$

$$\therefore \oint \bar{B}.\overline{d\ell} = \frac{\mu_0 I}{2\pi}(\theta_{AB} + \theta_{CD} + \ldots\ldots\ldots\ldots) = \frac{\mu_0 I}{2\pi}(2\pi) \quad \therefore \oint \bar{B}.\overline{d\ell} = \mu_0 I.$$

This is known as Amper's Circuital Law.

**27. Find the magnetic induction due to a long current carrying conductor.**

**A.** Consider a circular path of radius 'r' drawn concentrically around a long thin conductor carrying current 'I' as shown in fig.

By the symmetry, magnetic induction B is same in magnitude at every point on the circular path and It is directed along tangent.

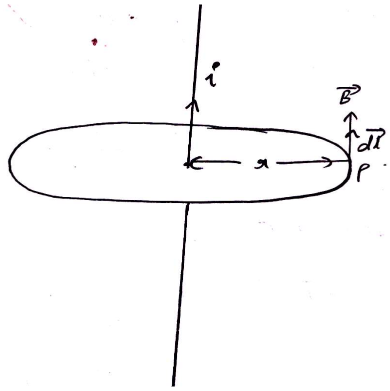
From amper's law,

$$\oint \bar{B}.\overline{d\ell} = \mu_0 I \; (\theta = 90^0)$$

$$\bar{B}\oint \overline{d\ell} = \mu_0 I$$

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

$$B = \frac{\mu_0 I}{2\pi r}.$$




**28. Derive an expression for the magnetic induction at the centre of a current carrying circular coil using Biot-Savart Law.**

**A.** Consider a circular loop with centre 'θ and radius 'r'. Let 'i' be the current through the loop. The magnetic field induction at the centre of the loop due to the small element $d\ell$ is given by

$$dB = \frac{\mu_0}{4\pi}\frac{i d\ell}{r^2}$$

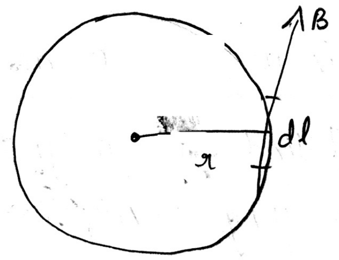
$$B = \int dB = \frac{\mu_0}{4\pi}\frac{i}{r^2}\int d\ell$$

$$\text{But } \int d\ell = 2\pi r$$

$$B = \frac{\mu_0 i}{4\pi r^2}(2\pi r)$$

$$B = \frac{\mu_0 i}{2r}$$

For 'n' turns $B = \frac{\mu_0 n i}{2r}$.




**29. Derive an expression for the magnetic dipole moment of a revolving electron.**

**A.** **Expression for the magnetic dipole moment of a revolving electron:** Consider a electron revolving in a circular orbit of raidus 'r' with a speed 'v' and frequency 'n'. Consider a point P on the circle. The electron cross the point once in every revolution. In one revolution, the electron travels a distance $2\pi r$. The number of revolutions made electron in one second is, $n = \left[\frac{v}{2\pi r}\right]$.

$$\text{Current } i = \frac{q}{t} = q(n)$$

$$i = e\left(\frac{v}{2\pi r}\right)$$

But dipole moment M = iA

$$M = \frac{ev}{2\pi r}[\pi r^2]$$

$$M = \frac{evr}{2}.$$

**30. What are the basic components of a cyclotron? Mention its uses?**

**A.** **Cyclotron :** Cyclotron is a device used to accelrate positively charged particles [like $\alpha$-particles, deutrons etc.] cyclotron consists of the following basic components.

i. **DEES** : Two flat semicircular metallic boxes $D_1$ and $D_2$ are called Dees.

ii. **Vacuum Chamber** : The dees $D_1$ and $D_2$ are enclosed in a vacuum chamber to minimise collisions between the ions and air molecules.

iii. **Source** : The source is placed at the centre of dees which supplies the +ve ions (or) charges.

iv. **Reasonant frequency Osicllator**: It provides a powerful alternating electric field in the gap between the dees.

v. **Powerful magnetic poles**: Dees enclosed vacuum chamber is placed between two powerful magnetic poles.agnetic field revolves the ions in circular path.

vi. **Deflector plate** : The fast moving ions are deflected by deflector plate and strikes the target.

