Set – I Std. – 12th HSC	Subject – Physics	Model Answer

Section – A

Q.1 Select and write the correct answer.

i) 1. the molar specific heat at constant pressure is the same for all gases.

ii) 4. Adiabatic

iii) 2. I/ω

iv) 3. Directly proportional to the square root of tension

v) 4. Harmonics

vi) 3. Holes and electrons recombine

vii) 2. Surface tension

viii) 2. 1:2

ix) 1. $6X10^{14}$Hz

x) 3. 32

Q.2 Answer the following.

i) The force of attraction between the molecules of the same substance is called cohesive force

ii) The laws of Boyle, Charles, and Gay-Lussac are strictly valid for real gases, only if the pressure of the gas is not too high and the temperature is not close to the liquefaction temperature of the gas.

iii) When two objects are at the same temperature, they are in thermal equilibrium.

iv) Time taken by simple pendulum to move from one end to the other is $T/2$ second.

Given : T/2 = ¼

∴ T = ½ second

∴ Frequency, n = 1/ T = 2 Hz

v) i. Kirchhoff's current law is based on the law of conservation of charge.

ii. Kirchhoff's voltage law is based on the law of conservation of energy.

vi) The ratio of magnetization to magnetic intensity indicates magnetic susceptibility (x).

vii) $F = \eta A \frac{dv}{dx}$

$dx = \eta A \frac{dv}{dx} = 0.01 \times 100 \times \frac{10}{200} = 0.05$ cm

viii) Dielectric polarization is the term given to describe the behaviour of a material when an external electric field is applied to it. It occurs when a dipole moment is formed in an insulating material because of an externally applied electric field.

Section – B

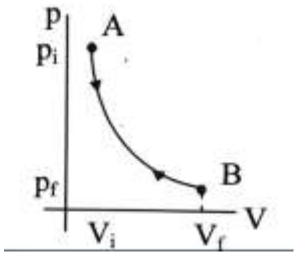
Attempt *any eight* :

Q.3 i. When the chip of the rim of a flywheel revolving with a constant angular velocity breaks away, its mass will decrease.

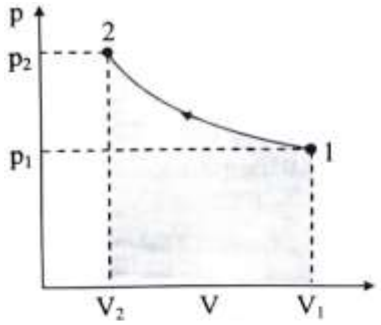
ii. Due to the decrease in its mass, the moment of inertia of the flywheel will decrease.

iii. In order to conserve angular momentum, the angular velocity of the flywheel will increase.

Q.4 p-V diagram of the reversible process:



Q.5 p-V diagram showing negative work with varying pressure:



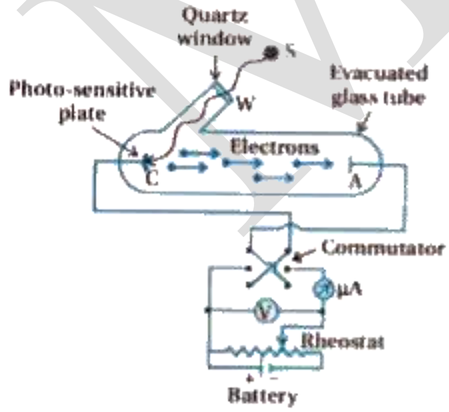
Q.6

Sr. no	Harmonic	Overtone
1	The first harmonic is the natural frequency of vibration	The first overtone is the next higher frequency of vibration
2	Harmonics are simply integral multiplies of the fundamental frequency.	Overtones are not necessarily integral multiplies of the fundamental frequency. They are frequencies other than the fundamental frequency.
3	All harmonics may or may not be present in vibration	All overtones are always present in the vibration

Q.7 i. When two identical waves travelling along the same path in opposite directions interfere with each other, the resultant wave is called a stationary wave.

ii. Stationary waves are called so because the resultant harmonic disturbance of the particles does not travel in any direction and there is no transport of energy

Q.8 Schematic of experimental set-up for photoelectric effect.



