HSC - BOARD - 2015

Date: 26.02.2015

PHYSICS (54) - SOLUTIONS

SECTION - I

Q.1

(i) (c) $4\pi\sqrt{\dfrac{l\cos\theta}{4g}}$ **(1)**

(ii) (c) Distribution of mass and angular speed **(1)**

(iii) (b) remain same **(1)**

(iv) (a) straight line with positive slope **(1)**

(v) (a) compression reflects as a compression **(1)**

(vi) (d) $\left[L^3 M^{-1} T^{-2}\right]$ **(1)**

(vii) (b) 1 : 4 **(1)**

Q.2

(i) Acceleration of a particle,

$$a = \lim_{\delta t \to 0}\left(\frac{\delta v}{\delta t}\right) \text{........ } \delta t \to 0 \text{ ; } \delta t \neq 0$$

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

But , $v = r\omega$

$$\therefore a = \frac{d}{dt}(r\omega)$$

$$= r\frac{d\omega}{dt} + \omega\frac{dr}{dt}$$ **(1/2)**

$\because r$ is constant

$$\frac{dr}{dt} = 0$$

$$\therefore\ a = r\frac{d\omega}{dt}$$

$\because \frac{d\omega}{dt} = \alpha$

$a = r\alpha$ **(1/2)**

Now, we have

$\bar{v} = \bar{\omega} \times \bar{r}$

differentiating w.r.t. time

$$\frac{d\bar{v}}{dt} = \frac{d}{dt}(\bar{\omega} \times \bar{r})$$

$$\frac{d\bar{v}}{dt} = \frac{d\bar{\omega}}{dt} \times \bar{r} + \bar{\omega} \times \frac{d\bar{r}}{dt}$$

$$\frac{d\bar{v}}{dt} = \bar{\alpha} \times \bar{r} + \bar{\omega} \times \bar{v}$$ **(1/2)**

$\therefore \bar{a} = \bar{a}_T + \bar{a}_r$

Where

$\bar{a}_T$ is the tangential component and $\bar{a}_r$ is the radial component of acceleration. **(1/2)**

(ii) The force with which a body is attracted towards the centre of the earth is the weight of the body. Weightlessness in a moving satellite is a feeling. It is not due to weight equal to zero.When an astronaut is on the surface of the earth gravitational force acts upon him, this gravitational force is the weight of the astronaut. The earth's surface exerts upward reaction on the astronaut and due to this the astronaut feels his weight on the earth. **(1/2)**

When an astronaut is in an orbiting satellite, a gravitational force still acts upon him. However, in this case due to circular motion there is a centripetal acceleration. This centripetal acceleration is equal to the acceleration due to gravity at the height at which the satellite is revolving. So both the astronaut as well as the satellite have the same acceleration towards the centre of the earth equal to the acceleration due to the gravity at the height at which the satellite is revolving. **(1/2)**

Therefore, the force exerted by the astronaut on the floor of the satellite is equal to zero i.e., the astronaut doesn't produce any action on the floor of the satellite. At the same time the floor of the satellite doesn't exertany reaction on the astronaut. Due to the absence of this force of reaction on the astronaut, the astronaut has feeling of weightlessness even though the gravitational force acts on him. This explains the feeling of weightlessness of as astronaut in an orbiting satellite. **(1)**

(iii) **Principle of Parallel axes theorm:** According to the principle of parallel axes theorem of moment of inertia, the moment of inertia of a body about an axis is equal to the sum of (i) it moment of inertia about a parallel axes through its centre of mass and (ii) the product of the mass of the body and the square of the distances between two axes. **(1)**

Principle of perpendicular axis theorem : According to the principle of perpendicular axis theorem of moment of inertia, the moment of inertia of a plane lamina about an axes perpendicular to its plane is equal to sum of its moments of inertia about two mutually perpendicular axes in its plane and meeting in the point where the perpendicular axes cuts the lamina. **(1)**

(iv) (a) **Wien's displacement law:** The wavelength (λ_m) emitted with maximum intensity by a black body is inversely proportional to its absolute temperature (T).

$$\lambda_m \propto \frac{1}{T}$$ **(1)**

(b) **First law of thermodynamics:** The energy (ΔQ) supplied to the system goes in partly to increase the internal energy of the system (ΔU) and the rest in work on the environment (ΔW).

Mathematically, $\Delta Q = \Delta U + \Delta W$ **(1)**

(v) **Given :**

$T = 2\sec$

$A = 10\ cm$

$x = 4$

To find : accelaration = ?