Uses:

Cyclotron is used

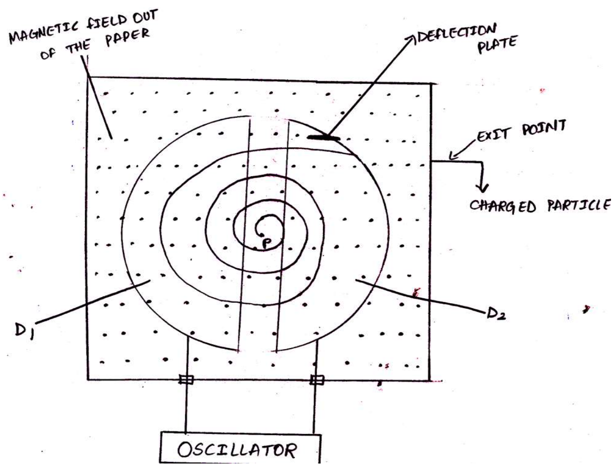
→ To accelerate protons, deutrons and $\alpha$-particles.

→ To bombard nuclei with energetic particles and study the resulting nuclear reactions.

→ To implant ions into solids and modify them.

→ To implant ions into solids and modify their properties or even synthesis new materials.

→ In hospitals to produce radiioactive substances which can be used in diagnosis and treatment.

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# MAGNATISM AND MATTER

**31. A Derive an expression for the axial field of a solenoid of radius 'r', containing 'n' turns per unit length and carrying 'i'.**

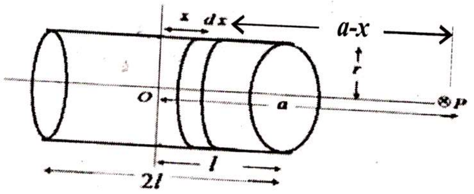
A. **Expression for the axial field of solenoid** : Consider a selenoid consisting of 'n' turns per unit length and carrying current 'i'. Let the length of the solenoid be 2l and 'r' be its radius. Consider a point P at a distance 'a' from the centre 'O' of the solenoid.

Consider a circular element of thickness dx of the solenoid at a distance 'x' from the centre. It consists of ndx turns. The magnitude of the field at the point P due to the circular elements is given by

$$dB = \frac{\mu_0 ndxir^2}{2\left[(a-x)^2 + r^2\right]^{3/2}}$$

The total magnetic induction is obtained by integrating between the limits x =- $\ell$ to x = +1

$$\therefore B = \frac{\mu_0 nir^2}{2}\int_{-1}^{+1}\frac{dx}{\left[(a-x)^2 + r^2\right]^{3/2}}$$




If r >>a and r >> $\ell$ , then $[(a-x)^2+r^2]^{3/2} \approx a^3$

$$\therefore B = \frac{\mu_0 nir^2}{2a^3}\int_{-1}^{+1} dx = \frac{\mu_0 ni}{2}\frac{2\ell r^2}{a^3}$$

But the magnetic moment of the solenoid M = n(2 $\ell$ )I($\pi r^2$)

$$\therefore B = \frac{\mu_0}{4\pi}\frac{2M}{a^3}$$

**32. Compare the properties of Para, Dia and Ferromagnetic substances.**

A. Properties of Para, Dia and Ferromagnetic substances.

| S.No | PARAMAGNETIC | DIAMAGNETIC | FERROMAGNETIC |
|---|---|---|---|
| 1. | They are freely attracted by a magnetic | They are freely repelled by a magnet. | They are strongly attracted by a magnet. |
| 2. | Magnetized freely in the Direction of magnetizing field | They are freely magnetized in opposite direction to the magnetizing field | Magnetized strongly in the direction of magnetizing field |
| 3. | They align with their length along direction magnetic field | They align with their length perpendicular to the magnetic field | They align with their length along, the direction magnetic field |
| 4. | They move from weaker to stronger part of the magnetic field | They move from stronger part of the magnetic field to the weaker part of the magnetic field | They move from weaker to stronger part of the magnetic field. |
| 5. | Magnetic permeability is greater than 1 and positive | Magnetic permeability is less than 1 and positive | Magnetic permeability is much greater than 1. |
| 6. | x is small and positive<br>Ex. Aluminium, plantinum Maganese, Chromium | x is small and negative<br>Ex. Bismuth, Copper, lead Silicon, water, glass etc. | x is high and positive.<br>Ex. Iron, Cobalt, Nickel and alloys like alnico. |

**33. Explain the elements of Earth's magnetic field and draw a sketch showing the relationship between the vertical component, horizontal component and angle of dip.**

A. Magnetic Elements of Earth's magnetism are three types : The magnetic field of earth, at a place can be completely characterised by three parameters given as

a) Magnetic declination.
b) Magnetic dip or inclination.
c) Horizontal components of earth's magnetic field.

