Q.1 (A) Answer in brief. (05)

1. A spring of force constant k is stretched so that its length becomes double. Its Force constant will be _______.
2. The equation of stationary wave is $Y=-10 \sin \frac{\pi x}{3} \cos 20\pi t$. CGS units then what is wave length and frequency of the component waves ?
3. Write dimensional formula of wave intensity.
4. No work is done when a stationary bomb explodes without any external force acting on it. Then why does kinetic energy of its fragments change after explosion ?
5. Two particles of mass m and 3m are separated by 12cm distance. What will be the distance of the particles from their center of mass ?

(B) Answer in eight to ten sentence. (Any 3) (06)

1. Show that for massless elastic spring $k = \frac{mg}{\Delta l}$ and write the unit of k and define k.
2. Write the equation of displacement of S.H.O. differentiating it obtain the equation of acceleration in term of displacement. State where the accelertion is maximum ? What is the slope of the graph of acceleration $\rightarrow$ displacement ?
3. Write the general equation of the frequency experienced by a listener in Doppler's effect. State the sign convention used in it. Write the equation of the frequency of sound experienced by (1) a thief when a police blowing whistles is running after him. (2) A listener when listens a source are going away from each other.
4. Define center of mass for a system of particles, there by obtain $\vec{P} = M\vec{V}cm$·

(C) Solve. (Any 3) (09)

1. For damped oscillations, find the time for decreasing of the amplitude to $\frac{A}{2^n}$.
2. Prove that for a wave propagating in a medium, the ratio of the instantaneous velocity of a particle of the medium to the

wave velocity is equal to the negative value of the slope of the wave form at that point.

3. In a lake, a person is standing on a stationary raft. The distance between the person and the bank is 20m. Mass of the person is 50 kg. and that of the raft is 40 kg. The person now starts running towards the bank with a velocity of 2.5 m/s with respect to the raft. How far will ther person be from the bank after 1 sec ?
4. A ball of 6kg. Mass hits a wall at an angle of 40^o and is then reflected making an angle of 80^o with its original direction of the duration of contact between the ball and the wall is 0.1 sec. Calculate the force exerted on the wall. The initial and the final Velocities of the ball are 2m/s.

Q.2 (A) Answer in brief. (05)

1. Define Torque.
2. Write units and dimensional equation of momentum of ineritia.
3. Why is total energy of a satellite negative ?
4. Heat is flowing through two cylindrical rods of the same material. The diameter of the rods are in the ratio 1:2 and their length are in the ratio 2:1 of the temperature difference between their ends is the same then the ratio of heat currents through them is _______.
5. Give two examples of irreversible processes.

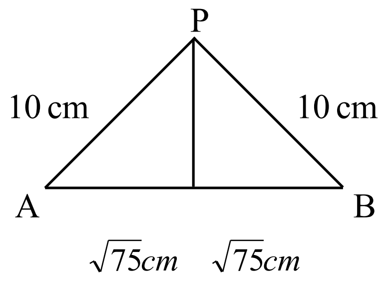
(B) Answer in eight to ten sentences. (Any 3) (06)

1. Draw the diagram of a simple pendulum showing the forces acting on its bob in a displaced position and hence derive $\frac{d^2\theta}{dt^2}+\varpi^2\theta=0$ for it.
2. Define inertial mass and gravitational mass and write the formulas to obtain them.
3. Write the stages of Carnot's cycle and state the relation between pressure and volume of each stage.
4. Identify the different terms in $\frac{dQ}{dt}=-kA\frac{dT}{dx}$ and define them.

(C) Solve. (Any 3) (09)

1. A rigid body experiences an angular displacement of 300 radians is 6 secnds, and attains an angular velocity of 1000 rad/sec. Find its initial angular velocity and its angular acceleration (assumed to be constant).

2. Prove that the ratio of the linear orbital velocity of a satellite orbiting close to the surface of the earth, to the escape velocity of a stationary body on the earth is $\frac{1}{\sqrt{2}}$.
3. Two sheres each of mass equal to 6 kg. Are placed at points A and B as shown in the figure.



If a small sphere of 10 gm is placed at a point P, what will be the acceleration experienced by it due to the gravitational forces of masses only the force due to gravitation of masses A and B.

4. One mole of ideal gas at NTP is expanded adiabatically to twice its initial volume and its temperature becomes 250 k. Calculate the change in the internal energy of the gas during this expansion. (Use γ=1.4, R=8.3 Joule/mole k).

Q.3 (A) Answer in brief. (05)

1. A carbon register has only three bands of color. What will be its tolerance ?
2. Under what condition will the EMF of a cell become equal to its terminal voltage.
3. What is the unit of magnetic flux ?
4. What is Inductor ?
5. One square coil has area of 10^{-2} met^2 ? It is kept perpendicular to uniform magnetic field of intensity 10^3 tesla. The flux passing through the coil will be _______.

(B) Answer in eight to ten sentence. (06)

1. By accepting single valuedness of electropotential in an appropriate circuit diagram, derive kirchoffs second rule.
2. Write an explain Faraday's second law of electrolysis and also define chemical equivlent.
3. A stright conductor of infinite length, carries electric current I along X-axis. Derive the formula for the magnetic field at a point laying on X-Y plane whose position co-ordinates are (x,y).
4. On what factor does mutual Inductance of a system of two coil depends.

(C) Solve. (Any 3) (09)

1. When a circuit is completed by connecting a resistance of 10 ohms to an electrical cell, a current of 5mA is obtained. Now if an unknown resistance X is connected in series. With the 10 ohm resistance the current obtained is 4mA. Find the value of X. (neglect internal resistance of the cell).
2. A DC motor is connected to a 110V direct voltage supply and draw 5amp. current. If its mechanical efficiency is 40% find the resistance of its windings.
3. A circular coil havig a average radius of 6cm has 1000 turns. A current of 5 amp passes through it. Find the magnetic field at a point on its axis 8 cm from the center $\left(\mu_0 = 4\pi \times 10^{-7} \dfrac{tesla - meter}{Amp}\right)$.
4. Flux linked per each turn of a coil of N turns changes from $\phi_1 \, to \, \phi_2$ If the total resistance of the circuit including the coil, is R, Prove that charge Q induces is given by $Q = \dfrac{N(\phi_2 - \phi_1)}{R}$

Q.4 (A) Answer in brief. (05)

1. If the phase lag between V and I in and a.c. circuit is δ, what is the time lag ?
2. The ratio of the number of turns in primary coil to that in the secondary coil is 5:1 if the current in the primary coil is 200mA then the current in the secondary coil will be _______.
3. What is the frequency of waves generated in Hertz Experiment ?
4. Define plane of Oscillations.
5. The ratio of amplitude of two interfering waves is 3:2 what is the ratio of maximum resultant intensity to the minimum resultant intensity ?