Formula: $a = -\omega^2 x$ **(1)**

Solution :

$a = -\omega^2 x$

$= -\left(\frac{2\pi}{T}\right)^2 x$

$= -\left(\frac{2 \times 3.14}{4}\right)^2 \times 6 \times 10^{-2}$ **(1/2)**

$= 9.8596 \times 6 \times 10^{-2}$

$\therefore\ a = 0.0591\ m/s^2$ **(1/2)**

(vi) **Given:**

$T_0 = 75.5\ dyne/cm$

$\alpha_{water} = 2.7 \times 10^{-3}\ {}^0C^{-1}$

To find : Surface tension of water at 25° = ?

Formula: $T_1 = T_0(1 - \alpha\Delta t)$ **(1)**

Solution :

Surface tension of water at 25^0 is,

$T_{25} = T_0(1 - \alpha\Delta t)$

$T_{25} = T_0(1 - \alpha(25 - 0))$ **(1/2)**

$= 75.5(1 - 2.7 \times 10^{-3} \times 25)$

$= 75.5(1 - 0.0675)$

$T_{25} = 70.40\ dyne/cm$ **(1/2)**

(vii) **Given:**

$n_1 = 15\ r.p.s$

$n_2 = 5\ r.p.s$

To find : angular accelarations $\alpha = ?$

Formula : $\alpha = \dfrac{\omega_2 - \omega}{t}$ **(1)**

Solution:

After 50 rerevolution $T = \dfrac{1}{50} = 0.02s.$

$\omega_1 = 2\pi n_1$

$\omega_2 = 2\pi n_2$

$$\alpha = \frac{\omega_2 - \omega}{t} \quad \textbf{(1/2)}$$

$$= \frac{2\pi\, n_2 - 2\pi n_1}{t}$$

$$= 2\pi \frac{(n_2 - n_1)}{t}$$

$$= \frac{6.25\,(15-5)}{0.02}$$

$$= \frac{6.25 \times 10}{0.02}$$

$$= 3140\ rad/s^2 \quad \textbf{(1/2)}$$

(viii) **Given:**

$\dfrac{r_{jupiter}}{r_{earth}} = 5$

$T_{earth} = 1$

To find : $T_{jupiter} = ?$ **(1)**

Formula: $T^2 \propto r^3$

Solution :

According to Kepler's Law,

$T^2 \propto r^3$

$T = kr^{3/2}$ .... k is constant

$$\therefore \frac{T_{jupiter}}{T_{earth}} = \left(\frac{r_{jupiter}}{r_{earth}}\right)^{3/2} \quad \textbf{(1/2)}$$

$$\therefore T_{jupiter} = T_{earth} \times (5)^{3/2}$$

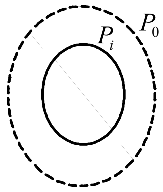
$$= 1\,year \times 5\sqrt{5} \qquad \therefore T_{jupiter} = 5\sqrt{5}\ years = 11.58\ years \quad \textbf{(1/2)}$$

Q.3

(i) Due to surface tension free liquid drops are spherical. Therefore the inside pressure will be greater than that of outside. Let outside perssure be P_0 and inside pressure be P_i, so that the excess pressure is $P_0 - P_i$.

Let radius of the drop increases from r to $r + \Delta r$. Δr is very small, so that inside pressure remains almost constant.

Initial surface area $A_1 = 4\pi r^2$. Final surface area $A_2 = 4\pi(r + \Delta r)^2$



$\therefore\ A_2 = 4\pi(r^2 + 2r\Delta r + \Delta r^2) = 4\pi r^2 + 8\pi r\Delta r + 4\pi\Delta r^2$

As Δr is very small, Δr^2 is neglected

$\therefore\ 4\pi\Delta r^2 = 0$

$\therefore\ A_2 = 4\pi r^2 + 8\pi r\Delta r$ **(1)**

Increase in surface area $= A_2 - A_1 = 4\pi r^2 + 8\pi r\Delta r - 4\pi r^2$

$\therefore$ Increase in surface area $= dA = 8\pi\, r\Delta r$

Work done to increase the surface area is extra surface energy.

$\therefore\ dW = TdA$

$\therefore dW = T(8\pi r\Delta r)$ .... (1)

This work done is also equal to product of force and the distance Δr

Excess force = Excess pressure $\times$ area

$\therefore\ dF = (P_i - P_0)4\pi r^2$

The increase in radius of drop is Δr.

$\therefore dW = dF\Delta r$ .... (2) **(1)**

From equation (1) and (2)

we get $T(8\pi r\Delta r) = (P_i - P_0)4\pi r^2\Delta r$

$\therefore\ P_i - P_0 = \dfrac{2T}{r}$ **(1)**

(ii) Whenever there is relative motion between a listener and source of sound, the pitch of the note heard by the listener is different from actual pitch of the note emitted by the source of sound. The apparent pitch is higher than the actual pitch when the distance between the source and listener is decreasing where as lower than the actual pitch when the distance between the source and listener is increasing. This effect is called as the Doppler Effect. **(1)**

The modified frequency heard by listener can be determine using following formulae

N be original frequency,

N' be modified frequency heard by listener.