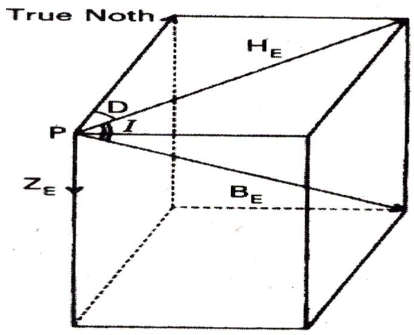
**a) Magnetic declination (D)** :- It is defined as the angle between the magnetic meridian and geographical meridian measured in the horizontal plane.

**b) Magnetic dip or inclination (I) :-** It is defined as the angle made by the resultant magnetic field of the earth at a place with the horizontal. At the magnetic poles of the earth the value of dip is $90^0$. At the magnetic equator, value of dip is $0^0$.

**c) Horizontal component of Earth's magnetic field ($H_E$) :-** It is the component of earth's total magnetic field along horizontal direction in the magnetic meridian. It is denoted by $H_E$.

Relation between the vertical component horizontal component and angle of dip

From the figure, we can find $H_E = B_E \cos I$ and $Z_E = B_E \sin I$ where $H_E$ and $Z_E$ are horizontal and vertical component of earth's magnetic field.




Now we can write $B_E = \sqrt{H_E^2 + Z_E^2}$ and $\tan I = \frac{Z_E}{H_E}$

# ATOMS

**34. Derive an expression for potential and kinetic energy of an electrolyte in any orbit of a hydrogen atom according to Bohr's atomic model. How does P.E change with increasing 'n'?**

**A. Expression for potential energy:** An electron possesses electrostatic potential energy because it is found in the field of nucleus. Potential energy of electron in $n^{th}$ orbit is given by

$$P.E. = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)}{r}$$

But,

$$r = \frac{n^2h^2\varepsilon_0}{\pi me^2Z}$$ and for hydrogen atom Z = 1,

$$P.E = -\frac{me^4}{4\pi\varepsilon_0^2n^2h^2}$$

**Expression for kinetic energy :** Kinetic energy is due to the motion of electron in the orbit. The coulomb's force of attraction between electron and the positively charged nucleus provides necessary untripetal force.

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}.\frac{Ze^2}{r^2}$$

or $$mv^2 = \frac{1}{4\pi\varepsilon_0}.\frac{Ze^2}{r}$$

or $$\frac{1}{2}mv^2 = \frac{1}{8\pi\varepsilon_0}.\frac{Ze^2}{r}$$

But, $r = \frac{n^2h^2\varepsilon_0}{\pi me^2Z}$ and for hydrogen atom Z = 1.

$$K.E = \frac{me^4}{8\varepsilon_0^2n^2h^2}$$

**Dependence of P.E on 'n' :**

$$PE \propto \left(-\frac{1}{n^2}\right)$$

As 'n' increases, P.E. becomes less negative and hence P.E. increases.
As the value of 'n' increases, the potential energyof the electron increases.

**35. What are the limitations of Bohr's theory of hydrogen atom?**

**A. Limitations of Bohr's model:**

i. Bohr's model is applicable to only single electron system (ie.) $H_2$ - atom.

ii. This model could not explain the five structure of spectral lines. It does not explain wave particles of electrons.

iii. It could not explain why hte orbits are circular when elliptical orbit are also possible.

iv. Bohr's model could not explain the binding of atoms into molecules.

v. No justification was given for the principle of quantization of angular momentum.

**36. Explain the different types of spectral series.**

**A.** **Spectral series :** The wavelength of the different members of the series for hydrogen atom can be found form the following relation.

$$\bar{v} = \frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

This relation explains the complete spectrum of hydrogen. A detailed account of the important radiations are listed below.

**Different type sof spectral lines.**

i. **Lyman Series :** When electron jumping on to the first orbit from higher energy levels than that series of spectral lines are called lyman series.

In Lyman series $\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$ where n = 2, 3, ........etc.

These lines are in ultraviolet region.

ii. **Balmer Series :** When electron jumping on the second orbti from higher energy levels than that series of spectral lines are called Balmer series.