Q.9 **Advantages:**

i. Quick response when exposed to light.

ii. The reverse current is linearly proportional to the intensity of incident light.(Linear response)

iii. High speed operations.

iv. Lightweight and compact size

v. Wide spectral response. e.g. photodiodes made from silicon respond to radiation of wavelengths from 190 nm (UV) to 1100 nm (IR)

vi. Relatively low cost.

Disadvantages:

i. Its properties are temperature-dependent, similar to many other semiconductor devices.

ii. Low reverse current for low illumination levels.

Q.10 Given: $I = 1.2\ kgm^2$, $\alpha = 25\ rad/s^2$, $\omega_0 = 0\ rad/s$, $(K.E)_{rot} = 1500\ J$

To find: Time (t)

Formulae: i. $\alpha = \frac{\omega - \omega 0}{t}$

ii. $K.E = \frac{1}{2} I \omega^2$

Calculation:

From formula (i),

$25 = \frac{\omega - 0}{t}$

$\omega = 25t$

From formula (ii),

$1500 = \frac{1}{2} \times 1.2 \times (25t)^2$

$t = \sqrt{4}$

t = 2 s.

An angular acceleration must be applied for 2 s.

Q.11 Given: Q = 1000 cal, $Q_a = 400$ cal

To find: Coefficient of emission (e)

Formula:

i. $a = \frac{Qa}{Q}$

ii. a = e

Calculation:

From formula (i),

$a = \frac{400}{1000} = 0.4$

From formula (ii),

e = a = 0.4

The coefficient of emission of the body is 0.4.

Q.12 Given: P = Q = R = 6 Ω

To find: Resistance (X)

Formula: $\frac{P}{Q} = \frac{R}{S}$

Calculation:

Let resistance connected across 18 Ω be X

Equivalent resistance for 18 Ω and X in parallel is given by,

$X' = S = \frac{18X}{18+X}$

From formula,

$1 = \frac{6(18+X)}{18X}$

X = 9 Ω

The resistance connected across 18 Ω resistance to balance the network is 9 Ω.

Q.13 i. The magnetic force is proportional to q and to the magnitude of the vector cross product v × B. In terms of the angle ϕ between v and B, the magnitude of the force equals qvB sin ϕ. The magnetic force on a moving charge reveals the sign of the charge carriers in a conductor.

ii. Eddy current:- Eddy currents are loops of electrical current induced within conductors by a changing magnetic field in the conductor according to Faraday's law of induction.

Q.14 i. In case of common emitter configuration, common base current gain or the current amplification factor (α_{DC}) is the ratio of the collector current to the emitter current

$\alpha_{DC} = \frac{IC}{IE}$ …….(1)

ii. Similarly, the common emitter current gain of the current amplification factor (β_{DC}) is defined as the ratio of the collector current to the base current.

$\beta_{DC} = \frac{IC}{IB}$ ………..(2)

iii. Since, $I_E = I_B + I_C$

Dividing throughout by I_C,

$\frac{IE}{IC} = \frac{IB}{IC} + 1$

$\therefore \frac{1}{\propto DC} = \frac{1}{\beta DC} + 1$ [From (1) and (2)]

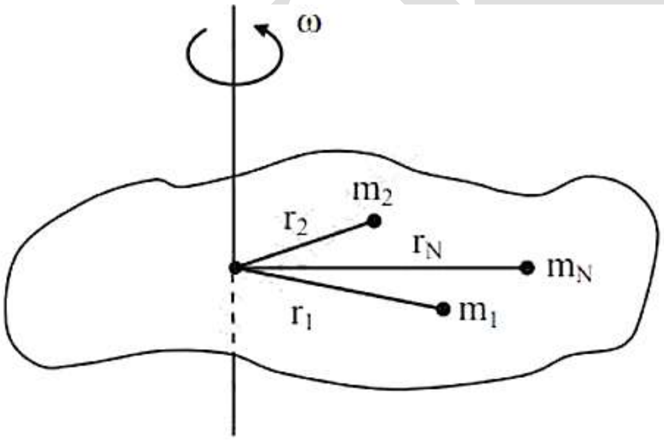
$\therefore \propto DC = \frac{\beta DC}{1+\beta DC}$

$\therefore \beta DC = \frac{\alpha DC}{1-\alpha DC}$

Section – C

Attempt *any eight* :

Q.15 i. Consider a rigid object rotating with a constant angular speed ω about an axis perpendicular to the plane of a paper.



