Q.1. (A) Answer the following questions in short as asked (5)

1. At which position of the simple hormonic oscillator, will the mechanical energy be four times the potential energy ?
2. Give Unit and dimensional formula of intensity of wave.
3. In order to create very sweet-music, the reverberation time should be ....
4. Linear momentum of one object becomes half the intial linear momentum. Then there will be ....% decrease in its kinetic energy.
5. Give the uitlity of the physical quantity phase.

(B) Answer any three in eight to ten sentences. (6)

1. Write he equation of displacement of S.H.O. with the helpp of differentiation, obtain the equation of velocity in terms of displacement. Write the values and positions of maxmum and minimum velocities.
2. Derive differential equation of forced oscillation with damping.
3. A wave originate at x=0 at t = 0 with initial Phase 'O'. If the wave is sinusiodal derive the equation y = Asin (wt-kx) at time t for a particle lying at distance x =x from the origin.
4. Define position vector of centre of mass, and explain centre of mass of a rigid body ?

(C) Attempt any THREE of the following Problems (9)

1. A spring of length ℓ having its force constant K is cut into two parts. These parts have their length in 4:1 proporotion and their force constants are K_1 and K_2 respectively show that $K_1 = \frac{5k}{4}$ and $K_2 = 5k$..
2. Prove that for a wave Propagating in a medium, the ratio of instantaneous velocity of a particle of the medium to the wave velocity is equal to the negative value of the slope of the waveform at that Point.
3. An atom is executing simple harmonic osceillations with an amplitude of 2.5 $x10^{-7}$ meter one is simultaneously emitting electromagnetic waves. These waves are recorded by a stationary recorder as shown in figure. If the velocity of waves emitted is 3×10^8 m/sec. Find out the maximum and the minimum frequencies as recorded by the recorder. The frequency of the oscillation of the atom is 2×10^{13} Hz. and it is emitting wave of the same frequency. Assume that the equations obtained for the Doppler effect for sound are also valid for electromagnetic waves.

4. A soldier is firing bullets, each having mass of 50 gm, with a speed of 1000 mmet/sec from a machine gun. He can withstand at most an average recoil force of 200 Newton what is the maximum number of bullets he can fire per second ?

Q.2. (A) Answer in Short. (5)

1. Write dimensional equation of torque.
2. What is Geodesic ?
3. Give Max plank's statement of the second law of thermodynamics ?
4. The ratio of temperature of two bodies of same material is 2:3 what is the ratio of their total emissive power ?
5. The ratio of radii of orbits of two artificial satellities is 4:1 what is the ratio of their periods ?

(B) Attempt any THREE of the following Questions. (6)

1. Taking $|\vec{L}| = I\,|\vec{w}|$ for a rotating rigid body drive $\vec{\tau} = I\vec{\alpha}$ and write the law of conservation of angular momentum for it.
2. Define gravitational potential and derive $\phi = \frac{-GM}{r}$
3. Accepting equation dφ = nc_vdT + d W for an adiabatic process of an ideal gas derive equation PV^{γ} = constant.
4. Draw the diagram to obtain the parallel axis theorem. Taking I = $\sum miri^2$ & $Ic = \sum m_i r_{ci}^{\ 2}$, using the destance formula deduce the mathematical form of the parallel axis theorem.

(C) Attempt any THREE of the following Problems. (9)

1. A race track having 300m radius of curuature has an inclination of $15°$. If the co-efficient of friction between the surface of the road and that of the race car wheel is 0.2, with what maximum speed can a race car be driven safetly on this road ? g = 9.8 m/s^2.
2. Prove that the projectiles thown in directions making equal angles with that of $45°$ to the horizontal direction have equal ranges.
3. A metal rod of 1m length is in a steady thermal state at atmosphereic pressure.

Its one end is placed in water at $100°$c and other end is placed in ice at $0°$ c. At what distance from its hot end a flame of temperature $2000°$ c should be placed so that per unit time, same amount of water evaporates at the hot end as the amount of ice melts at cold end ? Latent heat of evaporation of water = 540 cal/gm. Latent heat of melting of ice is 80 cal/gm.

4. A carnot engine is operating between 1000k and 500k. In order to extract work of 210 Joules per cycle from this engine how much heat must be absorbed from the source in each cycle (J = 4.2 joules/cal)

Q.3. (A) Answer in short (5)

1. A circular resistive wire has resistance equal to 10Ω.Then what will be the resistance between any two end points of the diameter ?
2. State Faraday's First law of electrolysis.
3. How much shunt is required to increase the range of Ammeter n times?
4. If the planes of two concentric coils is parpendicular to each other, then what will be the value of the mutual inductance of the system ?
5. The unit of Thomson co.efficient σ is ....

(B) Attempt any three of the following questions. (6)

1. Define 'purallel connection' of resistor. Prove $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ for 3 resistors.
2. On what does the direction of emt in seback effect depend ? What are reference junction and 'test junction'. By keeping reference junction temperature fixed at $0°$c. Plot graph e$\rightarrow$ t write emperical formula between e & t.
3. Drive equation F = q $(\vec{V}\times\vec{B})$for a charge q moving with velocity V in a magnetic field B. Also .write Lorentz force equation.
4. Using Faraday's law obtain E = -B ℓ v for a "U" shaped metallic frame placed in a maas field.

(C) Attempt any THREE of the following Problems. (9)

1. A conducting wire has a resistance of 10 ohms. Its length is now stretched to increase by 3% calculate the resulting value of the resistance.
2. For a thermocouple α=14μ $(°c^{-1})$and β=0.07μ (c^{-2}) find out netural and the inversion temperature.
3. A charge Q is uniformly spread over a disc of radius a made from a non-conducting material. This disc is now rotated about its geometrical axis with

frequency f find the magnetic field generated at the center of the disc.

4. Two solenoids, each of 1.5 meter length and having cross sections such that the larges one just fits outside the smaller one are placed co.axially with their ends matching each other. The smaller solenoid has 1500 turns and the larger one has 500 turns. If the cross sectional area of the smaller solenoid is $15x10^{-4}m^2$, find the mutual inductance of the system where $\mu_0 = 4\pi \times 10^{-7} \frac{T.M.}{A}$

Q.4. (A) Answer in short. (5)

1. When power is transmitted at voltage V and current I, the power loss is x. If voltage is stepped up 5 times then what will be the loss in power ?
(in terms of x)
2. What is modulation.
3. "Optic axis of a tourmaline plate is a direction". Do you agree ?
4. The ratio of intensitres of two interfering waves is 1:4 what's the ratio of maximum resultant intensity to the minimum resultant intensity ?
5. V and I in an ac circuit are given by V = 50 sin (100t), I = 50sin (100 t+$\pi/3$) find the power factor.

(B) Answer the following questions (any three) (6)

1. Define the term Real Power for an A.C circuit. Derive the expression for power in case of on A.C. circuit with L-C.R in series.
2. Explain 'Ground wave' with respect to propogation of Electromagnetic Waves.
3. Acepting the expression for path difference $r_2 - r_1 = \frac{dx}{D}$.Obtain the expression for distance between two consecutive bright fringes. Also write the expression for the width of the fringe.
4. Assume a differential equation $\frac{d^2Q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{Q}{LC} = \frac{V_m \text{coscot}}{L}$ for an A.C. circuit L-C-R in series. Write its complex form obtain the equation for complex charge (q).