V be velocity of sound,

V_0 be velocity of listener and V_s be velocity of source.

(a) When listener is moving towards stationary source of sound $N' = \left(\dfrac{V + V_0}{V}\right)N$

(b) When listener is moving away from stationary source of sound $N' = \left(\dfrac{V - V_0}{V}\right)N$

(c) When source of sound in moving towards stationary listener $N' = \left(\dfrac{V}{V - V_s}\right)N$

(d) When source of sound is moving away from stationary listener $N' = \left(\frac{V}{V+V_s}\right)N$

(e) When both are moving toward each other $N' = \left(\frac{V+V_0}{V-V_s}\right)N$

(f) When both are moving away from each other $N' = \left(\frac{V-V_0}{V+V_s}\right)N$. **(1)**

Application:

(1) Doppler effect is useful in echocardiography and ultrasonic study of blood vessel flow.

(2) It is useful to measure speeds of cars, aero planes, artifical satellite etc.

(3) Sonar pulses are used to estimate the speeds of submarines, shark fish etc.

(4) It is used to study circulatory motion. **(1)**

(iii) **Given:**

$T = 300\,k$

$R = 8320\ J/k\,mole\ K.$

$N = 6.03 \times 10^{2}\ molecules/K\ mole$

To find : (a) K.E per kilomole = ?

(b) K.E per kilogram = ?

Formula :(a) $KE/kilomole = \frac{3}{2}\frac{RT}{1000}$

(b) $KE/kg = \frac{3}{2}\frac{RT}{mass\ of\ O_2 \times 1000}$ **(1)**

Solution :

(a) $KE/kilomole = \frac{3}{2}\frac{RT}{1000}$

$$= \frac{3}{2} \times \frac{8.314 \times 10^{7} \times 3 \times 10^{2}}{1000}$$ **(1/2)**

$$= \frac{3}{2} \times 3 \times 8.314 \times 10^{6}$$

$$= \frac{9 \times 8.314}{2} \times 10^{6}$$

$$= 9 \times 4.157 \times 10^{6}$$

$$= 3.7413 \times 10^{6}\ J/kM$$ **(1/2)**

(b) $KE/kg = \frac{3}{2}\frac{RT}{mass\ of\ O_2 \times 1000}$ **(1/2)**

$= \frac{3.7414 \times 10^6}{32}$ **(1/2)**

$= 0.1169 \times 10^6$

$= 1.169 \times 10^5\ J/kg$ **(1/2)**

(iv) **Given:**

$A = 5\,mm^2 = 5 \times 10^{-6}\,m$

$T_1 = 0°C \quad and \quad T_2 = 25°C$

To find : Strain : ?

Formula : $Strain = \frac{F}{A \times Y}$ **(1)**

Solution :

$F = Y.\alpha \times \Delta\theta.A$

$= 20 \times 10^{10} \times 12 \times 10^{-6} \times 25 \times 5 \times 10^{-6}$ **(1/2)**

$F = 300\,N$

$Strain = \frac{F}{A \times Y}$ **(1/2)**

$= \frac{300}{5 \times 10^{-6} \times 20 \times 10^{10}}$

$= \frac{300}{5 \times 20} = 3 \times 10^{-4}\,m$ **(1)**

Q.4 **Forced vibrations:** If a body is made to vibrate, by an external periodic force, with a frequency which is different from natural frequency of the body, the vibration is called the forced vibrations. **(1/2)**

Resonance: If a body is made to vibrate, by an external periodic force, with a frequency which is same as the natural frequency of the body, the body begins to vibrate with a very amplitude. This phenomenon is called resonance. **(1/2)**

Consider vibrating air coloumn in a pipe closed at one end::

Stationary waves are produced due to superposition of two identical simple harmonic progressive waves travelling through the same part of the medium in opposite direction. In this case, the molecules of air in contact with closed end remains at rest. Therefore closed end becomes node, the air molecules near the open end are free to vibrate, and hence they vibrate with maximum amplitude.

Therefore the open end becomes as antinode.

The simplest mode of vibration is the fundamental mode of vibration. (figure A) in this case one node and one antinode are formed. If λ_1 be the corresponding wavelength and L be length of the pipe

$\therefore \; L = \lambda_1 / 4$

$\therefore \; \lambda_1 = 4L$

If 'n_1' be corresponding frequency and 'v' be velocity of sound in air $v = n_1\lambda_1$

$\therefore\ n_1 = v/\lambda_1$

$\therefore\ n_1 = v/4L$ .... (1) **(1/2)**

This is called 1st harmonic.