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right] \text{ where n = 3, 4, ..........etc.}$$

iii. **Paschen Series :** When electron jumping on to the third orbit from higher energy levels then that series of spectral lines are called Paschen series.

$$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n^2}\right] \text{ where n = 4, 5, ...........etc.}$$

These spectral lines are in near infrared region.

iv. **Brackett Series :** When electron jumping on to the fourth orbit from higher energy levels then that series of spectral lines are called Brackett series.

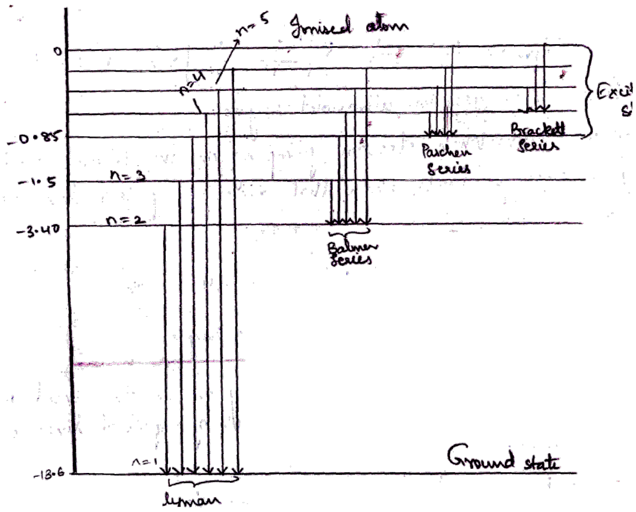
$$\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n^2}\right] \text{ where n = 5, 6,.............etc.}$$

These spectral lines are in middle infrared region.

v. **Pfund Series :** When electron jumping on to the fifth orbit from higher energy levels then that series of spectral ines are called Pfund series.

$$\frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n^2}\right] \text{ where n = 6, 7, ...........etc.}$$

These spectral lines are in for infrared region.



**37. Write a short note on Debroglie's explanation of Bohr's seond postulale of quantization.**

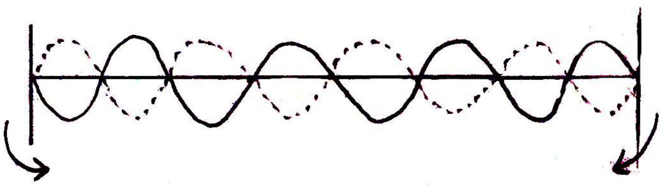
**A. Debroglee's explanation of Bohr's second postulate of quantization:**

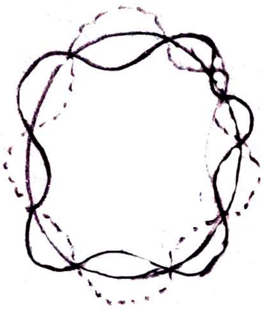
The seond wve associated with the moving particle is called matter, wave and the wavelength is called the De broglie wavelength. For a photon, momentum $P = \frac{E}{c}$ (or) $\frac{hv}{c}$ ($\therefore$ E = hv). If $\lambda$ is the wavelength of the wave, $p = \frac{h}{\lambda}$ ( $\therefore v = \frac{c}{\lambda}$ ) (or) $\lambda = \frac{h}{p}$

De broglie tried to explain Bohr's criterion to select the allowed orbits in which angular mometnum of the electron is an integral multiple of $\frac{h}{2\pi}$. According to his hypothesis, an electron revoling around nucleus is associated with certain wavelengths '$\lambda$' which depends on its momentum mv. It is given by

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

In an allowed orbit an electron can have an integral mutliple of this wavelength. That is the $n^{th}$ orbit consist of n complete de-broglie wavelengths i.e. $2\pi r_n = n\lambda_n$, where $r_n$ is the radius of $n^{th}$ orbit and $\lambda_n$ is the wavelength of $n^{th}$ orbit $\lambda_n = \frac{2\pi r_n}{n}$ (or) $\lambda_n = \frac{2\pi}{n}(0.53 \times n^2)\,A^0$ (or) $\lambda_n = 2\pi r_1\, n\, A^0$, where r is radius of first orbit of figure (a) shows the waves on a string having a wavelength related tothe length of the string allowing them to interfere constructively. If we imagine the string bent into a closed circle we get an idea of how electrons in circular orbits can intefere constructively as shown in figure (b). If the wavelength does not fit intothe circumference, the elecgtron interferes destrictively and it cannot exist in such an orbit.

a. 

b. 