(C) Attempt any THRE of the following problems (9)

1. Prove that if voltage obtained from an a.c. source is given by V=Vmsincot, its average value is $\frac{2V_m}{\lambda}$=0.637V_m for a half cycle of the wave.
2. In a series L-C-R circuit L=5 H, C = 80μ F and R = 40 ohm. A.C. of 230V and

variable frequency is applied to this series circuit calculate

1. resonant angular frequency ω_0.
2. impedence of circuit at resonance.
3. Potential drop across inductor V_L.

3. A parallel beam of a monochromatic light is incident normally on a slit having a width of 0.018 cm. The fraunhofer diffraction pattern formed at the focal planes of a lens of focal length 50 cm shows its first order maximum on the either side of the central peak with a separation of 0.45 cm between them. Find the wavelength and light used.
4. In young's dolue slit experiment seperation between the slits is 0.1 mm & a screen is placed at a distance of 1 meter from the slits. Find the seperation between consecutive bright fringes of the width of fringes for light of wavelenth $5000°$A.

Q.5. (A) Answer in short. (5)

1 What is the viscous force acting on stationary oil drop between two plates in Millikan's Experiment.
2. If stopping potential 5V, what is the value of maximum kinetic energy of the emitted electrons.
3. What is the function of moderator in a Nuclear reactor ?
4. .... gives measure of the stability of a nucleus.
5. What is depletion layer ?

(B) Attempt any three. (6)

1. In Thomson's Experiment of determining c/m, assuming $y = \frac{1}{2}\left(\frac{Ee}{m}\right)\frac{\ell^2}{v^2}$ explain with necessary equations, how the velocity of electron can be obtained. Obtain an expression for c/m of an electron.
2. Give the Einstein's Explanation for the photoelectric effect with necessary formula.
3. Asuming the radius of an electron in the n^{th} orbit in hydrogen atom $r = \frac{n^2h^2 \in_0}{\pi m Z_c^{\ 2}}$ obtain the experession for the energy of an electron in nth orbit.
4. Explain the reverse bias connection of PN junction diode with graph.

(C) Attempt any three Examples. (9)

1. Two electron beams have their velocity ratio 1:2. They enters in an uniform magnetic field perpendicular to it. Find the ratio of their deviations (Beams

are in the field for a very short duration)

2. Wavelength of Hα line in hydrogen atom is $6563 A^0$ calculate the wavelength of H_β lines.
3. 1 gm Ra^{226} has an activity of 3.7 x 10^{10} Becquerel calculate its half lite.
4. In a common emitter N-P-N amplifier if the collector current is changed by 8m A. When input voltage is given 4.0 milivoit, find its transconductance. If input resistance is 1000Ω, find voltage gain.

o-o-o-o-o

SOLUTION

A.1. (A) Answer the following Questions in short.

1. Mechanical energy = 4 (Potential Energy)

$$\therefore \frac{1}{2} KA^2 = 4\left(\frac{1}{2}ky^2\right)$$

$$\therefore A^2 = 4y^2$$

$$\therefore y = \pm A/2$$

At $y = \pm A/2$ Mechanical energy will be four times Potential Energy.

2. Unit of intensity of wave $\frac{Jolues}{(meter)^2.second} = \frac{Watt}{(meter)^2}$

Dimensional formula of intensity of wave = $M^1L^0T^{-3}$.

3. In order to create very sweet-music, the reverberation time should be less than 0.8 second.

4. Linear momentum of one object becomes half the initial linear momentum. Then there will be 75% decrease in its kinetic energy.

5. One basis of location of reference particle and no. of revolutions made by it before reaching that point the position of the SHO on its path and the no of oscillations can be known through the phase.

(B) Answer any three in eight to ten sentences.

1 Displacement of SHO is
$y = A \sin(\omega t + \phi)$ .... (1)
Differentiating (1) w.r.t. time

$$V = \frac{dy}{dt}$$

$$\therefore \quad V = \frac{dy}{dt}[A\sin(\omega t + \phi)]$$

$$V = A\omega\cos(\omega t + \phi)$$

Here $\cos(\omega t+\phi) = \pm\sqrt{1-\sin^2(\omega t+\phi)}$

$$\therefore \quad V = A\omega\sqrt{1-\sin^2(\omega t+\phi)}$$

$$= \pm A\omega\sqrt{1-y^2/A^2}$$

$$= \pm A\omega\sqrt{A^2-y^2}$$

Cases :-

1. at y = 0 ie at mean position $\Rightarrow v = \pm A\varpi$ → → →
2. At y = ± A (ie. at extreme end points) V = 0.

2. Oscillations under the influence of on external periodic force are called the

"forced oscillation". Let Fosinwt be the external periodic force.
W $\rightarrow$ angular frequency of external periodic force applied to the system.
These oscillations occurs under the following force.

1. Restoring force = -ky
2. Resistive force $=-b\frac{dy}{dt}$=-bv
3. External periodic force = Fosinwt.

Now according to Newton's 2nd law

$$m\frac{d^2y}{d+z} = -ky - b\frac{dy}{dt} + fo\sin wt$$

$$\frac{d^2y}{d+z} = \frac{-k}{m}y\frac{-b}{m}\frac{dy}{dt} + \frac{Fo}{m}\sin wt$$

writing $\frac{b}{m} = r, \frac{k}{m} = w_o^2$ and $\frac{Fo}{m} = a_o$ inabout equation & rearranging it, wege :

$$\frac{d^2y}{dt^2} + r,\frac{dy}{dt} + w_o^2 y = ao\sin\omega t.$$

3. o o o o o o o
0 1 2 3 4 5 6
|_______________x_______|

As shown in figure consider particles as 1-dimensional, electric medium.

Now at t = 0 suppose a disturbance is produced in such a way that particle at x = 0 starts performing SHM at its mean position with amplitude A & angular frequency ω. Here ϕ=0.

Hence desplacement of purticle at x = 0 is given by

y = Asin (ωt)......(1)

When the wave travels distance x, then 5th particle starts erpforming SHM. The phase of successive particles decreases as we go aw2ay from 0. Hence at any time the phase of 5th particle is less than the phase of 0, by δ then desplacement of 5th particle can be written as :

y = Asin (ωt-δ) ...(2)

from defination of wavelength.

$$\delta = \frac{2\pi x}{\lambda}$$

substituting value of δ in above eq.

y = Asin ($\omega t - \frac{2\pi x}{\lambda}$) ....(3)

but K=$\frac{2\pi}{\lambda}$, K $\rightarrow$ wave vector.

y = A Sin (ωt-kx) ....(4)

4. Defination of Position vector of centre of mess.
For a system made up of n particles, let the position vecotrs of the particles

with an arbitarily selected origin, be given by r_1, r_2....r_n Let m_1, m_2......m_n be the mass of the respective particles we define the centre of mass of the system of particles as a point whose position vector is given by expression.
vector r_{cm} is given by expression.

$$r_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + ... + m_n\vec{r}_n}{m_1 + m_2 + ... + m_n}$$

→ centre of Mass of rigid body

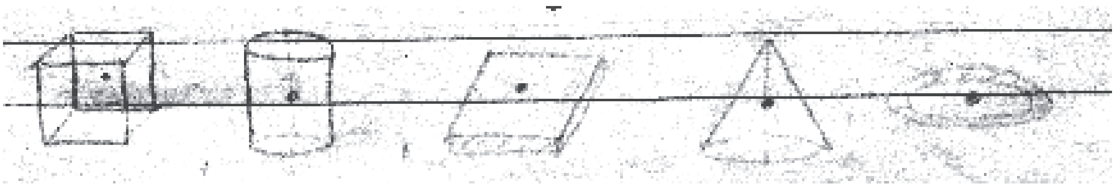
→ Location of center of mass of a body depends upon its hsape and distribution of mass within it.