(B) Answer in eight to ten sentences. (Any 3) (06)

1. Draw a neat diagram of A.C. dynamo or generator. Derive expression of flux linked with the coil at time 't'.
2. Explain the generation of oscillating eletric and magnetic fields in Hertz experiment.
3. Explain 'sky waves' and 'space wave' with necessary figure.
4. State the condition for m^{th} order minima and maximum in fraunhoffer diffraction by a single slit and plot graph of intensity.

(C) Solve. (Any 3) (09)

1. For an A.C. generator V=0 at t=0 and V=2 volt at $t = \dfrac{1}{100\pi}$ second.

The voltage reaches a peak value of 100 volt. Find the frequency of voltage.

2. Velocity of electromagnetic waves in vaccum is $3x10^{s}$ km/sec. If the permeability of vacuum is $4\pi \times 10^{-7}$ Weber / amp-met. Find its permittivity.
3. In young's double slit experiment the separation of slits is 0.05cm and a screen is placed at a distance of 100cm. Find the separation between centers of the third bright and the fifth dark fringes. For light of wave length 5000 A.
4. The ratio of intensities of rays emitted from two different coherent sources is α. For the interference pattern formed by them prove that : $\frac{Imax + Imin}{Imax - Imin} = \frac{\alpha + 1}{2\sqrt{\alpha}}$, I max = maximum of intensity in the interference pringes, I min = minimum of intensity in the interference fringe.

Q.5 (A) Answer in brief. (05)

1. The electric and magnetic field applied in Thomson's experiment of e/m are 4900 v/m and 3.5×10^{-4} tesla. What is the horizontal velocity of electrons.
2. The ratio of velocity of cathode ray in Thomson's experiment to that of velocity of light in vacuum is _______.
3. What idea regarding the nucleus is obtained from the binding energy per nucleon ?
4. What is avalanche current in. Reverse bias condition of PN junction diode.
5. α=0.98 for a transistor if I_c=4.9mA then find base current.

(B) Answer in eight to ten sentences. (Any 3) (06)

1. Describe the apparatus of Millikan's experiment of finding charge of an electron with necessary diagram.
2. Obtain the equation of the radius of the orbit of electron in n^{th} orbit in Bohr model.
3. Derive exponential law of radioactive disintegration. Using the equation draw the decay curve.
4. Draw the circuit diagram of half wave rectifier and explain the process of rectification taking place during one complete cycle of Input A.C.

(C) Solve. (Any 3) (09)

1. A 100 watt bulb converts 5% of electrical energy consumed by it into light energy of the wagelength emitted by the bulb is 6625 A^o, Calculate number of photons emitted per second. [$h=6.625 \times 10^{-34}$ joule-sec, $c = 3 \times 10^{8}$ m/sec].

2. Show that in a hydrogen atom angular speed of an electron is given by $\omega = \dfrac{\pi m e^4}{2\varepsilon_0^2 n^3 h^3}$
3. At a specific time the rate of radioactive decay of a substance is 8000 nuclei/sec. At that time the undecayed number of nuclei is 8×10^7. Find the decay constant and the half-life.
4. If the collector current of an NPN common emitter amplifier shows a change in its collector current by 4.5mA when the input voltage changes by 25 milli volt. Find its Tranconductance.

• • •

SOLUTION

Q.1 (A) 1. 2K

2. $k = \frac{\pi}{3} \Rightarrow \frac{2\pi}{\lambda} = \frac{\pi}{3} \Rightarrow \lambda = 6cm,$
$w = 20\pi \Rightarrow 2\pi f \Rightarrow f = 10Hz.$

3. $M^1L^0T^{-3}$.

4. Because internal energy associated with the chemical bonding is released which appears in the form of Kintu energy of its pragments.

5. $m_1 = m; m_2 = 3m$

$|\vec{r}_{cm}| = \frac{m_1|\vec{r}_1| + m_2|\vec{r}_2|}{m_1 + m_2}$ (Taking center of mass as origin).

$0 = \frac{m_1|\vec{r}_1| + m_2|\vec{r}_2|}{m_1 + m_2}$

$0 = m(r_1) + 3m(r_2)$ (ignoring negative sign)

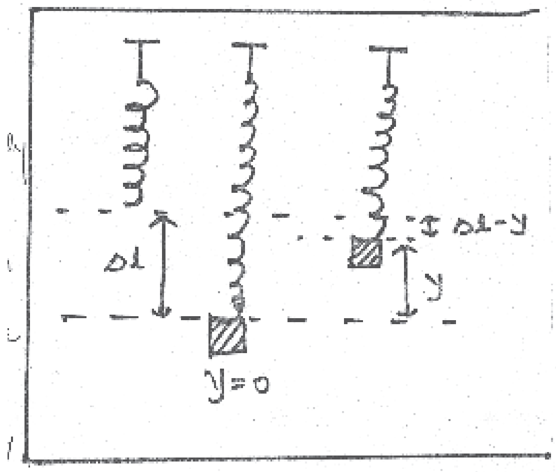
$\therefore r_1 = 3r_2$

but $r_1 + r_2 = 12\text{cm}$

$3r_2 + r_2 = 12$

$r_2 = 3\text{cm}$ *and* $r_1 = 9cm$ $(\because r_1 + r_2 = 12)$

(B) 1. A mass-less plastic spring obeying Hooke's law, is suspended in normal position, vertically from a rigid support as shown in Fig.



* When a body of mass in is suspended from its lower end, length of the spring increase by Δl under the influence of weight (mg) and the body comes into equilibrium.
* The suspended mass is acted upon the two forces.
  (i) Its weight mg acting down ward and
  (ii) The restoring force (KΔl) due to the elasticity of the spring acting upwards.
* For the equilibrium condition mg = KΔl where K = force constant of the spring.

Definition :
The force required (OR restoring force produced in the spring) per unit change in the legnth of the spring is called force constant (k) of the spring. Unit of K= N/m (MKS) dyne/cm in C.G.S. system.

2. The displacement of a S.H.O. is given by
$y = A\sin(\omega t+\phi)$ ...(1)

velocity of S.H.O.; $v = \frac{dy}{dt}$

$= d\frac{[A\sin(\omega t+\phi)]}{dt}$

$A\omega\cos(wt+\phi)$ ... (2)

the time derivative of velocity of SHO is called acceleration.