A body of n particles

ii. For theoretical simplification, let us consider the object to be consisting of N particles of masses $m_1, m_2, m_3, …. m_N$ at respective perpendicular distances $r_1, r_2, r_3, . . . r_N$ from the axis of rotation.

iii. As the object rotates, all these particles perform UCM with the same angular speed ω, but with different linear speeds,

$v_1 = r_1\omega, v_2 = r_2\omega, . . . , v_N = r_N\omega$

iv. Translational K.E. of the first particle is

(K.E.)1 = $\frac{1}{2}m_1 v_1^2 = \frac{1}{2}m_1 r_1^2 \omega^2$

Similar will be the case of all other particles.

v. The rotational K.E. of the object is the sum of individual translational kinetic energies.

Thus,

Rotational K.E. = $\frac{1}{2} m_1 r_1^2 \omega^2 + \frac{1}{2} m_2 r_2^2 \omega^2 + . . . + \frac{1}{2} m_N r_N^2 \omega^2$

∴ Rotational K.E. = $\frac{1}{2} (m_1 r_1^2 + m_2 r_2^2 \ldots + m_N r_N^2) \omega^2$

vi. But, I = $\sum_{i=1}^{N} m_i r_i^2 = m_1 r_1^2 + m_2 r_2^2 \ldots + m_N r_N^2$

∴ Rotational K.E. = $\frac{1}{2} I \omega^2$

Q.16 i. Let, PQRS = surface film of liquid in a container containing liquid. PS is the free surface of the liquid and QR is the inner layer parallel to PS at a distance equal to the range of molecular force.

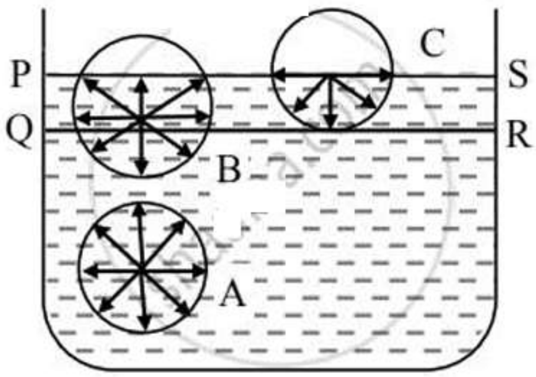
ii. Now, consider three molecules A, B, and C in a liquid in a vessel such that molecule A is well inside the liquid, B within the surface film and C is on the surface of the liquid as shown in the figure.

iii. The sphere of influence of molecule A is entirely inside the liquid. As a result, molecule A is acted upon by equal cohesive forces in all directions. Thus, net cohesive force on molecule is zero.

iv. For molecule B, large part of its sphere of influence is inside the liquid and a smaller part is outside the surface (in the air). The adhesive force acting on molecule B due to air molecules above it and within its sphere of influence is weak compared to the strong downward cohesive force acting on the molecule. As a result, molecule B gets attracted inside the liquid.

v. For molecule C, half of the sphere of influence is in air and half is in liquid. As the density of air is much less than that of the liquid, the number of molecules within the sphere of influence of molecule C above the free surface of the liquid is much less than the number of liquid molecules within the sphere of influence that lies within the liquid. Thus, the adhesive force due to the air molecules acting on molecule C is weak compared to the cohesive force acting on the molecule. As a result, molecule C also gets attracted inside the liquid.

vi. Thus, all molecules in the surface film are acted upon by an unbalanced net cohesive force directed into the liquid. Therefore, the number of molecules in the surface film are pulled inside the liquid. This minimizes the total number of molecules in the surface film. As a result, the surface film remains under tension. The surface film of a liquid behaves like a stretched elastic membrane. This tension is known as surface tension and the force due to its acts tangential to the free surface of the liquid.