→ The centre of mass may be inside the body even outside it.

→ cg. G circular disc of uniform density has its centre of mass located at the centre of the disc which is inside the body but for a ring it is at the centre of the ring but it is outside the matereal of the body.

→ centre of mass of rigid bodies having symmentry in shape and are of uniform density can reading be calculated mathematically But for a body which is not symmeture it can be difficult work.

→ For some symmeteric bodies, centre of mass are shown in fig.



(C) 1. Attempt any three problems.

1. for given spring $K \propto \frac{1}{\ell}$ $\therefore k \,.\, l$ = constant.

$\therefore$ $k_1\ell_1 = k_2\ell_2 = k\ell$ ....(1)

$\ell = \ell_1 + \ell_2$ ....(2)

$$\frac{\ell_1}{\ell_2} = \frac{4}{1}$$

$\therefore$ $\ell_1 = 4\ell_2$ ....(3)

$\ell_2 = \frac{\ell_1}{4}$ ....(4)

Substituting value of ℓ_2 in (2)

$$\ell = \ell_1 + \frac{\ell_1}{4} = \frac{5\ell_1}{4}$$

Now from (1) $k_1\ell_1 = k\ell = k\ \frac{5\ell_1}{4}$

$\therefore$ $K_1 = \frac{5\ell_1}{4}$

from (2) & (3) $\ell = 4\ell_2 + \ell_2 = 5\ell_2$

from (1) $k_2 \ell_2 = k\ell$

$= k \times 5\ell_2$

$\therefore \quad k_2 = 5k$

2. For a progressive harmonic wave

$y = A\sin(\omega t - kx)$

$\therefore$ Instantaneous velocity of a particle of the medium is

$$Vp = \frac{dy}{dt} = \frac{d}{dt}[A\sin(\omega t - kx)]$$

$\therefore \quad Vp = Aw\cos(\omega t - kx)$ ......(1)

Wave velocity ν is given by

$$\nu = \frac{w}{k} \quad ......(2)$$

$$\therefore \quad \frac{Vp}{\nu} = \frac{A\omega \cos(\omega t - kx)}{\omega / k}$$

$$\therefore \quad \frac{Vp}{\nu} = Ak\cos(\omega t - kx) \quad ......(3)$$

Now, slope of waveform at instant t at distance x is

$$\frac{dy}{dx} = \frac{d}{dx}[A\sin(\omega t - kx)]$$

$$= A\cos(\omega t - kx)(-k)$$

$$\frac{dy}{dx} = -Ak\cos(\omega t - kx) \quad ....(4)$$

from equation (3) & (4) we get

$$\frac{Vp}{\nu} = \frac{-dy}{dx}$$

3. $A = 2.5 \times 10^{-7}$ m

$fs = 2 \times 10_{13}$ Hz.

Let meximum velocity of the atom executing S.H.M. be Vs

$Vs = A\omega$

$= A(2\pi fs)$

$= 2.5 \times 10^{-7} \times 2 \times 3.14 \times 2 \times 10^{13}$

$= 3.14 \times 10^{7}$ m/s.

Maximum frequency (f1)when atom is moving towards the recorder then freq record by recorder will be maximum.

atom recorder

<---S L

$v_s = -ve \quad V_L = 0$

Here $V_L = 0$

$Vs = -3.14 \times 10^{7}$ m/s.

$f_1 = 2 \times 10^{13}$ Hz.

$V = 3 \times 10^{8}$ m/s.

$\therefore \quad f_L = f_1$

$\therefore \quad f_L = \left(\frac{V+\nu_L}{V+\nu_S}\right) f_S$

$f_1 = \left(\frac{3x10^8}{3x10^8 - 3.14x10^7}\right) 2x10^{13}$

$f_1 = 2.234 \times 10^{13}$ Hz.

Minimum frequency (f_2) when atom is moving away from recordes with maximum velocity then the frequency recorded by recordes will be minimum.

Here $V_L = 0$

$Vs = -3.14 \times 10^7$ m/s.

$f_1 = 2 \times 10^{13}$ Hz.

$V = 3 \times 10^8$ m/s.

$\therefore \quad f_L = f_1$

$\therefore \quad f_L = \left(\frac{V+\nu_L}{V+\nu_S}\right) f_S$

$f1 = \left(\frac{3\times10^8}{3\times10^8 + 3.14\times10^7}\right) 2\times10^{13}$

$f1 = 1.810 \times 10^{13}$ Hz.

Calculation

$\log f_2 = (\log 6 - \log 3.314) \times 10^{13}$

$\log f_2 = (0.7781 - 0.5203) \times 10^{13}$

$\log f_2 = (0.2578) \times 10^{13}$

$f_2 = 1.810 \times 10^{13}$ Hz

4. Momentum of each bullet = $\vec{P} = m\vec{v}$

$= 50 \times 10^{-3} \text{ kg} \times 1000 \frac{\text{mt}}{\text{sec.}}$

$= 50 \frac{\text{kg mt}}{\text{sec.}}$

Suppose he can fire n bullets per second.

$\therefore$ New momentum imparted to the bullet per second = Momen tum experience by the machine give in the opposite direction

= reactive force experience by the solder.

$\therefore$ n(50) = 200 Newton

$\therefore$ n=4 bullets per second

Q.2. (A) Answer the following in short :-

1. $M^1 L^2 T^{-2}$
2. In the four dimensional (x,y,z,t) space; the curve on the surface giving the minimum distance between any two points of any surface is called the geodesic.
3. It is impossible to construct a heat engine based on the cyclic process, which by absorbing heat from one body only and without making any change in the

working substance can convered it (heat) completely into the mechanical energy.

4. W = $e \sigma T^4$

$$\frac{W_2}{W_1} = \left(\frac{T_2}{T_1}\right)^4$$

$$\frac{W_2}{W_1} = \left(\frac{2}{3}\right)^2$$

$$= \frac{16}{81}$$

Ratio of emissive power is 16 : 81

5. $T^2 \propto R^3$

$T \alpha R^{3/2}$

$$\frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}$$

$$= \left(\frac{4}{1}\right)^{3/2}$$

$$= \frac{8}{1}$$

$\therefore$ Ratio of periods is 8:1

(B) Attempt any three of the following question.

1. Two equations of angular momentum are

$\vec{L} = I\vec{W}$......(1)

$\vec{L} = \vec{r}x\vec{p}$ ..... (2)

Differentating equation (2) w r t time

$$\therefore \quad \frac{d\vec{l}}{dt} = (\vec{r}x\frac{d\vec{p}}{dt}) + \left(\frac{d\vec{r}}{dt}x\vec{p}\right)$$

Now $\frac{d\vec{r}}{dt} = \bar{\nu}$, $\frac{d\bar{p}}{dt} = \vec{F}$

$$\frac{d\bar{p}}{dt} = \left(\vec{r} \times \vec{F}\right) + (\bar{v} \times \bar{p})$$

since V & P are along some direction

$\therefore \quad \bar{v} \times \bar{p} = 0$

Now $\vec{\tau} = \vec{r} \times \vec{F}$ represents the torque acting on the particle we have

$$\frac{d\vec{l}}{dt} = \vec{\tau}$$

Now from equation (1) $\frac{d\vec{l}}{dt} = I\frac{d\vec{w}}{dt} = I\,\vec{\alpha}$ = angular occeleration.