$a = \frac{dv}{dt}$

$a = \frac{d[Aw\cos(\omega t+\phi)]}{dt} \rightarrow$ from eqp. .....(2)

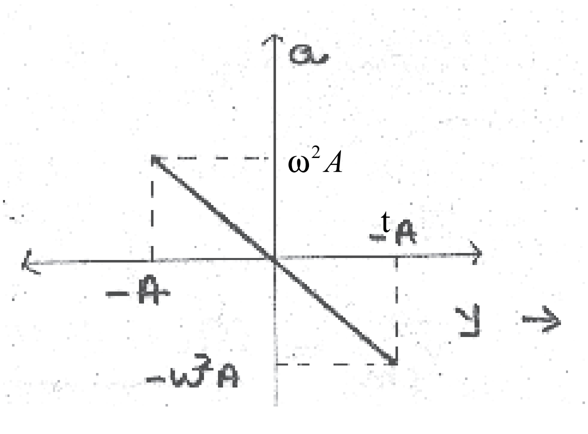
$a = -\omega^2 ASin(\omega t+\varphi)$ - from eq. ...(1)

$a = -w^2 . y$ ...(3)

Eq. (3) shows that $a \alpha -y$, i.e. the acceleration is directly proportional to the displacement and it is in opp. direction.

Graph of Acceleration $\rightarrow$ displacement. :

Slope of the graph is $-\omega^2$



3. Sign convention :-
Velocity in the direction from listener to the source is considered positive and velocity in opposite direction is considered negative. "Velocity of sound is always positive".

$\frac{f_L}{V+V_L} = \frac{f_S}{V+V_S}$ ....(1)

V = velocity of sound in still air.
V_S = velocity of the source.

V_L = Velocity of the listener to the source.
f_S = Frequency of sound waves emitted by the source.

(i) Both listerner and source are moving away from each other. the frequency of sound heared by the listener is smaller than the frequency emitted by the source. $f_L = \left(\frac{V - V_L}{V + V_S}\right) fs$

(ii) Frequency of sound heared by a thief when a policeman is blowing whistle and running after him. Here the thief is the listener and policeman is the source of sound. $f_L = \left(\frac{V - V_L}{V + V_S}\right) fs$.

4. Consider a system n particles of mass M_1, M_2, M_3 ....M_n. If $\vec{r}_1, \vec{r}_2, \vec{r}_3, ... \vec{r}_n$ are their respetive position vectors with respects to some origin then the center of mass of the system is defined as a point whose position vector $\vec{r}_{cm}$ is given by the following equation.

$$\vec{r}_{cm} = \frac{M_1\vec{r}_1 + M_2\vec{r}_2 + ... + M_n\vec{r}_n}{M_1 + M_2 + ... + M_n} \quad ....(1)$$

Taking $M_1 + M_2 + M_3 + ...M_n$=M=total mass of the system then from above equation.

$$M\vec{r}_{cm} = M_1\vec{r}_1 + M_2\vec{r}_2 + ... + M_n\vec{r}_n$$

differentiating above equation with respect to time, taking masses constant.

$$M\frac{d\vec{r}_{cm}}{dt} = M_1\frac{d\vec{r}_1}{dt} + M_2\frac{d\vec{r}_2}{dt} + ... + M_n\frac{d\vec{r}_n}{dt}$$

But $\frac{d\vec{r}_1}{dt} = \vec{V}_1 \; \frac{d\vec{r}_2}{dt} = \vec{V}_2 .... \frac{d\vec{r}_n}{dt} - \vec{V}_n$

and $\frac{d\vec{r}_n}{dt} - \vec{V}_{cm}$ velocity of the center of mass then.

$M\vec{V}_{cm} = M_1\vec{V}_1 + M_2\vec{V}_2 + ... + M_n\vec{V}_n$;

$M_1\vec{V}_1 = \vec{P}_1 .... M_n\vec{V}_n = \vec{P}_n$

are the linear momenter of n particles resp. and

$M\vec{V}_{cm} = \vec{P}$ = linear momentum.

$\therefore M\vec{V}_{cm} = \vec{P} = \vec{P}_1 + \vec{P}_2 + ... \vec{P}_n$

Thus linear momentum of center of mass of a system of particles is equal to the vector sum of linear momentum of all particles and it is equal to the product of total mass and velocity of center of mass.

(C) 1. $A(t) = Ae \text{ -btn} = A \exp\left(-\frac{bt}{2m}\right)$

$$\frac{A}{2^n} = A\exp\left(\frac{-btn}{Qm}\right) \quad \therefore 2^{-n} = \text{Exp}\left(-\frac{btn}{Qm}\right)$$

$$n\ln 2 = \frac{btn}{2m} \quad \therefore tn = \frac{2m}{b} n.\ln 2$$

$$tn = \left(\frac{2m}{b}\right)(n)(2.303)\log 2$$

$$tn = \left(\frac{2m}{b}\right)(n)(0.693)$$

2. The equation of propagating harmonic wave is $y = A \sin(\omega t - kx)$
Instantaneous velocity of particle is given by

$\vartheta_p = \frac{dy}{dt} = A\omega \cos(wt - kx)$ 1

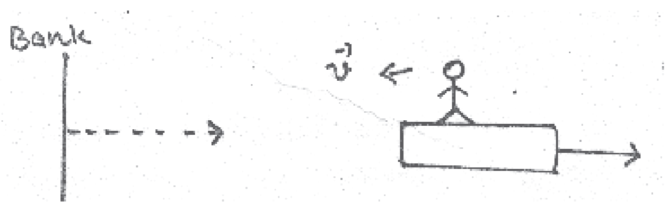
Slope of the wave form is given by $\frac{dy}{dx} = -A(k) \cos(\omega t - kx)$ ....(2)

from eq. (1) $\div$ (2)

$\frac{\vartheta_p}{slope} = -\frac{w}{k}$ But, $\frac{w}{k} = \vartheta$ = wave velocity

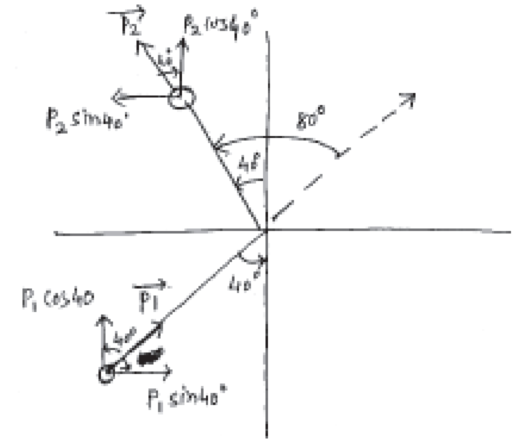
$\therefore \frac{\vartheta_p}{slope} = -v$ $\therefore \frac{\vartheta_p}{v} = -slope$

3.