Q.17 i. Consider a particle simultaneously subjected to two SHMs having the same period and along the same path (let it be X axis) but of different amplitudes and initial phases. The resultant displacement at any instant is equal to the vector sum of its displacement due to both the SHMs at that instant.

ii. Let the two linear SHMs be given by equations,

$x_1 = A_1 \sin[\omega t + \phi_1]$. . . . (1)

$x_2 = A_2 \sin[\omega t + \phi_2]$. . . .(2)

where A_1 and A_2 are amplitudes, ϕ_1 and ϕ_2 are initial phase angles, and x1 and x2 are the displacements of two SHMs in time ‘t’. ω is the same for both SHMs.

iii. The resultant displacement of the two SHMs is given by

$x = x_1 + x_2$ . . . (3)

Using equations (1) and (2), equation (3) can be written as:

$x = A_1\sin[\omega t+\phi_1] + A_2 \sin[\omega t+\phi_2]$

$= A_1[\sin \omega t \cos \phi_1 + \cos \omega t \sin \phi_1] + A_2[\sin \omega t \cos \phi_2 + \cos \omega t \sin \phi_2]$

$= A_1\sin \omega t \cos \phi_1 + A_1 \cos \omega t \sin \phi_1] + A_2 \sin \omega t \cos \phi_2 + A_2 \cos \omega t \sin \phi_2$

$= [A_1\sin \omega t \cos \phi_1 + A_2 \sin \omega t \cos \phi_2] + [A_1 \cos \omega t \sin \phi_1 + A_2 \cos \omega t \sin \phi_2]$

$\therefore x = \sin \omega t [A_1 \cos \phi_1 + A_2 \cos \phi_2] + \cos \omega t [A_1 \sin \phi_1 + A_2 \sin \phi_2]$

iv. As A1, A2, ϕ_1 and ϕ_2 are constants; we can combine them in terms of another convenient constants R and δ as

$A_1 \cos \phi_1 + A_2 \cos \phi_2 = R \cos \delta$ . . . (5) and

$A1 \sin \phi_1 + A_2 \sin \phi_2 = R \sin \delta$ . . . (6)

v. Using equations (5) and (6), equation (4) can be written as,

$x = \sin \omega t\, R \cos \delta + \cos \omega t\, R \sin \delta = R [\sin \omega t \cos \delta + \cos \omega t \sin \delta]$

$\therefore x = R \sin (\omega t + \delta)$ . . . (7)

Equation (7) is the equation of an SHM of the same angular frequency (hence, the same period) but of amplitude R and initial phase δ. It shows that the combination (superposition) of two linear SHMs of the same period and occurring along the same path is also an SHM.

vi. Resultant amplitude is,

$R = \sqrt{(Rsin\delta)^2 + (Rcos\delta)^2}$

Squaring and adding equations (5) and (6), we get

$(A_1 \cos \phi_1 + A_2 \cos \phi_2)^2 + (A_1 \sin \phi_1 + A_2 \sin \phi_2)^2 = R \cos^2 \delta + R \sin^2 \delta$

$\therefore A_1^2 \cos^2 \phi_1 + A_2^2 \cos^2 \phi_2 + 2A_1A_2 \cos \phi_1 \cos \phi_2 + A_1^2 \sin^2 \phi_1 + A_2^2 \sin^2 \phi_2 + 2A_1A_2 \sin \phi_1 \sin \phi_2 = R^2(\cos^2 \delta + \sin^2 \delta)$