Hence $\vec{\tau} = I\vec{\alpha}$

Law of conservation of angular momentum "If resultant torque acting on a rigid body is zero then the total angular momentum remains constant".

2. Gravitational Potential (ϕ)

The work done in bringing a particle of unit mass from an infinite distance to specific point in the gravitational field is known as the gravitational potential ϕ at that point

→ Suppose we want to find potential at any point of the gravitational field due to a particle of mass M.

→ consider a unit mass (m=1) at a destance x, from the particle of mass M. The gravitational force acting on particle of unit mass will be

$$F = \frac{GM}{x^2}$$

→ Suppose unit mass is displaced towards M by dx then work done

$$dw = \frac{GM}{x^2}.dx$$

→ If the unit mass is displaced from a point at distance x =r_1 from M to another point at destance x = r then the total work done will be

$$w = \int_{r1}^{r} \frac{GM}{x^2} dx = GM\left[\frac{-1}{x}\right]_{r1}^{r}$$

$$= \text{-GM}\left[\frac{1}{r} - \frac{1}{r1}\right]_{r1}$$

If we take $r_1=\infty$ then w=$\frac{-GM}{r}$ and as we are taken a body of unit mass so work done becomes gravitational potential (ϕ)

for earth M=Mc

$$\phi = \frac{-GMe}{r}$$

3. Consider a system of n-mole ideal gas for a n adiultratic process for differential changes dQ = 0

Hence from 1st law of thermodynamics.

→ $dT = nc_v dt + dw = 0$

or $dw = - nc_v dT$

→ but dw = pdv = work done during very small change in volume/

$Pdv = -nc_v dT$ ......(1)

→ for an ideal gas PV = nRT

$Pdv + vdp = nRdT = R(ndT)$

sustituting value of ndT from this eq. to eq (1)

$$Pdv + vdp = \frac{-Pdv}{c_v} R$$

but $C_p - C_v = R$

→ $$Pdv + Vdp = -\left(\frac{Cp - Cv}{Cv}\right)Pdv$$

$$= -\left(\frac{Cp - Cv}{Cv}\right)Pdv$$

$$= (1-\gamma)Pdv$$

Where $\gamma = \frac{C_p}{C_v}$

Pdv + Vdp = Pdv - γ Pdv

Vdp + γpdv = 0

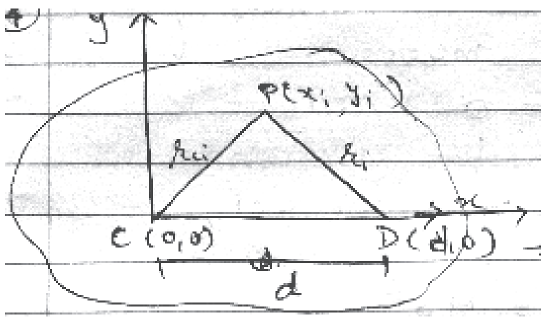
dividing above equation by Pv, we get $\frac{dp}{p} + \gamma\frac{dv}{v} = 0$

Integrating on both the sides ln P + γln V = constant

→ In (Pv^{γ}) = constant

Pv^{γ} = constant

4. Fig shows crossection of a rigid body with the plane of paper through its center of mass C.



→ Let Ic, be moment of inertia of body about axis passing through c & ⊥er to plane of paper.

→ I = moment of inertia of the body about an axis passing through point D & parallel to the axis passing through C.

Distance CD between two wxis is 'd'

Then I = $\sum_{i=1}^{n} m_i r_1^2$ ....(1)

Ic = $\sum m_i r_{ci}^2$ ....(2)

from distance formula r_1^2 = $(x_i-d)^2 + (y_i-0)^2$

= x_i^2 - 2dxi + $d^2 + y_i^2$

By multiplying $\sum m_i$ on both the sides

→ $I = \sum_i m_i x_i^2 - 2d \, , \sum_i m_i x_i + d^2 \sum_i m_i y_1^2 + d^2 \sum m_i$

→ But again from distance formula

$x_i^2 + y_i^2 = r_{ci}^2$

$\sum mi = M$ = total mass of body.

Also $\sum \frac{m_i x_i}{M}$ = x co-ordinate of centre of mass = 0

Using these relation we get,

$$I = \sum m_i x_{ci}^2 + Md^2$$

$$I = I_c + Md^2$$

(C) Attempt any three

1. r = 300 m

θ = 15^o

μ = 0.2

g = 9.8 m/s^2

v = ?

$$\frac{V^2}{rg} = \frac{\tan\theta + \mu}{1 - \mu\tan\theta}$$

where $\tan 15^o = 0.2679$

$$V^2 = rg\left(\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right)$$

$$= 300 \text{ x } 9.8 \left(\frac{0.2 + 0.2679}{1 - (0.2)(0.2679)}\right)$$

$$= 2940\left(\frac{0.4679}{1 - 0.05358}\right)$$

$$= 2940\left(\frac{0.4679}{0.9464}\right)$$

v^2 = 1453.53

V = 38.12 m,/sec.

2. Let the angle of projections be $\theta_1 = 45^o + \alpha$ and $\theta_2 = 45^o - \alpha$

$$R_1 = \frac{V_o^2 \sin 2\theta_1}{g} = \frac{v_o^2 \sin 2(45^\circ + \alpha)}{g}$$

$$= \frac{V_o^2 \sin 2(90 + 2\propto)}{g}$$

$$R_1 = \frac{V_o^2 \cos 2\alpha}{g} \text{......(1)}$$

$$R_2 = \frac{V_o^2 \sin 2\propto}{g} = \frac{V_o^2 \sin 2(45^\circ - \propto)}{g}$$

$$= \frac{V_o^2 \sin(90 - 2\propto)}{g}$$

$$R_2 = \frac{V_o^2 \cos 2\propto}{g} \text{....(2)}$$

From equation (2\1) & (2) $R_1 = R_2$

3. Let flame be placed at x cm from hot end. Let in 1 sec m gm of water evaporates at hot end & same amount of ice melts at coldend.

For Water :-

$L = 540$ cal/gm

$T_1 = 2000^o C$

$T_2 = 100^o C$

$t = 1$ sec/

$$mL = \frac{KA(T_1-T_2)}{x}$$

$$m(540) = KA\left(\frac{2000-100}{x}\right)$$

$$= \frac{KA(1900)}{x} \quad ....(1)$$

For Ice :-

Flame is kept at a distance x from hot end

$\therefore$ From cold end at distance of (100-x)

$$mL = \frac{KA(T_1-T_2)}{100-x}$$

$$m(80) = KA\left(\frac{2000-0}{100-x}\right)$$

$$= \frac{KA(2000)}{100-x} \quad ...... (2)$$

dividing (1) by (2)

$$\frac{540}{80} = \left(\frac{1900}{2000}\right)\left(\frac{100-x}{x}\right)$$

$$\frac{27x}{4} = \frac{19}{20}(100-x)$$

540 x = 7600 - 76x

616x = 7600

$$x = \frac{7600}{616}$$

x = 12.33 cm.