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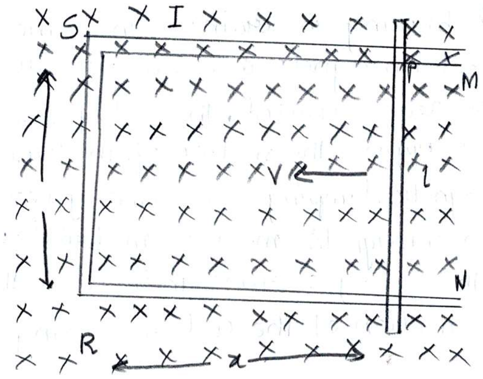
# ELECTROMAGNETIC INDUCTION

**38. Obtain an expression for the emf induced across a conductor which is moved in a uniform magnetic field which is perpendicular to the plane of motion.**

**A.**




Let us consider a striaght conductor 'PQ' moving in uniform magnetic field of induction $\vec{B}$ let the straight conductor pQ is free to move on smooth parallel side of a U shaped conductor .

We know that $e = \frac{d\phi}{dt}$

But $\phi = BA\ (\theta = 0^0)$

$$e = \frac{-d}{dt}(BA)$$

But $A = \ell x$

$$e = \frac{-d}{dt}(B\ell x)$$

$$e = B\ell \cdot \frac{dx}{dt} \quad e = B\ell v \quad e = \ell\left(\vec{V} \times \vec{B}\right)$$

**39. Describe the ways in which eddy current are used to advantage.**

**A.** Eddy current are used to advantage in

i. **Magnetic braking in trains :** In some electric trains electromagnets are situated above the rails when these are activated, the eddy current induced in the rails oppose the motion of the train.

ii. **Electromagnetic damping :** In some galvanometers core is made of nonmagnetic metallic material. when the coils oscillates, the eddy currents induced in the core oppose the motion of the coil and bring it to rest quickly.

iii. **Induction FUrnance :** In an induction, a metallic block to be melted is placed in high frquency chaning magnetic field. Strong eddy currents are induced in the block. Due to the high resistance of the metal, a large amount of heat is produced in it. This heat ultimately melts the metalic block.

iv. **Electric power meters :** The shiny metal disc in the electric power meter rotates due to eddy currents. Electric currents induced in the disc by magnetic fields produced by sinusoidally varying currents in the coil.

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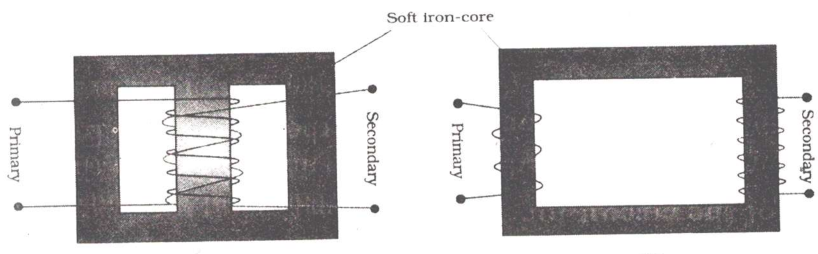
# ALTERNATING CURRENT

**40. State the principle on which a transformer works. Describe the working of a transformer with neccesary theory.**

A. **Transformer** :- A transfromer converts high voltage low currents into low voltage high currents and vice-versa. Transformer works only for AC.

**Principle** :- A transformer works on the principle of mutual inductance between two coils linked by a common magnetic flux.

**Construction :-** A transformer consists of two mutually coupled insulted coils of wire wound on a continous iron core. One of the coils is called primary coil and the other is called secondary coil. The primary is connected to an AC e.m.f and secondary to a load. Due to this alternating flux linkage, an e.m.f is induced in the secondary due to mutual induction.




(a) (b)

**Working :-** Let $N_P$ and $N_S$ be the number of turns in the primary and secondary coils respectively The induced e.m.f's produced in primary and secondary coils are given by

$$V_P = -N_P\left(\frac{d\phi}{dt}\right) \text{ and } VS = -N_s\left(\frac{d\phi}{dt}\right),$$

Hence $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

Where $v_p$ and $v_s$ are the primary and secondary voltages.