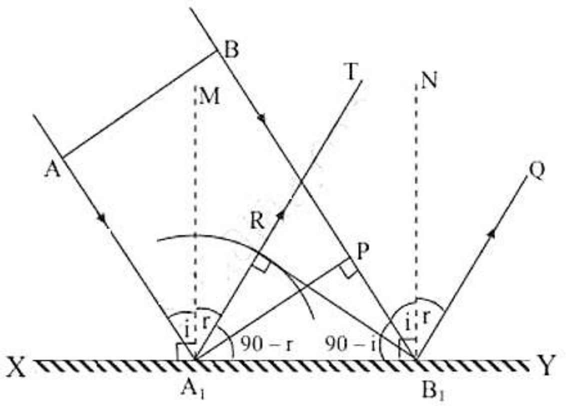
$\therefore A_1^2 (\cos^2 \phi_1 + \sin^2 \phi_1) + A_2^2 (\cos^2 \phi_2 + \sin^2 \phi_2) + 2A_1A_2 (\cos \phi_1 \cos \phi_2 + \sin \phi_1 \sin \phi_2) = R^2$

$\therefore A_1^2 + A_2^2 + 2A_1A_2 \cos(\phi_1 - \phi_2) = R^2$

$\therefore R = \sqrt{A_1^2 + A_2^2 + 2A1A2 \cos(\phi 1 - \phi 2)}$ . . . (8)

Equation (8) represents resultant amplitude of two SHMs.

Q.18



XY: Plane reflecting surface

AB: Plane wavefront

RB_1: Reflecting wavefront

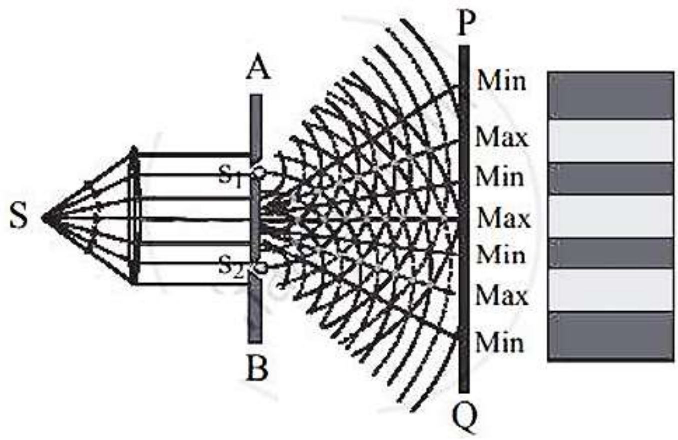
A_1M, B_1N: Normal to the plane

$\angle AA_1M = \angle BB_1N = \angle I$ = Angle of incidence

Explanation:

i. A plane wavefront AB is advancing obliquely towards the plane reflecting surface XY. AA_1 and BB_1 are incident rays.
ii. When A reaches XY at A_1, the ray B reaches point P and it has to cover distance PB_1 to reach the reflecting surface XY.
iii. Let "t" be the time required to cover distanced PB_1. During this time interval, secondary wavelets are emitted from A_1 and will spread over a hemisphere of radius A_1R in the same medium. Distance covered by secondary wavelets to reach from A_1 to R in time t is the same distance covered by primary waves to reach from P to B_1. Thus, $A_1R = PB_1 = ct$.
iv. All other rays between AA_1 and BB_1 will reach XY after A_1 and before B_1. Hence, they will also emit secondary wavelets of decreasing radii.
v. the surface touching all such hemispheres is RB1 which is reflected wavefront, bounded by reflected rays A_1R and B_1Q.
vi. Draw $A_1M \perp XY$ and $B_1N \perp XY$.
Thus, angle of incidence is $\angle AA_1M = \angle BB_1N = I$ and angle of reflection is $\angle MA_1R = \angle NB_1Q = r$.
$\therefore \angle RA_1B_1 = 90 - r$ and $\angle PB_1A_1 = 90 - i$
vii. In ΔA_1RB_1 and ΔA_1PB_1,
$\angle A_1RB_1 \cong \angle A_1PB_1$
$A_1R = PB_1$ (reflected waves travel equal distance in the same medium in equal time)
$A_1B_1 = A_1B_1$ . . . (common side)
$\therefore \Delta A_1RB_1 \cong \Delta A_1PB_1$
$\therefore \angle RA_1B_1 = \angle PB_1A_1$
$\therefore 90 - r = 90 - i$
$\therefore i = r$
viii. Also, from the figure, it is clear that incident ray, reflected ray, and the normal lie in the same plane.
ix. Assuming rays AA_1 and BB_1 to be coming from extremities of the object, A_1B_1 is the size of the object. Distance between corresponding reflected rays A_1T and B_1Q will be the same as A_1B_1 as they are corresponding parts of congruent triangles. This implies the size of the object in a reflected image is the same as the actual size of the object.
x. Also, taking A and B to be the right and left sides of the object respectively, after reflection right side at A is seen at T and left side at B is seen at Q. This explains lateral inversion.