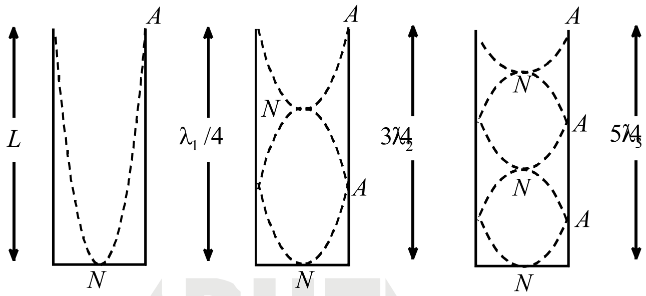
The next possible mode of vibration is called 1st overtone (figure b)

In this case two nodes and two antinodes are formed.

If λ_2 and n_2 be the corresponding wavelength and frequency,

$L = 3\lambda_2/4$ $\therefore\ \lambda_2 = 4L/3$. But $v = n_2\lambda_2$ i.e., $n_2 = v/\lambda_2$

$\therefore\ n_2 = 3v/4$. This is called 3rd harmonic. **(1/2)**



(A) (B) (C)

The next possible mode of vibration is caled 2nd overtone. (figure c)

In this case wavelength and frequency, $L = 5\lambda_3/4$ $\therefore\ \lambda_3 = 4L/5$. But $v = n_3\lambda_3$ i.e., $n_3 = v/\lambda_3$

$\therefore\ n_3 = 5v/4L$. This is called 5th harmonic.

$n_1 : n_2 : n_3 :: 1:3:5$. Hence in a closed pipe at 1 end only odd harmnics are present. **(1)**

Problem:

Given :

$n_1 = 256\ Hz$

$\Delta l = 10\,cm$

$n_2 = 320\,Hz$

To Find : $l = ?$

Formula : $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$ **(1)**

Solution :

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$$256 = \frac{1}{2l}\sqrt{\frac{T}{m}} \qquad ......(i)$$

according to 2nd condition

$$320 = \frac{1}{2(l-0.1)}\sqrt{\frac{T}{m}} \qquad ......(ii)$$ **(1)**

Equation (i) / (ii)

$$\frac{252}{320} = \frac{l-0.1}{l}$$

$\therefore 0.8\,l = l - 0.1$

$\therefore 0.1 = l - 0.8l$

$\frac{1}{10} = \frac{10l - 8l}{10}$

$\therefore\ l = 0.5\ m$

$\therefore$ original length is 50 cm. **(1)**

OR

Problem:

Given:

$n_1 = 100\ r.p.m$

$m = 20\,gm$

$r = 5\,cm$

$I_1 = 2 \times 10^{-4}\ kg\,m^2$

To find: $n_2 = ?$

Formula : $I_1\omega_1 = I_2\omega_2$ **(1)**

Solution:

$I_1\omega_1 = I_2\omega_2$

$I_1\ 2\pi n_1 = I_2\ 2\pi n_2$

$I_2 = I_1 + mr^2$

$\therefore I_1 n_1 = \left(I_1 + mr^2\right) n_2$ **(1/2)**

$I_1 n_1 - I_1 n_2 = mr^2 n_2$

$I_1\left(n_1 - n_2\right) = mr^2 n_2$

$n_1 - n_2 = \frac{mr^2 n_2}{I_1}$

$n_1 - n_2 = \frac{20 \times 10^{-3} \times 25 \times 10^{-4}\,n_2}{2 \times 10^{-4}}$

$= 250 \times 10^{-3} \times n_2$

$n_1 - n_2 = 0.25 n_2$

$n = n_2 + 0.25\,n$

$n_1 = 1.25\ n_2$ **(1/2)**

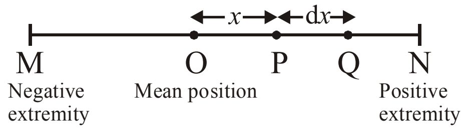
$100 = 1.25\ n_2$

$\frac{100}{1.25} = n_2$

$n_2 = 80\ r.p.m.$ **(1)**

OR

Expression for potential energy :



When a particle of mass m performing S.H.M is at any displacement x, the restoring force acting on it is given by

$F = -kx$ ...(i) **(1/2)**

Let dx be the small displacement given to the particle against the force

$\therefore \quad dW = Fdx \cos\theta = -Fdx$

$\theta = 180°$

$\therefore \quad dW = kx.dx$

$\therefore$ Total work done $= W \int_0^x dW = \int_0^x kx\,dx = k\int_0^x x\,dx = k\left[\frac{x^2}{2}\right]_0^x$ **(1/2)**

$\therefore \quad W = \frac{1}{2}kx^2$

This is the potential energy.