Here no external force is acting on the system comprising of the pason and the raft. Therefore momentum of this system is conserved. As shown in figure, let $\vec{\vartheta}$ be the velocity of the person relative of the raft. A let $\vec{\vartheta}$ be the velocity of the raft relative to the bank.
Velocity of the person relative to the bank = $\vec{\vartheta} - \vec{v}$
Momentum of the person with respect
to the bank = M $(\vec{\vartheta} - \vec{v})$
M = mass of the person.
Momentum of the raft = M $\vec{v}$ (M being the mass of the raft)
Acc to law of convervation of linear momentium m $(\vec{\vartheta} - \vec{v}) = M\vec{v}$
$M\vec{v} = (m + M)\vec{v}$ $\therefore$ 50 x 2.5 = (50 + 40)
$\therefore$ V = 1.38 m/sec.
Velocity of person with respect to bank = (2.5 - 1.38) = 1.12 met/sec.
Initially the person is 20 m away from the bank.
After 1 second he will be 20 - 1.12 = 18.87 meter away from the bank.

4.



Initial momentum $\vec{P_1} = P_1 \sin 40° \hat{i} + P_1 \cos 40° \hat{j}$

$= MV_1 \sin 40 \hat{i} + MV_1 \cos 40 \hat{j}$ —(1)

Final momentum $\vec{P_2} = -P_2 \sin 40 \hat{i} + P_2 \cos 40 \hat{j}$

$= -MV_2 \sin 40 \hat{i} + MV_2 \cos 40 \hat{j}$ —(2)

∴ change in momentum $\Delta \vec{p} = \vec{P_2} - \vec{P_1}$ $(\because V_1 = V_2)$

$= -2MV \sin 40° \hat{i}$

$= -2 \times 6 \times 2 \times 0.6428$

$= -15.427 \hat{i}$ N.S

∴ momentum imparted to the wall $= -15.427 \hat{i}$ N.S

∴ Force on the wall $= \dfrac{\text{momentum imparted}}{\text{contact time}}$

$= \dfrac{-15.43 \hat{i}}{0.1}$

$= -154.3 \hat{i}$ Newton.

∴ the wall will experience a force of +154.3 Newton in +Ve x- direction.

Q.2 (A) 1. The cross product of position vector of a particle with respect to a reference point and force acting on it is called torque acting on the particle.

2. Unit : kg - m^2 dimensional equatio $M^1L^2T^0$.

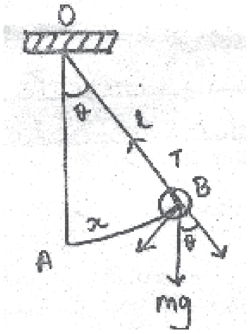
3. Because its negative potential energy is more than its kinetic energy.

4. $$\frac{d\theta}{dt} = -kA\frac{\Delta T}{\Delta x} = -k\pi r^2 \frac{\Delta T}{l}$$

$$\frac{(d\theta/dt)_1}{(d\theta/dt)_2} = \left(\frac{r_1}{r_2}\right)^2 \frac{l_2}{l_1} = \left(\frac{1}{2}\right)^2 \frac{1}{2} = \frac{1}{8}$$

5. Rusting of iron and errosion of the rocks.

(B) 1. Consider simple pendulum as shown in pig. let m - mass of the bob
$\bar{l} = OA = OB$ length of the pendulum.



B = displaced position.
(i) mg = weight of the bob is vertically downword direction
(ii) T = tension in the string acting parallel to string.
the line of action of the tension T passes through the point of suspension, hence the toque due to it is zero.

$\vec{\tau} = \vec{l} \times m\vec{g}$

$\tau = -mgl\sin\theta$

-ve sign shows that torque is in oppditn to the angular displacement θ of the bob,

$$\tau = I\alpha = I\frac{dw}{dt} = I\frac{d^2\theta}{d^2\theta} \ and \ I = ml^2$$

$$ml^2\frac{d^2\theta}{dt^2} = -lmg\sin\theta$$

$$\Rightarrow \frac{d^2\theta}{dt^2} = -\frac{g\sin\theta}{l}$$

- Angular displacement is very small then $Sin\theta \cong \theta$

hence $\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta$

substituting $\frac{-g}{l} by = \omega^2$

we get

$$\frac{d^2\theta}{dt^2} + w^2\theta = 0$$

This is the diff. Eqn. of angular harmonic motion.

2. In Newton's second law of motion. Force = Mass x accelaation the term "mass" appears as a parameter, which "opposes" the action of applied force. Accl^n, which represents the change in the state of motion, is inversely proportionaly to this mass.

- "The mass which tends to oppose the change in the state of Motion of a body is called the inertial mass of the body. "The enertial mass is denoted by m_i and is give by equation;

F = Mi x a 1

- The force acting on a body in the gravitional field of another body is proportional to its mass. This force acting on the body is given by

$$F = \frac{GMemg}{\mathrm{Re}^2} \quad ....2$$

m_g in the above equation is called gravitational mass.

3. Four stages of carnot's cyclic process & their corresponding equation are as follows :-

1. Isothermal expansion : $Q_1 = nRT_1 \ell n \frac{V_2}{V_1}$ 1

   and $P_1V_1 = P_2V_2$ 2
2. Adiabatic Expansion :

   $P_2\gamma_2 = P_3\gamma_3$ 3
3. Isothermal Compression :

   $Q_2 = nRT_2 \ell n \frac{V_3}{V_4}$ 4

   $P_3\gamma_3 = P_4\gamma_4$ 5
4. Adiabatu compression : $P_4\gamma_4 = P_1\gamma_1$ 6

4. In equation $\frac{dQ}{dt} = -kA\frac{dT}{dx}$

K = Thermal conductivity of the substance at a given temp.

A = Area of coss section.

$\frac{dT}{dx}$ = temp gradient at distance x from the hot end.

Defination : "The temp deference (or change in temp) per unit length (distance)"

- V_e sign indicates that as x increases, the temp of successive part descrease.

$\frac{dQ}{dt}$ = rate of heat flow or heat current.

Defination : The amount of heat energy passing normally through a unit area of cross section in the unit length is called heat current in the rod.