4. $T_1 = 100$k

$T_2 = 500$k

W = 210 joules

Q = ?

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\eta = \frac{W}{Q1}$$

$$\frac{W}{Q1} = \perp - \frac{T_2}{T_1}$$

$$= 1 - \frac{500}{1000}$$

$$\frac{W}{Q1} = \frac{1}{2}$$

$$Q1 = 2W$$

$$= 2\ (210)$$

$$= 420 \text{ Joules}$$

$$= \frac{420}{4.2} cal$$

$$Q = 100 \text{ cal}$$

Q.3 (A) Anwer in short

1. <u>2.5 Ω</u> will be resistance between any two end points of diameter.
2. Faraday's 1st law : "The mass m of an element deposited on the cathed on passing on electric current through it is directly. Propostional to the amount of charge passing through the electrolyte.
3. It <u>resistence</u> will <u>decrease</u> and will be equal to $\frac{G}{(n-1)}$

   (Resistance of ammetes = $\frac{GS}{G+S}$

$$= \frac{G\left(\frac{G}{n-1}\right)}{G+\left(\frac{G}{n-1}\right)}$$

$$= \frac{G^2}{G(n-1)+G}$$

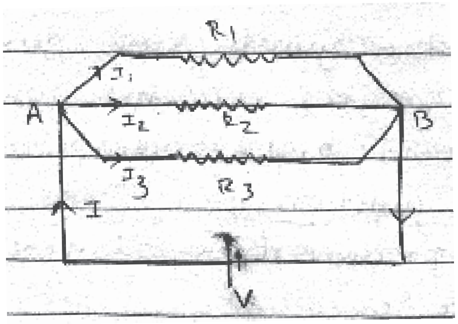
$$= \frac{G}{n-1}$$

4. :Zero.
5. <u>volt/centigrade</u> is unit of Thomson co-efficient.

(B) Attempt anythree

1. Parallel connnection:- The combination of more then one resistance in which potential difference across each of them is equal to the applied potential diference is called parallel connection suppose three resistences R_1, R_2, R_3

are connected in parallel and potential difference V is applied across them by connecting a battery.



→ Let I the electric cuirrent passing through the battery.

→ Let I_1, I_2, I_3 be the currents passing through resistance R_1, R_2, R_3 respectively.

Applying Kirchoff's second law at junctionm A I =I,+I_2+I_3

Applying Kirchoff's second law in loop V-A-R_1-B-V; V.A-R_2-B-V and V.A-R_3-B-V respectively we get

$$V=I_1R_1 \qquad I_1 = \frac{v}{R_1}$$

Similarly

$$I_2 = \frac{v}{R_2}$$

$$I_3 = \frac{V}{R_3}$$

$$I = \frac{v}{R_1} + \frac{v}{R_2} + \frac{V}{R_3}$$

$$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

If R is eqvivalent resistance of circuit then according to ohm's law.

$$\frac{I}{V} = \frac{1}{R}$$

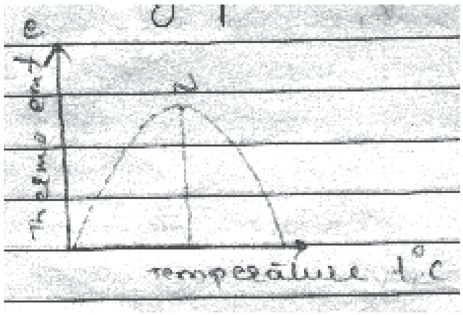
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

2. In theromocouple the junction at lower temperature is known as reference juction and the junction at higher temperature is known as test junction.

→ The thermo emf produced is of the order of micro volts per °c.

→ The direction of emf produced in thermo couple depends on the type of metal used and on juction temperature. In case of Bi & Antimony (sb). the thermo emf is produced from Antimany to Bismuth.

→ When reference junction is kept at °C and that of test junction is increased then the thermo emf changes according to the graph shown in figure.



→ When temperature of reference junction is °c then the relation between thermo emt and temperature is obtained emprically as, are constants depending on the type of metals.

$e = \propto t + \frac{1}{2}\beta t^2$ $\propto$ and β are constant depend on type of metal.

3. Suppose I electric current passes through a conductor of length dI

n→ number of positively charged partirterles per unit volume of the conductor.

q = charge on one particle,

v = drift volocity of positive charge in dirction of current.

We known that

I = q n A V

$\therefore$ I $\bar{dl}$ = q n A $\bar{v}$ d ℓ.

If this conductor is placed in a magnetic field of intensity $\bar{B}$ then the force acting on it is given by :

$\bar{df}$ = I$\bar{dl}$ x $\bar{B}$

ℓ = q n A dl $(\bar{v} \times \bar{B})$

But n A d l = total number of charged particles on the current element

Force action on one particle = $\frac{\bar{df}}{nAdl}$

= q (v x $\bar{B}$)

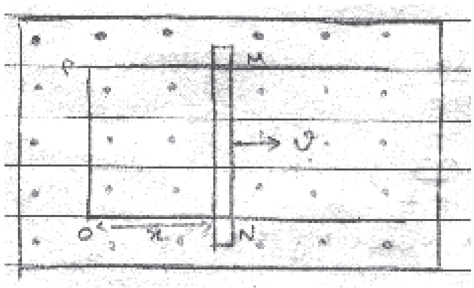
Thus $\bar{F}$ = q $(\bar{v} x \bar{B})$

In addition to magnetic field if the eletric field is also present then the resulatant force acting on charged particle will be

$\overline{F} = q\overline{E} + q\left(\overline{v}x\overline{B}\right)$

Above equation is called Lorentz force.

4. In figure, the magnetic field lines of force of a uniform magnetic field are representive by dots. The lines are coming out of plane of paper namally.



→ A U-shaped conducting wire is placed in magnetic field such that its plane remins perpendicular to the magnetic field. A conducting rod is placed on this wire which can slide over it without friction.

Suppose B = Magnetic field intensity.

l = $\perp$er destance between two arms of wire.

At time t the position of the rod is represented by MN.

If ϕ is flux linked with closed loop PMNO, then ϕ = B x (area of PMNO)

= B l x

Where x = PM = ON

Now when rod moves over the wire with velocity if, the value of X & hence the fluxchanges. So induced emf is produced.Now according to Farady's law value of induced cmf is given by.

$$\varepsilon = \frac{-d\phi}{dt}$$

$$\varepsilon = d\left(\frac{Bix}{dt}\right)$$

$$= -.Bl..\frac{dx}{dt}$$

But $\frac{dx}{dt} = \vartheta \rightarrow$ velocity of rod.

$\therefore \quad \varepsilon = -Bl\vartheta$ Here -Ve sign indicate the presence of Lenz's law.