If the efficiency of the transformer is 100%, then $V_s i_s = v_p i_p$ or $\frac{i_p}{i_s} = \frac{V_s}{V_p} = \frac{N_s}{N_p}$ ($\because$ Power = iv) $\frac{N_s}{N_p}$ is called transformer ratio. If Ns > Np, then it is called a step-up transformer, If Ns < Np, then it is called a step-down transfromer.

# ELECTROMAGNETIC RAYS

**41. What is Greenhouse effect and its cotribution towards the surface temperature of earth?**

A. **Greenhouse effect** :- The earth surface is a source of thermal radiation as it absorbs received from sun. The wave lengh of this radiation lies in the infrared region. But a large portion of this radiation is absorbed by greenhouse gases like $Co_2$, $CH_4$, $N_2O$, $O_3$. This heats up the atmosphere which in turn gives more energy to earth. As a result the surface of earth becomes warmer. This increases the intensity of radiation from the surface. This process is repeated until no radiation is available for absorption. The net result is heating up of earth's surface and atmosphere. This is known as greenhouse effect. without the green house effect the emperature of the earth be - $18^0$ C.

Concentration of greenhouse gases has enhanced due to human activities. As a result the average temeprature of earth has increased by $0.3^0$C to 0.6 $^0$C By the middle of the next century the temperature may be increased by $1^0$C to $3^0$C. This global warming may cause problems for human life, Plants and animals.

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# NUCLEI

**42. Define half life period and decay constant for a radioactive substance. Deduce the relation between them.**

**A.** **Half life period ($T_{1/2}$) :** Time interval in which the mass of a radioactive substance or the number of it's atom reduces of half of it's initial value is called the half life of the substance.

**Decay Constant :** Decay constant is defined as the ratio of its instant rate of disintegration to the number of atoms present at that time. $\lambda = \frac{dN/dt}{N}$.

Relation : If N = $\frac{N_0}{2}$ then t = $T_{1/2}$

Hence from $N = N_0 e^{-\lambda 1} \Rightarrow \frac{N_0}{2} = N_0 e^{-\lambda(T_{1/2})} \Rightarrow T_{1/2} = \frac{\log_e 2}{\lambda} = \frac{2.303 \log_{10}^{2}}{\lambda} = \frac{0.693}{\lambda}$.

**43. Define average life of a radioactive substance. Obtain the relation between decay constant and average life.**

**A.** **Average life :** It is the ratio of total life of all the atoms of a given sample to the total number of atoms present in the sample.

**Relation between decay constant and average life:** Let $N_0$ be the number of atoms present at t = 0 in the substance. Let N be the number of atoms present in a time t. Let dN be the number of atoms disintegrated in a time interval of t and t + dt i.e., each of dN atoms lived afor a time t.

Total life of dN atoms = t dN

$$\text{Average life } (\tau) = \frac{\text{Total life of all atoms}}{\text{Number of atoms}} = \frac{\int_0^\infty t\,dN}{N_0}$$

But $\frac{dN}{dt} = \lambda N \Rightarrow dN = -\lambda N \; dt$

$$\tau = \int_0^\infty \frac{-t\lambda N dt}{N_0} \Rightarrow \tau = \int_0^\infty \frac{-t\lambda N_0 e^{-\lambda t} dt}{N_0}$$

$$\text{Average life } \tau = \frac{1}{\lambda} \left[\because \int_0^\infty -\lambda t N e^{-\lambda t} dt = \frac{1}{\lambda}\right]$$

But $T_{1/2} = \frac{0.693}{\lambda} \Rightarrow \lambda = \frac{0.693}{t_{1/2}}$

$\tau = \frac{T_{1/2}}{0.693} \Rightarrow \tau = 1.44 t_{1/2}$.

**44. Distinguish between nuclear fission and nuclear fusion.**

**A.**

| Nuclear Fission | Nuclear Fusion |
|---|---|
| 1) The process of splitting of a heavier nucleus into two or more stable fragements | 1) Fusing two lighter nuclei into a heavier nucleus, to attain stability. |
| 2) Each fission gives about 200 MeV of energy equivalent to mass defect. | 2) Each fusion gives about 28 MeV of equivalent to the mass defect. |
| 3) Energy released per nucleon is less and equal to 0.85 MeV. | 3) Energy released per nucleon is more and equal to 6 MeV. |
| 4) This is the principle of atom bomb. | 4) This is the principle of hydrogen bomb. |
| 5) Fission takes place at room termperature. | 5) Fusion takes place at high temperature. |
| 6) Energy produced by nuclear reactors is by fission. | 6) Energy released by stars and sun is by fusion. |