$\therefore \quad P.E = \frac{1}{2}kx^2$ **(1/2)**

But $k = m\omega^2$

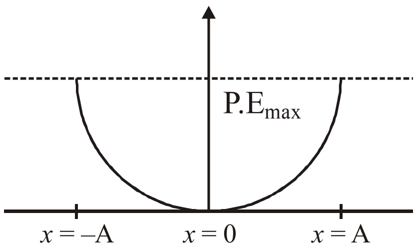
$\therefore \quad P.E = \frac{1}{2}m\omega^2 x^2$ **(1/2)**

At mean position $x = 0$

$\therefore \quad P.E = 0$

At extreme position $x = \pm A$

$\therefore P.E = \frac{1}{2}kA^2 = \frac{1}{2}m\omega^2 A^2$ **(1)**



(1)

SECTION - II

Q.5

(i) (a) $\frac{\sigma}{\in_0}\left[\frac{R}{r}\right]^2$ **(1)**

(ii) (c) Potentiometer **(1)**

(iii) (c) more than 2 times **(1)**

(iv) (b) $\frac{1}{n}$ **(1)**

(v) (b) indium **(1)**

(vi) (d) $\left(\frac{l}{\lambda}\right)^2$ **(1)**

(vii) (c) 25×10^{-7} m **(1)**

Q.6

(i) **POLAROID :** It is a large sheet of synthetic material packed with tiny crystal of a dichroic substance oriented parallel to one another, so that it transmit light only in one direction of the electric vector. **(1)**

Uses of Polaroid : **(1)**

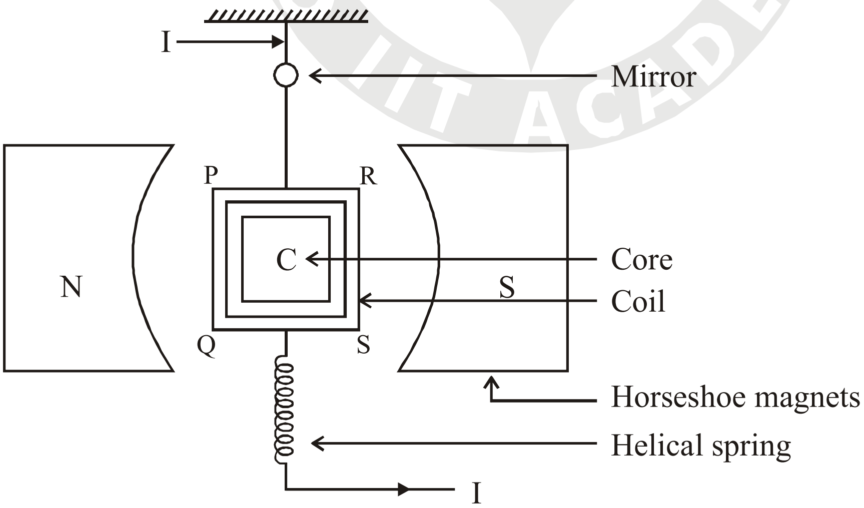
(a) In three dimension movie cameras.

(b) In motor car head lights to remove headlight glare.

(c) In polarizing sunglasses to protect the eyes from glare of sunlight.

(d) They are used to improve colour contrast in old oil painting.

(ii) **Labelling - (1 mark) Diagram : (1 mark)**



(2)

(iii) (a) **Magnetization :** The net magnetic dipole moment per unit volume. **(1/2)**

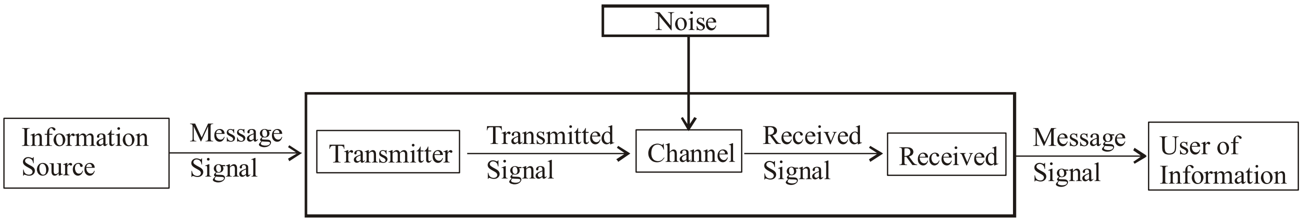
$$M_z = \frac{M_{net}}{volume}$$ **(1/2)**