Q.19 i. In Young's double slit interference experiment, a plane wavefront is made to fall on an opaque screen AB having two similar narrow slits S1 and S2.
ii. The figure below shows a cross section of the experimental setup and the slits have their lengths perpendicular to the plane of a paper.



iii. The slits are about 2-4 mm apart from each other.
iv. An observing screen PQ is placed behind AB.
v. Assuming that the slits S1 and S2 are equidistant from S, the wavefronts starting from S and reaching the S1 and S2 at every instant of time are in phase.
vi. When the rays fall on S1 and S2, the two slits act as secondary sources of light emitting cylindrical wavelets (with axis along the slit length) to the right of AB.
vii. The two secondary sources emit waves in phase with each other.
viii. The crests/ troughs of the secondary wavelets superpose as shown in the figure and interfere constructively high intensity giving rise to a bright band.
ix. When the crest of one wave coincides with the trough of the other causing zero intensity, dark images of the slits are produced on the screen PQ.
x. The dark and bright regions are called fringes and the whole pattern is called an interference pattern.

Q.20

Basis	Resistance	Impedance
Definition	The opposition offered to the flow of current in an electric circuit is called as resistance.	The opposition offered to the flow of current in an AC circuit because of resistance, capacitance, and inductance is called as impedance.
Circuit	It occurs in both AC and DC circuit.	It occurs only in AC circuit.
Elements	It is the contribution of the resistive element in the circuit.	It is the contribution of both resistance and reactance.
Symbol	Denoted by R.	Denoted by Z.
Real and imaginary value	It is a simple value consisting of only real numbers. E.g. 3.4 Ohm, 6.2 Ohm etc.	It is a complex value consisting of real and imaginary values. E.g. R+ij
Frequency	It is constant in a circuit and does not vary as per frequency of AC or DC.	It varies as per the frequency of AC current.
Phase angle	It does not have any phase angle.	It has magnitude and phase angle.
Power dissipation and energy stored	It only represents power dissipation in any material if kept in an electromagnetic field.	If kept in an electromagnetic field, it represents both power dissipation and energy stored.

Q.21 i. The opposing nature of an inductor to the flow of alternating current is called as inductive reactance.
ii. In an inductive circuit,
$i_0 = \frac{e0}{\omega L}$ . . (1)
iii. For a resistive AC circuit, according to Ohm's law:
$i = \frac{V}{R}$ . . (2)
where R is resistance in the circuit.
iv. Comparing equations (1) and (2), we can conclude that ωL plays a similar role in an inductive AC circuit as a resistor in a pure resistor circuit.
v. Hence, the effective resistance X_L offered by the inductance L is called inductive reactance and is given as:
$X_L = \omega L = 2\pi fL$ . . ($\because \omega=2\pi/T = 2\pi f$) where f= frequency of the AC supply.
vi. X_L is directly proportional to the inductance L and the frequency f of the alternating current.
vii. In DC circuits, f=0

$\therefore X_L = 0$

It implies that a pure inductor offers zero resistance to DC i.e. it cannot reduce DC.

Thus it passes DC and blocks AC of very high frequency.

viii. In an inductive circuit, the self-induced emf opposes the growth as well as decay of current.

ix. The dimensions of inductive reactance are $[ML^2T^{-3}I^{-2}]$ and its SI unit is Ohm (Ω).