(C) Attempt any three problems

1. Resistance of conducting wire $R = \frac{\rho l}{A}$ .. (1)

Differentating about eq.

$$dR = \frac{\rho l}{A} dl = \frac{\rho l}{A^2} \times \frac{A}{\rho L} = \frac{\rho l dA}{A^2} \times \frac{A}{\rho l}$$

$$= \frac{dl}{l} - \frac{dA}{A} \text{ ..... (2)}$$

But volume of wire A.ℓ= constant

dA.ℓ + A.dℓ = o

$$\therefore \quad \frac{dA}{A} = \frac{-dl}{l} \text{ .... (3)}$$

From equation (2) & (3) we get

$$= \frac{dR}{R} = 2\frac{dl}{l}$$

$$= 2\left(\frac{3}{100}\right)$$

$$= \frac{6}{100}$$

$= 0.06$

dR = 0.06 x R = 0.06 x 10 = 0.6Ω

Now resistence = R + dR = 10 + 0.6

= 10.6Ω

2. For netural temperature.

$$\frac{de}{dt} = \propto + \beta t = 0$$

$$\therefore \quad t = \frac{-\alpha}{\beta}$$

$$\therefore \quad t = -\frac{(14)(10^{-6})}{-(0.07)(10^{-6})}$$

$$\frac{14}{7x10^{-2}}$$

t = 200°C

For invesion temperature e = 0

$$\alpha t + \beta t^2 = 0$$

$$t(\alpha + \frac{1}{\beta} t) = 0$$

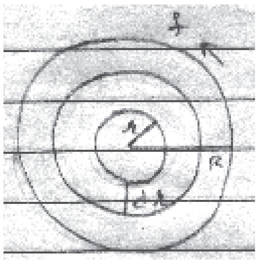
$$\alpha + \frac{1}{\beta} t = 0$$

$$t = \frac{-2\alpha}{\beta} = 2\left(-\propto/\beta\right) = 2(200)$$

$\therefore$ t = 400° C.

3. The disc can be considered to be made up of a series of rings each of width dr. One of such element ring of radius r is shown in fig.

charge per unit area of the disc $= \frac{Q}{\pi R^2}$



The charge on the elemental ring under consideration $= \frac{Q}{\pi R^2}$ x $2\pi r dr$

($\therefore$ area of ring = πr^2 = dA = $2\pi r$ d r)

When the disc is rotated, the current due to this ring is I = $\frac{Q}{\pi R^2}\ 2\pi r$ dr.f

Magnetic field at the centre of the disc due to this current $\frac{\mu_0 I}{2r}$

$$dB = \frac{\mu_o Q 2\pi r dr.f}{\pi R^2 2r}$$

$$B = \frac{\mu_o Qf}{R^2}\int_0^R dr$$

$$= \frac{\mu_o Qf}{R}$$

4. Mutual inductance between two coaxial solenoid is M = $\frac{\mu_o N_1 N_2 a}{l}$

$$M = \frac{4\pi x 10^{-7} x 1500 x 500 x 15 x 10^{-4}}{1.5}$$

$= 9.42 \times 10^{-4}$

M = 0.942×10^{-3} henry.

Q.4. (A) Answer in short

1. Power loss αI^2 (Power loss = I^2R)
   voltage is stepped up 5 times.

   then current becomes $\frac{I}{5}$

   If voltage is stepped up 5 times then loss in power = $\left(\frac{I}{5}\right)^2$ R

   loss in power = $\frac{x}{25}$ ($\therefore$ I^2R = x given)

2. <u>Modulation</u> :-
   The sound waves are converted into electrical signals in the transmiter.

These signals cannot travel long destance. So electrical signals are carried over high frequency radio waves. As a result the amplitude of carrier wave is changed as per the variation of the sound waves. These waves are called modulated waves. These modulated waves are able to travel long distance. This process is called modulation.

3. Yes, - Optic axis of a tourmaline Plate is a direction.

4. $\frac{I_1}{I_2} = \frac{1}{4}$

$$\left(\frac{A_1}{A_2}\right)^2 = \frac{1}{4} \Rightarrow \frac{A_1}{A_2} = \frac{1}{2}$$

$$\frac{A\max}{A\min} = \frac{A_1 + A_2}{A_1 - A_2}$$

$$= \frac{3}{1}$$

$$\therefore \quad \frac{\text{Im}ax}{\text{Im}in} = \frac{9}{1} \qquad \because 1 \propto A^2$$

5. Power factor $= \cos\delta$

$= \cos \pi/3$

Power factor = 0.5

(B) Answer any three

1. Since voltage and current in A.C. circuits vary periodically with time the instantaneous power can be defined but cannot be measured. Hence in practise actual or real power is defined & measure.

→ Real power - Average value of power taken over one pariod.

→ Now instantaneous power can be givin by P =VI

$= V_m\cos\omega t \times I_m \cos(\omega t - \delta)$

$= V_m I_m [\cos\omega t \times \cos(\omega t - \delta)]$

$= \frac{vm\,\text{Im}}{2} [\cos\delta + \cos(2\omega t - \delta)]$

Effective power

$$P = \frac{vm\,\text{Im}}{2} \frac{1}{T}\int_0^T \cos\delta dt + \frac{1}{T}\int_0^T \cos(2\omega t - \delta)dt]$$

$$\text{but} \int_0^T \cos(2wt - \delta)dt = 0$$

$$P = \frac{vm\,\text{Im}}{2}\frac{T}{T}\cos\delta$$

$$P = \frac{Vm}{\sqrt{2}}\frac{\text{Im}}{\sqrt{2}}\cos\delta$$

Where $\cos\delta$ is called power factor.

P = Vrms Irms cosδ

2. <u>Ground waves</u> :-

→ The radio waves of VLF, LF, and MF after being transmitted from the antenna move on the curved surface of the earth, keeping close to it and following the curvature of the surface such waves are called <u>Ground waves.</u>

→ The Electrical properties of the ground affect these waves much Hard oil absorbs them considerably but in sea water the absorption is very less.

→ The absorption also increases with increase in frequency.

→ Depending on the value of frequency and modulation, these waves can be sent from several kilometer distance to about (500 km.)

3. The condition of constructive interference is $\frac{xd}{D}$ where n = 1, 2, 3.......
x is distance of n^{th} bright fringe from central maximum.
D=distance of the screen from the S_1 & S_2
Now suppose Xm = distance of m^{th} bright fringe from central maximum & $(x_{m+1})^{th}$ is distance of $(m+1)^{th}$ bright fringe from central maximum

$$X_m = \frac{m\lambda D}{d}, \qquad x_{m+1} = \frac{(m+1)}{d}\lambda D$$

$$\bar{x} = x_{m+1} - x_m = \text{distance between consecutive bright fringe.}$$

$$= \frac{(m+1)\lambda D}{d} - \frac{m\lambda D}{d}$$

$$\bar{x} = \frac{\lambda D}{d}$$

since $\bar{x}$ does not depend on the order of fringe it can be stated that all the bright fringes have same width

4. Differential equation for charge of an A.C circuit having L-C-R in series

$$\frac{d^2Q}{dt^2} + \frac{R}{L}\frac{dQ}{dt} + \frac{Q}{Lc} = \frac{Vm\cos\omega t}{L} \quad \text{......... (1)}$$

Now RHS of (1) can be expressed as real part of complex voltage.

$$\frac{Vm}{L}c^{iwt} = \frac{Vm}{L}\cos\omega t.$$

$$= \text{Re}\left[\frac{Vm}{L}e^{j\omega t}\right]$$

where j = $\sqrt{-1}$

q is complex charge and can be written in complex form as

$$\frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{Lc} = \frac{Vm}{L}e^{j\omega t} \text{.....(2)}$$

solution of (2) can be given as under

$q = q_0 e^{jwt}$(3)

$$\frac{dq}{dt} = j\omega q_O e^{j\omega t}, \quad \frac{d^2q}{dt^2} = -w^2 q_o e^{j\omega t}$$

$$-w^2 q_o e^{jwt} + \frac{R}{L} j\omega q_o e^{j\omega t} + \frac{q_o e^{jwt}}{Lc} = \frac{Vm}{L} e^{j\omega t}$$

$$q_o = \frac{Vm}{L\left(-\omega^2 + \frac{Rj\omega}{L} + \frac{1}{LC}\right)}$$

$$q_o = \frac{Vm}{L\left(-\omega^2 L + Rj\omega + \frac{1}{C}\right)}$$

substituting value in (3)

$$q = \frac{Vm}{R + j\omega L - \frac{j}{\omega L}} e^{j\omega t}$$

(C) Solve anythree

V=Vmsinωt.