(b) **Magnetic Intensity :** The strength of magnetic field at a point in terms of vector quantity is called magnetic intensity. It is denoted by H. **(1/2)**

$$\boxed{H = \frac{B_0}{\mu_0}}$$ **(1/2)**

(iv) **Block diagram of generalized communication system :** **(2)**

Labelling - (1 mark) **Diagram : (1 mark)**



(v) Given: **(1/2)**

$l = 3.142\ m$

$d = 5\ cm;\ r = 1.5\ cm = 2.5 \times 10^{-2}\ m$

$n = 2 \times 500$ turns

$I = 5A$

$B = \mu_o nI$ **(1/2)**

$= \mu_o \left(\dfrac{N}{L}\right) I$ **(1/2)**

$= \dfrac{4\pi \times 10^{-7} \times 1000 \times 5}{3.142}$

$= 2 \times 10^{-3}\ T$ **(1/2)**

(vi) Given: **(1/2)**

$n = 300\ turns$

$A = 5 \times 10^{-3} m^2$

$I = 15\ A$

Magnetic moment,

$M = nIA$ **(1/2)**

$= 300 \times 5 \times 10^{-3} \times 15$ **(1/2)**

$M = 22.5\ Am^2$ **(1/2)**

(vii) $\phi = \left(8t^2 + 6t + C\right) \times 10^{-3}\ wb$ **(1/2)**

induced e.m.f,

$e = \dfrac{d\phi}{dt}$

$= \dfrac{d}{dt}\left(8t^2 + 6t + C\right) \times 10^{-1}$ **(1/2)**

$e = \left(16t + 6\right) \times 10^{-3}$

at $t = 2$ sec **(1/2)**

$e = \left(16 \times 2 + 6\right)$

$= 38 \times 10^{-3} V$

$e = 38\, mV$ **(1/2)**

(viii) Given: **(1/2)**

$E_g = -13.6\ eV$

$E_5 = ?$

$E_n = \frac{E_g}{n^2}$ **(1/2)**

For 5^{th} orbit ionisation energy is,

$E_5 = -\frac{13.6}{5^2}$ **(1/2)**

$= -\frac{13.6}{25}$

$= 0.544\, eV$

$E_{5(ionisation)} = E_\infty - E_5$

$= 0.000 - (-0.544)$

$\therefore E_5 = 0.544\, eV$ **(1/2)**

Q.7

(i) Expression for radius:

Consider the electron of mass *m* having charge –e and moving with velocity *v* in n^{th} orbit. **(1/2)**

According to Bohr's 1st postulate

$$\frac{e^2}{4\pi \in_o r_n^2} = \frac{mv_n^2}{r_n}$$

$$\therefore v_n^2 = \frac{e^2}{4\pi \in_o mrn} \qquad \text{.........(I)}$$ **(1/2)**

According to Bohr's 2nd postulate

$$mv_n r_n = \frac{nh}{2\pi}$$

$$\therefore v_n^2 = \frac{n^2h^2}{4\pi^2 m^2 r_n^2} \qquad \text{........(II)}$$ **(1/2)**

From I and II **(1/2)**

$$\frac{n^2h^2}{4\pi^2 m^2 rn_n^2} = \frac{e^2}{4\pi \in_o mr_n}$$

$$\therefore r_n = \frac{n^2 h^2 \in_o}{\pi me^2}$$

$$\therefore r_n = \left(\frac{h^2 \in_o}{\pi me^2}\right) n^2$$

Thus the radius of Bohr's orbit varies with square of its quantum number. **(1/2)**

(ii) α & β parameters are current ratios.

α_{dc} : It is the ratio of collector current to emitter current. **(1/2)**

$\therefore\ \alpha_{dc} = I_c / I_E$ **(1/2)**

β_{dc} : It is ratio of collector current to base current. **(1/2)**

$$\beta_{dc} = \frac{I_C}{I_B}$$ **(1/2)**

Relation between α_{dc} & β_{dc}

$I_E = I_B + I_C$

Divide through out by I_c

$$\therefore\ \frac{I_E}{I_C} = \frac{I_B}{I_C} + 1$$

$$\frac{1}{\alpha_{dc}} = \frac{1}{\beta_{dc}} + 1$$ **(1/2)**

$$\therefore\ \boxed{\alpha_{dc} = \frac{\beta_{dc}}{1+\beta_c}}$$ **(1/2)**

$$\boxed{\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}}}$$

(iii) **Data given and Unit conversions:** **(1)**

$\sigma_1 = 5\,\mu c/m^2 = 5 \times 10^{-6}\ c/m^2$ $\quad\therefore q_1 = \sigma_1\ 4\pi r_1^2$

$\sigma_2 = -2\,\mu c/m^2 = -2 \times 10^{-6}\ c/m^2$ $\quad\therefore q_2 = \sigma_2 4\pi r_2^2$