(C) 1. θ = 300 radians. $\theta = \left(\frac{w + w0}{2}\right)t$

t = 6 Sec. $300 = \left(\frac{100 + w0}{2}\right)6$

w = 100 rad/sec. $\therefore 100 = 100 + wo$

wo = ? $\therefore wo = 0 rad / sec.$

α = ?

$$\alpha = \frac{w - wo}{t} = \alpha = \frac{100 - 0}{6} = \frac{100}{6} = 16.6 rad / \sec^2$$

2. $\frac{MV^2}{Re} = \frac{GMem}{Re^2} = gm$

$\therefore$ Orbital velocity $V = \sqrt{g\,Re}$

Escape Velocity on surface of the earth is

$$v = \sqrt{\frac{2GMe}{Re}} = \sqrt{\frac{2GMe\,Re}{Re^2}} = \sqrt{g\,Re}$$

$$\frac{v}{v_e} = \frac{1}{\sqrt{2}}$$

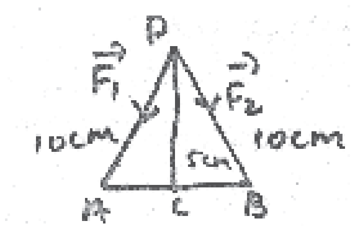
3. $M_1 = M_2 = 6$Kg. = Masses of two spheres of points A & B.

$M = 10 \times 10^{-3}$ Kg = Mass of the sphere at PtP.

r = 0.1m = 10^{-1}m

G = 6.67 x 10-11 Nm^2/Kg^2

Suppose F_1 & F_2 are force acting on melue to M_1 & M_2 respectively.



$$F_1 = \frac{GM_1M}{r^2} \ \& \ F_2 = \frac{GM_2M}{r^2} \qquad (m_1 = m_2)$$

$$F_1 = F_2 = \frac{6.67\times10^{-11}\times6\times10\times10^{-3}}{10^{-2}} = 4.00\times10^{-10}\,N.$$

From Pig ΔPCA $Cos\theta = \frac{5}{10} = \frac{1}{2}$ $\therefore \theta = 60^0$

$\therefore$ angle between $\vec{F_1}$ & $\vec{F_2}$ is $2\theta = 120^0$

resultant porce $\vec{F} = \vec{F_1} + \vec{F_2}$

$$\therefore F = \sqrt{\vec{F_1} + \vec{F_2} + 2F_1F_2Cos120^0}$$

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1(-\frac{1}{2})} \quad (\because F_1 = F_2)$$

$$F = 4.00\times10^{-10}\,N.$$

Now,

$$a = \frac{F}{M} = \frac{4.00\times10^{-10}}{10\times10^{-3}} = 40.0\times10^{-9}$$

$$a = 40.0\times10^{-9}\,\frac{meter}{\sec^2}$$

4. Here n=1, $V_2 = 2V_1$, $T_1 = 27^oC = 300$ K

$T_2 = 250$ K $\qquad \gamma = 1.4 \qquad$ R = 8.3 J/mole

K Δ U = ?

The equation of work done during an adiabatic process is

$$w = \frac{nR}{\gamma-1}\left[T_1 - T_2\right] = \frac{1\times8.3}{0.4}(300-250) = \frac{8.3\times50}{0.4}$$

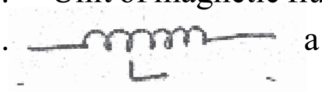
$= 8.3 \times 125 = 1037.5$ Joule

Now for an adiabatic process $\Delta Q = 0$ $\therefore$ from 1st law of thermodynamics.

$\Delta u = -Dw$ $\therefore$ $\Delta u = -1037.5$ J

$\Delta u = -1037$ x 5J i.e. the internal energy decrease by 1037.53.

Q.3. (A) 1. 20%

2. When no current is flowing.
3. Unit of magnetic flux is weber.
4. 

a component which has self inductance is called an "inductor"
5. $A = 10^{-2}$ mt^2

$B = 10^3$ tesla

$\phi = ?$

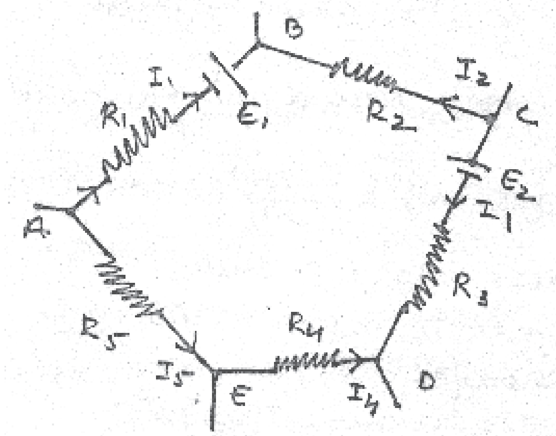
ϕ = area x magnetic field.

$\phi = 10^{-2} \times 10^3$

ϕ = 10 weber.

(B) 1. Consider a loop ABCDEFA as shown in fig.

The loop is formal by resistance R_1, R_2, R_3, R_4 & R_5 and batteries of e.m.f., E_1, & E_2. Suppose electric potential at Pt A is VA.



Suppose positive change are moved in the loop in clock wise direction. The value of electric potential increases or decrease according to the direction of current the connection of cells.

On the direction of current potential decreases IR after passing through resistance R in opposite directon of the current the potential increases by IR.

Insasteadly circuit due to single valued ness of electripotential, value of potential becomes equal to VA again.

using

$$VA = I_1R_1 + \in_1 + I_2R_2 - \in_2 - I_3R_3 + I_uR_u + I_5R_5 = VA$$

$$\sum IR = \sum \in$$

These equation represent kirchhof's second law.

Kirchhoff's Second Law :- "Along aclosed circuit loop the algebraic sum of the product of resistance with the corresponsding value of current flowing through them is equal to the algebraic sum of the e.m.f. applied along the loop."

2. Law : 2

"When same current is passed for same time through different electrolytes the masses of elements deposided from the electrolytes are in proportion to the chemical requivalents.

Chemical equivalent of any element is the ratio of atomic weight the valency of that element :

$$e = \frac{atomicweight}{valancy}$$

Wt M_1 & M_2 be masses of two substance liberated at the electrodes when same current I is passed theough two chemical cells, for same time interval e_1, e_2 are their chemical equivalents resp. then according to Faraday's Second law of electrolyses.

$$\frac{M_1}{M_2} = \frac{e_1}{e_2} \qquad \text{........ 1}$$

3. In equation

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int_{\infty}^{\infty} \frac{ydx}{(x^2 + y^2)^{3/2}} \hat{K}$$

$$x = y \tan\theta$$

$$dx = y \sec^2 \theta d\theta$$

- $x = -\infty \Rightarrow \frac{-\pi}{2}$

$$x = \infty \Rightarrow \frac{\pi}{2}$$

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int_{-\pi/2}^{\pi/2} \frac{ySec^2\theta d\theta}{(y^2 \tan^2\theta + y^2)^{3/2}} \hat{K}$$

$$= \frac{\mu_0 I}{4\pi} \int_{-\pi/2}^{+\pi/2} \frac{y^2 Sec^2\theta}{y^3 Sec^3\theta} d\theta \hat{K}$$

$$= \frac{\mu_0 I}{4\pi y} \int_{-\pi/2}^{\pi/2} Cos\theta \bullet d\theta$$

$$= \frac{\mu_0 I}{4\pi y} [Sin\theta]_{-\pi/2}^{\pi/2} \hat{K}$$

$$= \frac{\mu_0 I}{4\pi y} [1+1] \hat{K}$$

$$|\vec{B}| = \frac{\mu_0 I}{2\pi y}$$

4. Mutual inductance of a coild depends upon
   1. Shapes of the coil
   2. Size of the coil
   3. Number of lines of the coil
   4. Distance between them.
   5. Their mutual encilination angle.
   6. Material on which they are wound.