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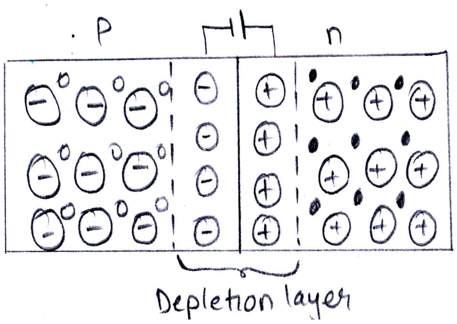
# SEMICONDUCTOR ELECTRONICS

**45. What are n-type and p-type semiconductors? How is a semiconductor junction formed?**

**A.** **n-type Extrinsic Semiconductor:** Pentavalent substance like arsenic, phosphorus, antimony, bismuth are dopped in a pure semiconductor. Arsenic is called donor impurity. Majority charge carriers are electrons and minority charge carriers are holes. Hence it is called N-type semiconducotr, Fermi energy level is nearer to the conduction band.

**p-type extrinsic semiconductor :** Trivalent substance like boron, aluminium, gallium, indium etc are dopped in a pure semi-conductor. Boron is called acceptor impurity. Majority charge carriers are holes and minority charge carriers are electrons and hence it is called p-type semi-conductor. Fermi energy level is near to the valence band.

**p-n junction :** A p-n junction is formed by doping n-type on one side and p-type on the other side of a pure semi-conductor. p-side of semiconductor contains excess holes and n-side of semicondudor contains excess of electrons.



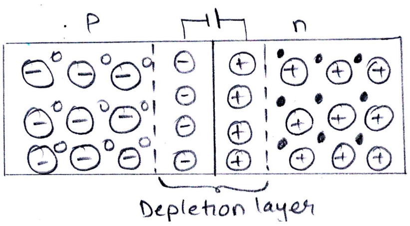

**Junction barrier :** The electrons from n-side diffuse to p-side and combine with holes there. Similarly, holes from p-side diffuse to into n-side and combines with electrons there. Due to diffusion, positive ion are left over in n-region an dnegative ion are left over in p-region, near the junction. these ions are immobile. Due to the immobile ions on either sides of the juncitons an internal electric field is formed at the junction which is directed from n to p. At p-n junction a neutral region where there are no charge carrier is formed and it is called depletion layer. The potential difference across the barrier prevents diffuse of charge carrier through the junction and it is called potential barrier.

**46. Discuss the behaviour of a p-n junction. How does a potential barrier develop at the junction?**

**A. Depletion layer - Potential barrier :**

i. In a p-n junction electrons from n-side diffuse to p-side and combine with holes there. simillarly holes from p-side diffuse into n-side and combines with electrons there.

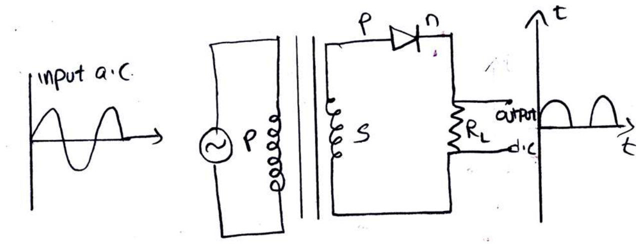
ii. Due to diffusion, positive ions are left over in n-region and negative ions are left over in p-region, near the junction. Due to these immobile ions on either side of the junction an internal electric field is formed at the junction which is directed from n to p. At p-n junction a neutral region where there are no charge carrier is formed and it is called depletion layer. The potential difference accross the barriers prevents diffusion of charge carriers through the junction and it is called potential barrier. The potential barrier depends on the nature of semiconductor doping concentration and temperature of the junction. There is no current in the p-n junction diode in the absence of any external battery.



**47. Describe how a semiconductor diode is used as a half wave rectifier?**

**A.** **Rectifier :** Conversion of A.C voltage into D.C voltage is called rectification. A p-n junction diode is used as a rectifier.

**Half wave rectifier**: In a half wave rectifier a single diode is used. The a.c. from the secondary of the transformer is applied to the diode and a load resistances $R_L$ in series. During the positive half cycle, the diode is forward biased and current flows though the diode and the load resistance. during the negative half cycle, the diode is reverse biased and current doe not flow through the diode. Thus current flows during the positive half cycle only. The output across the load resistance contains. Rectified voltage which is a variable DC.