$r_1 = 2\,mm = 2 \times 10^{-3} m$

$r_2 = 1\ mm = 1 \times 10^{-3} m$

To find: **(1/2)**

$q = ?$

Formula :

$q = q_1 + q_2$ **(1/2)**

Solution:

$$q = q_1 + q_2$$

$$= 4\pi\left(\sigma_1 r_1^2 + \sigma_2 r_2^2\right)$$

$$= 4\pi\left(5 \times 10^{-6} + 4 \times 10^{-6} \times (-2 \times 10^{-6})\right)$$

$$\therefore q = 72\,\pi \times 10^{-12}\ C$$ **(1)**

(iv) **Data given and Unit conversions:** **(1)**

$\lambda_o = 3800\ \AA$

$= 38 \times 10^{-8}\ m$

$\lambda = 2600\ \AA$

$= 26 \times 10^{-8} m$

To find KE_{max} : **(1/2)**

Formula:

$$KE = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_o}\right)$$ **(1/2)**

Solution :

$$KE = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_o}\right)$$

$$= 6.63 \times 3 \times 10^{8} \times 10^{-34}\left(\frac{1}{26 \times 10^{-8}} - \frac{1}{38 \times 10^{-8}}\right)$$

$$= 6.63 + 3 \times 10^{-26}\left(\frac{38 - 26}{26 \times 38}\right) \times 10^{8}$$

$$= 19.89 \times \frac{12}{988} \times 10^{8} \times 10^{-26}$$

$$= 0.12078 \times 10^{-18} J$$

$$= 0.2415 \times 10^{-18} J$$

$$= \frac{0.2415 \times 10^{-18+19}}{1.6}$$

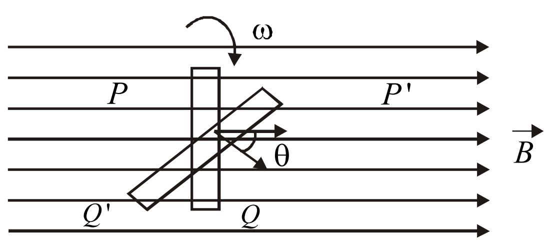
$$= 1.5\, eV$$ **(1)**

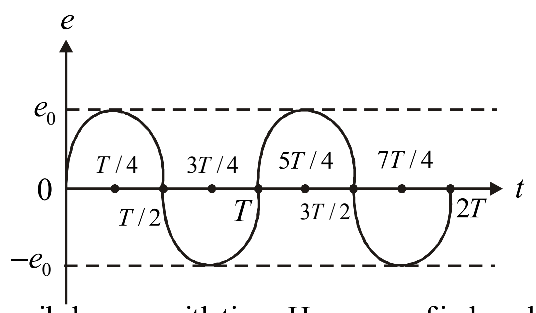
Q.8

(i) Consider a conducting coil of N turns and area A rotating with an uniform angular velocity ω about an axis in the plane of the coil and perpendicular to uniform magnetic induction B. At time t = 0, the coil is in position PQ.

$\therefore$ Flux through the coil is maximum. In time 't' the coil rotates through an angle θ and takes up the position P'Q'. In this position flux through the coil is $\phi = NBA\cos\theta$. But

$$\theta = \omega t \quad \therefore \phi = NBA\cos\omega t.$$ **(1)**





(1)

As coil rotates, the magnetic flux through the coil changes with time. Hence e.m.f induced in the coil is given by

$$e = -\frac{d\varphi}{dt} \therefore e = -\frac{d}{dt}(NAB\cos\omega t) \therefore e = -NBA\frac{d}{dt}(\cos\omega t)$$

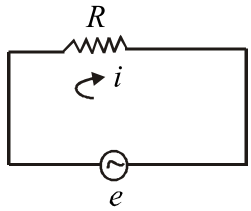
$$e = NBA\omega\sin\omega t$$

From this formula, it is clear that the induced e.m.f. is not constant. It is sine function. Hence it is called sinusoidal e.m.f. Such a e.m.f. is called an alternating e.m.f. Let $e_0 = NBA\omega \therefore e = e_0 \sin\omega t$.

The maximum value is called peak value of e.m.f. it is equal to $e_0 = NBA\omega$ **(1)**

The variation of e.m.f. with time is as shown in fig. The frequency of a.c. e.m.f. is same as frequency of coil.