Now average value of ac voltage over half cycle of period is

$$\prec V \succ = \frac{1}{1/2} \int_0^{T/2} Vm \sin \omega t . dx$$

$$= \frac{vm}{\varpi\, T/2} \int_0^{T/2} \sin \varpi t \;\; d(\varpi t.)$$

Let ωt = x

Now Change the limits

When t = 0 $\Rightarrow$ x = 0

t = I $\Rightarrow$ x = Π

$$\langle V \rangle = \frac{Vm}{\pi} \int_0^{\pi} \sin x dx$$

$$= \frac{vm}{\pi} [-\cos x]^{\pi}{}_0$$

$$= \frac{-Vm}{\pi} [\cos\pi - \cos o]$$

$$= \frac{-Vm}{\pi} [-1-1]$$

$$\langle v \rangle = \frac{+2Vm}{\pi} = 0.637 \text{ Vm}$$

2. (1) angular frequency = ϖo

$$\varpi o = \frac{1}{\sqrt{LC}}$$

$$= \frac{1}{\sqrt{5 \times 80 \times 10^{-6}}}$$

$$= \frac{1}{\sqrt{400x10^{-6}}}$$

$$= \frac{1}{0.02}$$

= 50 rad / sec.

At resonance impedence |z| = R

$$\text{Irms} = \frac{Vrms}{121}$$

$$= \frac{230}{40}$$

$$= \frac{23}{4}$$

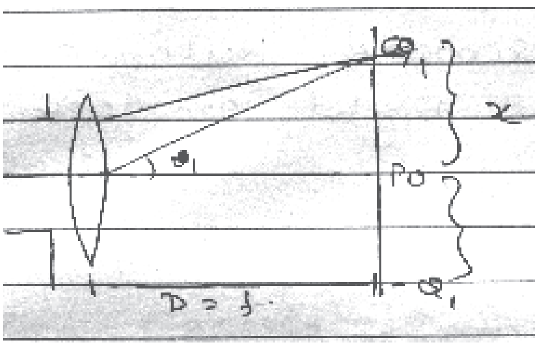
= 5.75 Amp.

Polential drop ocross inductor (V_L) = Irms (w_oL)

= 5.75 x 50 x 5

V_L = 1437.5 voltas.

3.



Given

d = 0.018 cm,

= 18 x 10^{-3} cm

f = D = 50 cm

2x = 0.45 cm

x = 0.225 cm.

m = 1

λ = ?

For m^{th} order maxima

$d\sin\theta_m = (m+\frac{1}{2})$

θ is small

$\sin\theta = \tan\theta = \frac{x}{D} \quad \Rightarrow \frac{xd}{D} = (m+\frac{1}{2})\lambda \qquad (\therefore m=1)$

$\frac{dx}{D} = \frac{3\lambda}{2}$

$\lambda = \frac{2dx}{3D}$

$= \frac{2\times 0.225\times 18\times 10^3}{3\times 50}$

$= 54 \times 10^{-6}$ cm

$= 5400\times10^{-8}$ cm

$\lambda = 5400\ A^o$

4. $d = 0.1$ mm

$= 10^{-4}$ m

$D = 1$ m

$\lambda = 5400\ A^o$

$= 5 \times 10^{-7}$ m

$\bar{x} = ?$

In young's experiment distance between two consecutive bright or dark fringe is

$\bar{x} = \frac{\lambda D}{d}$

$= \frac{5x10^{-7}x1}{10^{-4}}$

$\bar{x} = 5 \times 10^{-3}$ m

width of the fringe $= \frac{\bar{x}}{2}$

$= \frac{5x10^{-3}}{2}$

width of the fringe = 2.5×10^{-3}m

Q.5. (A) Answer in short

1. Viscous Force acting on stationary oil drop between two plates in Millikan's experiment is zero
2. Maximum Kinetic energy $= e\,v_o$

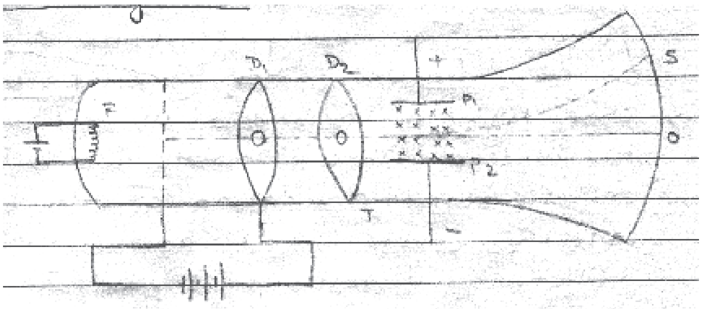
   $= 5$ ev.

   Maximum kinetic energy emitted by electrons - 5ev.
3. To slow down Fission neutron in nuclear reactor is Moderator.
4. Binding energy per nucleon gives measure of stability of a nucleus.
5. Depletion layer.

The region close to the junction in P-N junction diode is depleted of their respective majority charge carries.This region which is empty of charge carriers is known as depletion layer.

(B) Answer any three

1.



Here displacement of electrons due to an eletric field is given by

$$y = \frac{1}{2}[\frac{Ee}{m}]\frac{l^2}{v^2}$$

Now magnetic field of intensity B is applied normal to the electric field in the direction going inward direction such that the force on the electron due to both the fields becomes equal & opposite. Therefore the bright spot comes back to 0 moving from S.

$$BeV = Ee$$

$$V = \frac{E}{B} ....(2)$$

from (1) & (2) $y = \frac{1}{2}\left[\frac{E.e}{m}\right]\frac{l^2B^2}{E^2}$

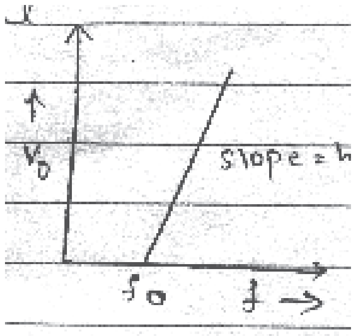
→ $\frac{e}{m} = \frac{2yE}{l^2B^2}$

→ The value of $\frac{e}{m}$ thus obtained was $1.7 \times 10^{11}\frac{Coal}{kg}$ More precise value of $\frac{e}{m}$ is 1.75890×10^{11} c/kg.

2. According to Einstein, emission, propogation and absosption of light takes place in the form of bundles of energy known as photons. The energy of photons depends on the frequency of light i c E = h f.

→ When light is incident on metal, photons are all incident. These photons are either entirely absorbed, or donot lose any energy when an electron absorbs the photon, it gains energy h f. If this energy is greater than the binding energy of the electron only then it would be emitted.