Efficiency of half-wave rectifier = $\frac{\text{DC power output}}{\text{AC power input}} = \frac{0.406 R_L}{R_L + r_f}$

Where $r_f$ = forward resistance of iode.

$R_L$ = load resistance

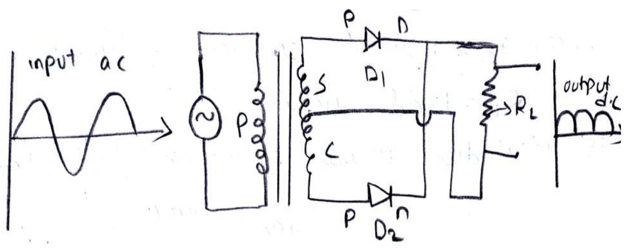
for ideal diode forward resistance $r_f \simeq 0 \Rightarrow m_{max} = m_{max} = 0.406$.

Maximum efficiency of the half-wave rectifier is 40.6%

**48. What is rectification? Explain the working of a full wave rectifier?**

**A.** **Rectification :** Conversion of A.C. voltage into D.C votlage is called rectification. A p-n junction diode is used as a rectifier.

Full - wave rectifier : In a full wave rectifier two dioides are used. The secondary of the transformer is centre tapped between diode $D_1$ & $D_2$ as shown. Across the common point of n-ends and the central tap C a load resistance $R_L$ is connected. During the positive half cycle of a.c. diode $D_1$ is forward biased and $D_2$ as reverse biased. During the negative half cycle of a.c. diode $D_2$ is forward biased and $D_1$ reverse biased. Hence current flows through the load resistance $R_L$ during the full cycle of a.c . Thus a full wave of a.c is rectified.




Efficiency of the full - wave rectifier = $\frac{\text{DC power output}}{\text{AC power input}} = \frac{0.812 R_L}{r_f + R_L}$

Where $r_f$ = forward resistance of diode.

$R_L$ = load resistance

for ideal diode forward resistance $r_f \simeq 0 \Rightarrow m_{max} = m_{max} = 0.812$.

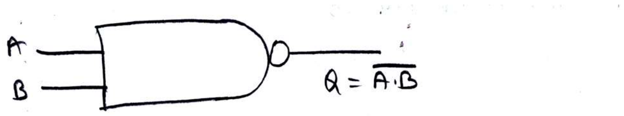
Maximum efficiency of the full-wave rectifier is 81.2%.

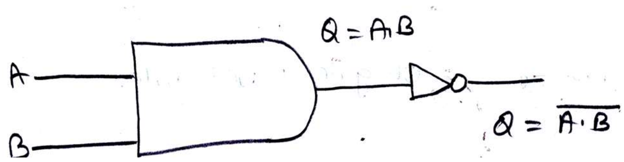
**49. Define NAND and NOR gates. Give their truth tables.**

**A.** **NAND Gate:** It has two input terminal and output terminal. The output of a NAND gate is an inversion of the output of an AND gate. If A and B are the input of the NAND gate is output is not truth table of NAND gate.

| Input | | Output |
|---|---|---|
| A | B | Q |
| 0 | 0 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 1 | 0 |

The logical function shown by the truth table is written as A NAND B. The out put Q = A.B and the symbol, used for the logic gate is



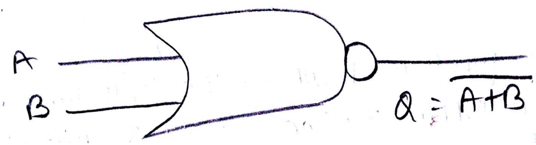




**NOR GATE** : It has two inputs terminals and one output terminal. A and B are the input of NOR gate output is NOT.

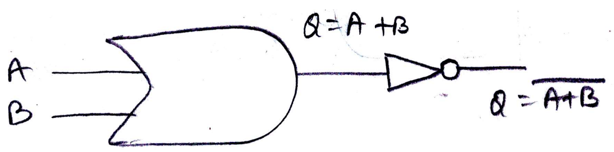
**<u>The truth table of NOR gate</u>**

| Input | | Output |
|---|---|---|
| A | B | Q |
| 0 | 0 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 1 | 0 |

**<u>NOR GATE:</u>**




NOR gate is inversion of OR gate and diagram in terms of OR gate is




Nor gate = OR gate + NOT gate.

*******_The End_******