Q.5. (A) 1. R_1 = 10 ohm R_2 = (10 + x) ohm
I_1 = 5 Milliamp. I_2 = 4 milliamp
= 5 x 10^{-3} amp. x = ?

$I_1 R_1 = I_2 R_2$

$5\times10^{-3}\times10 = 4\times10^{-3}\times(10+x)$

5.0 = 40 + 4x

4x = 10

x = 2.5 Ohm.

2. V = 110 Volt, Mechanical efficiency = 40 %
I = 5 amp = 0.4 R = ?
Power being consumed P = VI = (110) (5)
= 550 watt
Mechanical Power = Efficiency electric power
0.4 x 550 = 220 Watt.
Power dissipated in the form of heat
= 550 - 220 = 330 Watt.
R = Resistance of Motor Windeng's

$$R = \frac{330}{25} = 13.2\Omega$$

3. a = 6 cm = 10^{-2}m.
N = 1000
I = 5A
x = 8 cm = 8 x 10^{-2} m.
$r_0 = 4T\times10^{-7}\, T - m/A$
B = ?

$$= \quad B = \frac{\mu_0 I a^2 N}{2(a^2+x^2)^{3/2}} = \frac{4\pi\times10^{-7}\times5\times36\times10^{-4}\times1000}{\left\{2C36\times10^{-4}+64\times10^{-4}\right\}^{3/2}}$$

$$= \quad 11.3\times10^{-3}\, T$$

4. $\in = \dfrac{N\Delta\phi}{\Delta t}$

We ingnore the negative sign in the problem)

$$\in = \frac{N(\varnothing_2 - \varnothing_1)}{Dt}$$

$\therefore I = \frac{\in}{R} = \frac{N(\varnothing_2 - \varnothing_1)}{Rt}$

Q = It

$= \quad N\frac{(\varnothing_2 - \varnothing_1)}{R}$

$Q \quad = \quad \frac{N(\varnothing_2 - \varnothing_1)}{R}$

Hence proneel.

(B) 1. Time lag is $\frac{\delta}{\omega}$.

2. $\frac{N_1}{N_2} = \frac{5}{1}; I_1, = 200 \times 10^{-3}$ amp

$I_2 = \frac{N_1}{N_2} = \frac{5}{1}; I_1, = 5 \times 200 \times 10^{-3} = 1$ amp.

3. The frequency of the waves generate is same as the frequency of the oscillation of the change between the spheres. (along the spark gap)

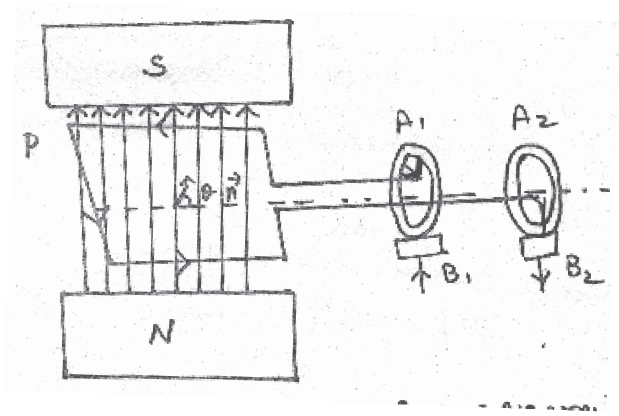
4. The plane containing the direction of the beam and the direction of the $\vec{E}$ vectors of plane polarized light is called the plane of oscillation.

5. $\frac{A_1}{A_2} = \frac{3}{2} \therefore \frac{A max}{A min} = \frac{A_1 + A_2}{A_1 - A_2} = \frac{5}{1}$

$\Rightarrow \frac{Imax}{Imin} = \left(\frac{A max}{A min}\right)^2 = \frac{25}{1}$

$\therefore Imax : Imin = 25 : 1$

(B) 1.



A.C. Dynamo or A.C. generator.

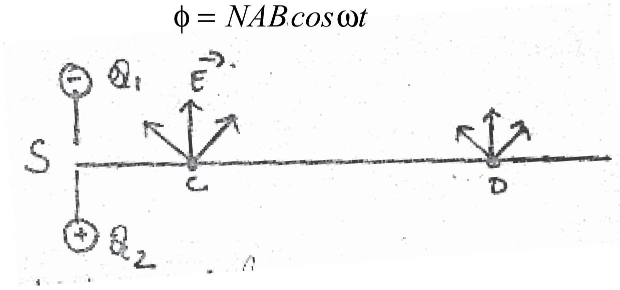
* Conducting coil PQRS having N then is kept in a uniform magnetic field $\vec{B}$.
* The coil is rotating with uniform angular speed to about x-axis.
* Mangite field ($\vec{B}$) is directed along y-axis.
* A_1 and A_2 are slip rings connected with the two ends of the coil, making sliding contacts with Bruches B_1 and B_2.

If ever vector $\vec{A}$ of the coil makes angle with magnite field $\vec{B}$ at time t=0 then the magnetic flux linked with the coil at t=0 is

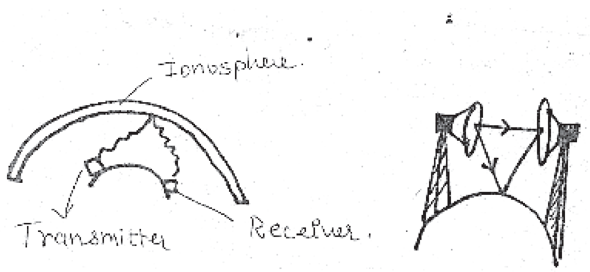
$$\phi_o = NAB \cos 0 = NAB$$

If the coil is rotating with angular velocity to then at time 't' $\phi = \omega t$ hence the magneti flux at time 't' can be given by.

$$\phi = NAB cos \omega t$$

2. 