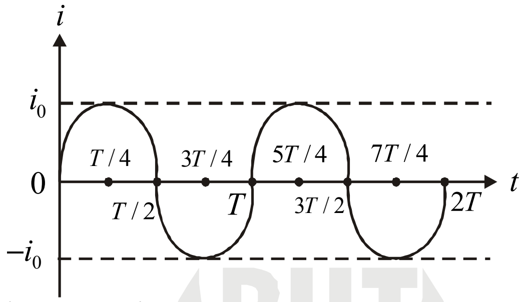
If such is connected across any resistance, the current in the circuit will be 'i'



$\therefore$ By ohm's law $e = iR \therefore iR \therefore iR = e_0 \sin \omega t$

$\therefore i = \frac{e_0}{R} \sin \omega t \quad \therefore i = i_0 \sin \omega t$, where $i_0 = \frac{e_0}{R}$ **(1)**

$\therefore$ A.C. current is also sinusoidal. The variation of current with time is as shown in fig.



(1)

(ii) **Data given and Unit conversions:** **(1)**

$E_1 = 1.5\ V,\ R = 0.1\ \Omega / cm = 0.1 \times 10^{-2}\ \Omega / m = 10\ \Omega / m$

$l_1 = 300\ cm = 3m$

$E_2 = 1.4\ V$

To Find : **(1/2)**

$l_2 = ?$

$I = ?$

Formula :

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$ **(1/2)**

Solution:

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\frac{1.5}{1.4} = \frac{3}{l_2}$$

$$l_2 = \frac{3 \times 1.4}{1.5}$$

$$= 2.8\ m$$

Total resistance $= 2.8 \times 10\ m$

$= 28\ \Omega$ **(1/2)**

Current $= I = \frac{V}{R} = \frac{1.4}{28} = 0.05\ A$ **(1/2)**

OR

(i) (a) This experiment is used in the laboratory to measure the wavelength of monochromatic light.

(b) Apparatus consist of Monochromatic source (sodium lamp), optical bench, lens, micrometer, biprism etc.

(c) A narrow vertical slit S is illuminated by a source of monochromatic light. The biprism B is placed close to the slit S.

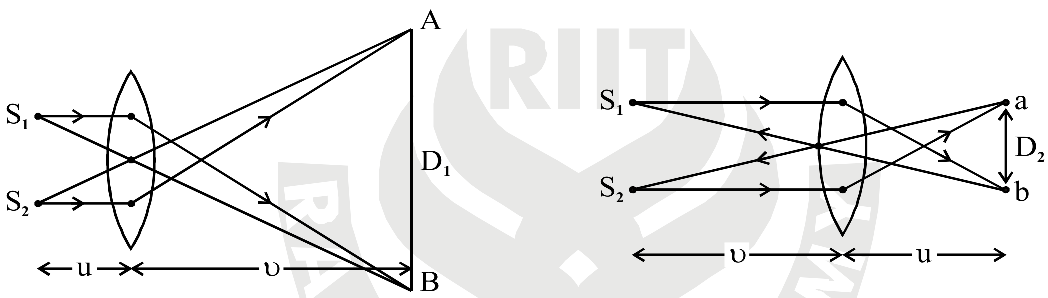
(d) When light from S falls on the refracting edge of the prism then due to refraction, two virtual images S_1 and S_2 of the slit S are formed.

(e) The eye piece (E) carrying micrometer is kept at large distance from the biprism. The interference pattern is observed through (E).

(f) To measure the band width, a vertical cross wire of the micrometer is adjusted on one bright band and the micrometer reading is noted.

(g) Similarly the cross wire is adjusted on next bright bands and the corresponding micrometer readings are noted. The difference gives the band widths.

Determination of *d* : **(1)**



(1)

(h) Conjugate foci method is used in the determination of d. A convex lens (L) of suitable focal length is fixed between the biprism and eye piece on the optical bench.

(i) The convex lens is move towards the slit, the distance between them is measured as d_1. When the convex lens is move away from the slit the diminished images of S_1 and S_2 are seen and thedistance between them is measured as d_2. Therefore, the distance between S_1 and S_2 is given by the formula,

$d = \sqrt{d_1 d_2}$ **(1/2)**

Since, band width is given by $X = \dfrac{\lambda D}{d}$ **(1/2)**

$$\lambda = \frac{Xd}{D}$$ **(1/2)**

Substituting the value of $d = \sqrt{d_1 d_2}$

$$\lambda = \frac{X\sqrt{d_1 d_2}}{D}$$ **(1/2)**

Putting value of X, d_1, d_2 and D wavelength can be measured exactly.

(ii) **Given :** **(1/2)**

$$\mu = \sin^{-1}\left(\frac{3}{5}\right)$$

To find : $i_p = ?$ **(1/2)**

Formula :

$$\mu = \tan i_p$$ **(1/2)**

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

Solution:

$$\mu = \tan i_p$$ **(1/2)**

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

$$\therefore \quad \mu = \frac{1}{\frac{3}{5}} = \frac{5}{3} = 1.667$$ **(1/2)**

$$\therefore \quad i_p = \tan^{-1}(1.667)$$

$$\therefore \quad i_p = 59°2'$$ **(1/2)**