→ If the work function of a metal is wo = hfo then out of energy hf ($f>f_0$), the energy equal to the work function of metal will be utilised in liberating the electron from the metal. The remaining will be associates with it as maximum kinetic energy.



$\frac{1}{2}Mv^2max = hf - hfo.$

If Vo is the stopping potential

then $V_o e = hf - hfo$

$$V_c = \left(\frac{h}{e}\right)f - \frac{hfo}{e}$$

Thus the graph of $V_o \rightarrow f$ is a straight line with slope $\frac{h}{e}$

These facts agree with experimental.

3. The radius of on electronic in nth arbit in a hydrogen

atom $r = \frac{n^2h^2 \in_0}{\pi m z_e^{\ 2}}$ ....(1)

Now energy of an electron

En = kinetic energy + Polential energy

$$En = \frac{1}{2}mv^2 = \frac{ze^2}{r}\frac{1}{4\Pi \in o} \quad ....(2)$$

Now centripetal force

$$\frac{1}{2}mv^2 = \frac{1}{4\Pi \in o}\frac{ze^2}{r}$$

$$\frac{1}{2}mv^2 = \frac{1}{8\Pi \in o}\frac{ze^2}{r}$$

substituting value of $\frac{1}{2}mv^2$ in ....(2)

$$En = \frac{1}{8\pi \in o}\frac{ze^2}{r} - \frac{ze^2}{r}\frac{1}{4\pi \in 0}$$

$$En = \frac{1}{8\pi \in o}\frac{ze^2}{r} \quad .... (3)$$

subsitute the values of r from eq.(1) in (3)

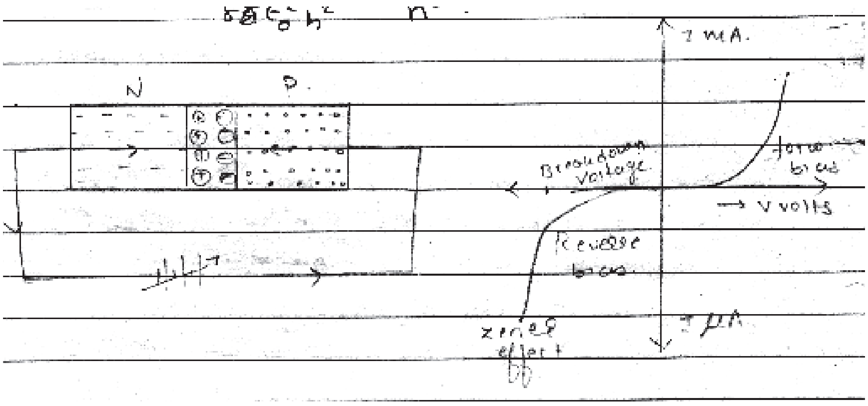
$$En = \frac{1}{8\pi \in o}\frac{ze^2}{r} - \frac{ze^2}{r}\frac{1}{4\pi \in 0}$$

$$= \frac{-z^2e^4m}{8\pi^2h^2 \in_0{}^2}$$

for hydrogen Z = 1

$$En = \left(\frac{-me^4}{8\in^2{}_0 h^2}\right)\frac{1}{n^2}$$

4.



As shown in fig. the terminal of the battery is connected to P type & the -Ve terminal is connected to N-Type then such connection is called forward bais.

→ In such condition the emf of the battery and potential difference of the depletion layer are in opposite condition. Therefore height of potential barrier reduces of the width of the depletion layer also decreases.

Therefore Electron require less work in going from N to P. These electrons move through holes & reach the the N terminal of the battery from -Ve terminal. They again enter in N-type & consequently the current is maintained.

As shown in figure I→V relations for P - N junction diode are called the characteristics of P-N junction diode. Here current increases with increase in voltage applied.

Q.5. (A) Solve any three.

1. Force F_1 & F_2 acting on electrons in the two beams are respectively.

$F_1 = Bev_1$ and $F_2 = Bev_2$

Their trajectories are areas of circles with radi R_1 & R_2 such that.

$$F_1 = Bev_1 = \frac{mv_1{}^2}{R}$$

$\therefore \quad v_1 = \frac{BeR_1}{m}$ .... (1)

$F_2 = Bev_2 = \frac{mv_2^{\ 2}}{R_2}$

$\therefore \quad v_2 = \frac{BeR_2}{m}$ .... (2)

$\frac{\vartheta_1}{v_2} = \frac{R_1}{R_2}$ ....(3)

Electrons are in field for short time

Deviation $D_1 \propto \frac{1}{R_1}$, & $D_2 \propto \frac{1}{R_2}$

$\therefore \quad \frac{D_1}{D_2} = \frac{R_2}{R_1}$ ....(4)

from (5) & (4)

$\frac{D_1}{D_2} = \frac{V_2}{V_1} = \frac{2}{1}$

2. $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$ for Balmer series.

for $H\alpha$ line n=3 $\quad H_\beta$ line n=4

$\frac{1}{\lambda_\alpha} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$= R\frac{5}{36}$

$\therefore \lambda_\alpha = \frac{36}{5R}$

$\frac{1}{\lambda_\beta} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

$= R\left(\frac{3}{16}\right)$

$\lambda_\beta = \frac{16}{3R}$

$\lambda_\beta = \frac{16}{3R}$

$\frac{\lambda_\beta}{\lambda\alpha} = \frac{16}{3R} \times \frac{5R}{36}$

$\lambda_\beta = \frac{80}{108} \times 6563 \times 10^{-8}$

$\lambda_\beta = 4860.44 \times 10^{-8}$

$\lambda_\beta = 4860.44^o A$

Calculation

$\log \lambda_\beta = \log 80 + \log 6563 - \log 108$

$= 1.9030 + 3.8171 - 2.0334$

$\log \lambda_\beta = 3.6866$

$\lambda_\beta = 4860.44$

3. By defination

Activity $I = \frac{dN}{dt} = \lambda N$

$\tau \frac{1}{2} = \frac{0.693}{\lambda}$

$\lambda = \frac{0.693}{\tau \frac{1}{2}}$

$\lambda = \frac{0.693}{\tau \frac{1}{2}} \times N$

$\tau \frac{1}{2} = \frac{0.693 \times N}{I}$

Now number of atoms in 226 gm. of Ra = 6.02 x 10^{23}

1 gm of Ra has $N = \frac{6.02 \times 10^{23}}{226}$

$\tau \frac{1}{2} = \frac{0.693 \times 6.02 \times 10^{23}}{226 \times 3.7 \times 10^{10}}$

= 49.89 x 10^9

$\tau \frac{1}{2} = 4.989 \times 10^{10}$ (Second)

4. Transconductance $gm = \frac{\beta ac}{ri}$

$= \frac{\delta Ic}{\delta I_B \times ri}$

$\delta V_{BE} = ri \times \delta I_B$

$gm = \frac{\delta Ic}{\delta V_{BE}}$

$= \frac{8 \times 10^{-3}}{40 \times 10^{-3}}$

(Given δV_{BE} = 4 x 10^{-3} Volt

δI_C = 8 x 10^{-3} (Amp.)

$\therefore gm = \frac{8}{40}$

$\therefore gm = \frac{1}{5}$

gm = 0.4 mho

voltage gain Av = gm R_L (neglect -ve sign)

$\therefore A_V = 0.2 \times 1000$

$A_V = 200$

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