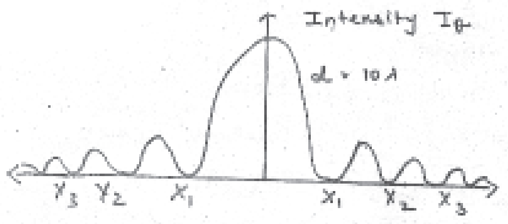
* As shown in figure suppose sphere Q_1 in the appratus of Hertz's experiment is negatively changed and Q_2 is positively charged at an instant.
* The intensity of electric field at points C and D are in upward direction as shown in fig.
* When the spark passes through S the electrons on Q_1 are transferred to Q_2.
* The oscillating electrons from periodically changing electric current which gives rise to Periodically changing magnetic fields at point C and D.

3. 

<u>Sky Waves :-</u> HF waves gets absorbed by the soil. But the part of these waves entering the atmosphere gets reflected back by the ionosphere and can be received by the receiver. Such wave are called Sky Waves.
<u>Space Waves :-</u> The VHF and frequencies more propagates on straight path from the transmitter to the receiver as shown in figure where as some waves reach the receive after being reflected from earth surface.

4. For mth order minimum we can show that $\text{Sin}\phi m = \frac{m\lambda}{d}$ where m = 1,2,3....

The graph of intensity $I\phi \rightarrow \phi$ for different points on the screen is shown in the fig.



(C) 1. Here, $t = \frac{1}{100\pi} sec, v = 2volt, v_m = 100volt, f = ?$ here value of

$t = \frac{1}{100\pi}$ is small then value of ωt is small. Then $Sin\omega t = \omega t$.

Now, V $= V_m Sin\omega t$

V $= V_m\, cot$

$\omega = \frac{V}{V_m t} = 2\pi f \Rightarrow f = \frac{V}{2\pi V_m t}$

$= \frac{2}{2\times\pi\times100}\times\frac{1}{100\pi}$

$\therefore f = 1Hz.$

2. Given C = 3 x 10^5 km/sec Co = 4π x 10^{-7} weber/amp mt.
= 3 x 10^8 m/sec

$C = \frac{1}{\sqrt{\mu_0 \in_0}} \Rightarrow 3\times10^8 = \frac{1}{\sqrt{4\pi\times10^{-7}}}$

$\therefore (3\times10^8) = \frac{1}{4\pi\times10^{-1} \in 0}$

$\in_0 = \frac{1}{9\times10^{16}\times4\pi\times10^{-7}} = \frac{1}{36\times3.14}\times10^{-9}$

$\log \in_0 = \left[log 1 - (log 36 - 1 log 3.145\right]\times10^{-9}$

$= [0.0000 - (1.5563 + 0.4969)]\times10^{-9}$

$= [0.0 - 2.0532]\times10^{-9}$

$= [\bar{3}.9468]\times10^{-9}$

$\in_0 = anti\,log[\bar{3}.9468]\times10^{-9}$

$= 0.008847\times10^{-9}$

$\in_0 = 8.847\times10^{-12}\, coulonub^2 / N.mt^2$

3. Given d = 0.05 cm = 5 x 10^{-4} m
D = 100 cm = 1m; $\lambda = 5000\times10^{-10} m$
n = 3 (Bright f); 1 = 5 x 10^{-7} m.
n = 5 (Dark f); x_5 - x_3 = ?

$\rightarrow$ n = 3

$\frac{xnd}{D} = n\lambda \Rightarrow x_3 = \frac{3\lambda D}{d}$

n = 5

$\frac{xnd}{D} = (2n-1)\frac{\lambda}{2} \Rightarrow x_5 = \frac{9\lambda D}{rd} = \frac{4.5\lambda D}{d}$

Distance between 3rd 5th fringe.

$$x_5 - x_3 = 4.5\frac{\lambda D}{d} - \frac{3\lambda D}{d}$$

$$= \frac{\lambda D}{d}(4.5-3) = 1.5$$

$$= 1.5 \times \frac{5\times10^{-7}\times1}{5\times10^{-4}} = 1.5\times10^{-3}\, m$$

$$x_5 - x_3 = 1.5\times10^{-3}\, m$$

4. Given $\frac{I_1}{I_2} = \alpha;$

$$\frac{I_1}{I_2} = \frac{A^2{}_1}{A^2{}_2} = \alpha; \frac{A_1}{A_2} = \sqrt{\alpha}$$

$$\frac{A_1 + A_2}{A_1 + A_2} = \frac{1+\sqrt{\alpha}}{\sqrt{\alpha}-1}; \frac{A max}{A min} = \frac{1+\sqrt{\alpha}}{\sqrt{\alpha}-1}$$

$$\rightarrow \frac{Imax}{Imin} = \frac{A^2\, max}{A^2\, min} = \frac{(1+\sqrt{2})^2}{(\sqrt{\alpha}-1)^2} = \frac{1+2\sqrt{2}+2}{\alpha-2\sqrt{2}+1}$$

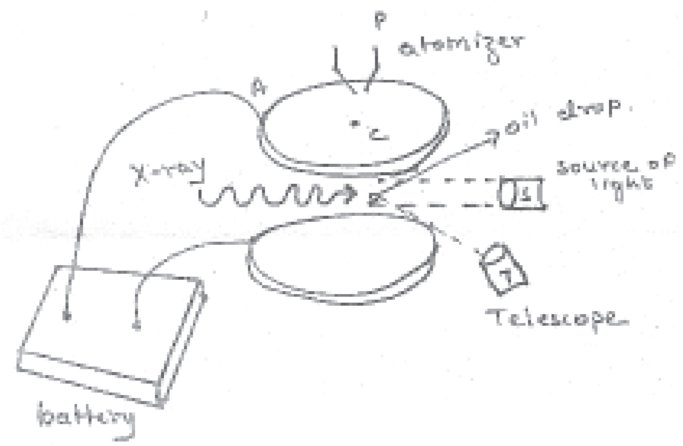
$$\frac{Imax+Imin}{Imax-Imin} = \frac{1+2\sqrt{2}+\alpha+2-2\sqrt{2}+1}{1-2\sqrt{\alpha}+\alpha+2-C+2\sqrt{2}-1}$$

$$= \frac{2(\alpha+1)}{4\sqrt{\alpha}} = \frac{\alpha+1}{\alpha\sqrt{2}}$$

Q.5 (A) 1. Velocity $V = \frac{E}{B} = \frac{4900}{3.5\times10^{-4}} = 1.4\times10^7$ *Met / Sec.*

2. 1:10
3. Binding energy per nucleons is a measure of the stability of the nucleus.
4. The sudden increase in the current at breakdown voltage in reverse based R N junction diode is known as avalenche.
5. 0.1 mA.

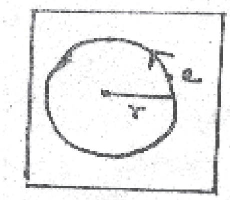
(B) 1.



A & B are circular metallic disc of diameter about 22cm aranged parallel to each other at a distance 1.5 cm. At the center of the upper dis.

- P is an atomizer with the help of which a liquid can be sprayed.
- The region bet^n the hoo plates can be illuminated with a light source S. The shinning drop of liquid can be observed with the help of a telescope T.

2. A showin Fig. electron moving around the nucleus in a hydrogen atom suppose



M = mass
r = radius of the orbit of electron
v = linear velocity resp.
e = value of charge on 1 electron
Ze = Change of the nucleus.

$$\therefore \frac{Mv^2}{r} = \frac{1}{4\pi \in_0} \frac{Zc^2}{r^2} \qquad .... 1$$

$\in_O$ = the permittivity of vaccum.
Acc to Bohr's first postulate.

$$Mvr = \frac{nh}{2\pi}, \text{ n = 1,2, 3.............}$$

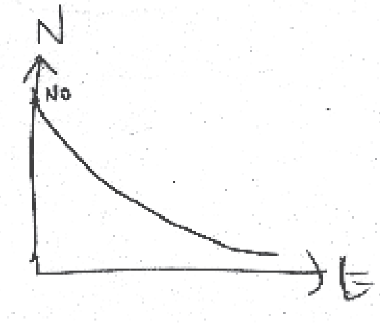
Principle quantum Number

$$M^2V^2r^2 = \frac{n^2h^2}{4\pi^2} \qquad .... 3$$

Eliminating V from equation

$$r = \frac{n^2h^2 \in 0}{M\pi Ze^2} \qquad .... 4$$

3. Instantaneous activity of a radioactive element



$$\frac{dN}{dt} = -\lambda N \qquad .... 1$$

λ = radioactive constant of given element.

$$\therefore \frac{dN}{dt} = -\lambda dt$$

Integrating on both sides,

$$\ell nN = -\lambda t + C \qquad .... 2$$

C = Constant of integration

Now N = No at t=0

we get

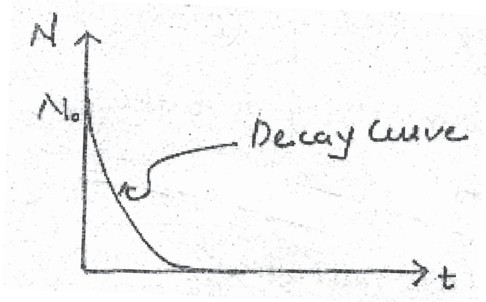
$$\ell nN = C \qquad .... 3$$

$$\ell nN = \lambda t + \ell nNo$$

$$\ell nN - \ell No = -\lambda t$$

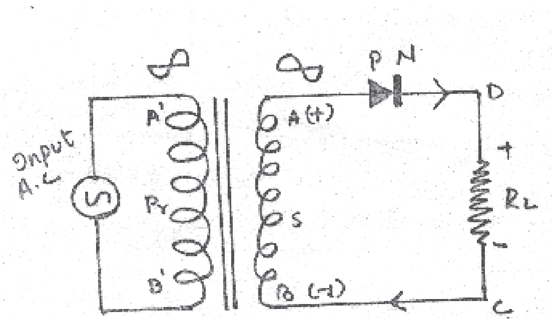
$$N = Noe^{-\lambda t}$$

$$I = Ioe^{-\lambda t} \qquad .... 4$$

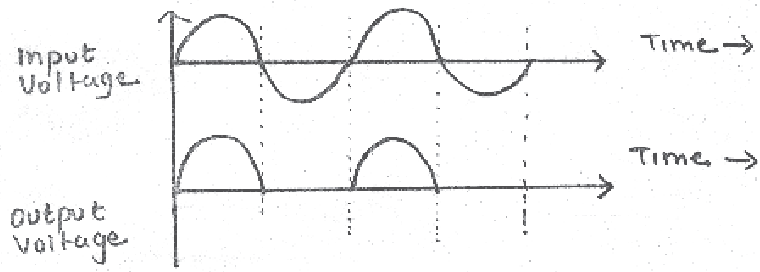


Equation [4] is called the exponential law of radioactive dis integration. The graph of N $\rightarrow$ t is shown in fig. which is called decen / culve.

4.



- The primary coit of a lense former is connected to the source of A.C. Voltage (Mains). One of the terminals of the secondary coil (Scy A) is connected to the anode and the terminal B to the cathode via the resistor RL working.



(C) 1. $E = nhf = nh\dfrac{c}{\lambda}$

$$n = \frac{E\lambda}{hc} = \frac{5}{3} \times 10^{34-15}$$

$= 1.66 \times 10^{17}$ Photons

2. $\dfrac{Mv^2}{r} = \dfrac{1}{4\pi \in 0}\dfrac{Ze^2}{r^2}$ For Z = 1 hydrogen atom.

$$\frac{Mr^2w^2}{r} = \frac{1}{4\pi \in 0}\frac{Ze^2}{r^2}$$

$$\omega^2 = \frac{1}{4\pi \in 0}\frac{Ze^2}{mr^3} \quad \text{........... 1}$$

Now $Mrv = \frac{nh}{2\pi}; mr^2\omega = \frac{nh}{2\pi}$

$r^2 = \frac{nh}{2\pi m\omega}$

$r^3 = \left[\frac{nh}{2\pi m\omega}\right]^{3/2}$

Putting this in Eq. (1) we get

$\omega = \frac{4\pi me^4}{2 \in_o^2 n^3h^3}$

3. $\frac{dN}{dt} = \lambda N$ (-ve sign ignored)

$\lambda = \frac{\frac{dN}{dt}}{N} = \frac{8000}{8 \times 10^7} = 10^{-4}\, Sec^{-1}$

$\overline{C}_{\frac{1}{2}} = \frac{0.693}{\lambda} = \frac{0.693}{10^{-4}} = 6930 Sec.$

4. Given $\delta V_{BE} = 25$ milivolt

$= 25 \times 10^{-3}$ volt

$\delta Ic = 4.5$ Mili Amp. = 4.5×10^{-3} Amp.

gm = ?

$Av = -\frac{Rl\delta Ic}{\delta V_{BE}}$ $A_v = -g_m R_L$

$g_m = -\frac{\delta Ic}{\delta V_{BE}} = \frac{4.5 \times 10^{-3}}{25 \times 10^{-3}} = 0.18$ Mho.

g_m = 0.18 mho.

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