Q.22 Given: $e_{rms} = 230$ V, f = 50 Hz, R = 50 Ω

i. RMS value of current $i_{rms} = \frac{e_{rms}}{R}$ = 230/ 50 = 4.6 A.

ii. a. Peak value of current,

$i_0 = i_{rms} \text{ X } \sqrt{2}$

$= 4.6 \text{ X } \sqrt{2}$

= 6.5 A

$\therefore$ Equation for instantaneous value of current,

$I = i_0 \sin 2\pi ft$

$= 6.5 \sin (2 \text{ X } \pi \text{ X } 50 \text{ X } t)$

$\therefore i = 6.5 \sin 100\ \pi t$

b. Peak value of voltage

$e_0 = e_{rms} \text{ X } \sqrt{2} = 230 \text{ X } \sqrt{2} = 325.27$ V

$\therefore$ Equation for instantaneous value of voltage,

$e = e_0 \sin 2\pi ft$

$= 325.27 \sin (2 \text{ X } \pi \text{ X } 50 \text{ X } t)$

$\therefore e = 325.27 \sin 100\ \pi t$

i. RMS value of current is 4.6 A.

ii. Equation for instantaneous value of current and voltage are $i = 6.5 \sin 100\ \pi t$ and $e = 325.27 \sin 100\ \pi t$ respectively.

Q.23 Using formula (i),

$\lambda_0 = \frac{6.63 \text{ X } 10^{-34} \text{ X } 3 \text{ X } 10^{8}}{3.1 \text{ X } 1.6 \text{ X } 10^{-19}}$

$= \frac{6.63 \text{ X } 3}{3.1 \text{ X } 1.6} \text{ X } 10^{-7}$

= antilog {log 6.63 + log 3- log 3.1 – log 1.6} X 10^{-7}

= antilog {0.8215+0.4771-0.4914-0.2041} X 10^{-7}

= antilog {0.6031} X 10^{-7}

= 4.010 X 10^{-7}

= 4010 A^o

Using formula (ii),

$\lambda = \frac{3 \text{ X } 10^{8}}{1 \text{ X } 10^{15}}$

= 3 X 10^{-7} m = 3000 A^o

As λ is less than λ_0, photoelectric emission will occur.

Incident wavelength is 3000 A^o

Photoelectric emission will occur.

Q.24 Given: Np = 40, ep = 100V, Pp = 100 Watt, e_S = 400V

To find:

Number of turns in the secondary (Ns)

Current in the secondary (Is)

Current in the primary (Ip)

Formulae:

i. $\frac{e_p}{e_s} = \frac{N_p}{N_s}$

ii. P = Ie

From formula (i),

Ns = Np X $\frac{e_s}{e_p} = \frac{40 \ X \ 400}{100}$

∴ Ns = 160

For an ideal transformer, Ps = Pp

From formula (ii),

Ps = $I_S e_S$

∴ $I_p e_p = I_S e_S$

∴ $I_s = \frac{I_p e_p}{e_s}$

$= \frac{p_p}{e_S} = \frac{100}{400}$ = 0.25 A

$I_p = \frac{p_p}{e_p} = \frac{100}{100}$ = 1 A

∴ I_p = 1 A

The number of turns in the secondary is 160.

The current in the secondary is 0.25 A.

The current in the primary is 1 A.

Q.25 Data: R = z = 9.7 cm = 9.7 X 10-2 m, I = 2.3 A, N = 1

a) At the centre of the coil:

The magnitude of the magnetic induction

$B = \frac{\mu_0 NI}{2R}$

$= \frac{4\pi \ X \ 10^{-7} \ X \ 1 \ X \ 2.3}{2 \ (9.7 \ X \ 10^{-2})} = \frac{2 \ X \ 3.142 \ X \ 2.3}{9.7}$ X 10^{-5}

= 1.49 X 10^{-5} T

b) On the axis, at a distance z = 2 m from the coil

$B = \frac{\mu_0}{4\pi} \frac{2\pi I R^2}{(R^2+Z^2)^{3/2}}$

$(R^2 + Z^2)^{3/2} = (2R^2)^{3/2} = 2\sqrt{2R^3}$ (∵R = Z)

∴ $B = \frac{\mu_0}{4\pi} \frac{2\pi I R^2}{2\sqrt{2R^3}} = \frac{\mu_0}{4\pi} \frac{\pi I}{\sqrt{2R}}$

$= (10^{-7}) \frac{3.142 \ X \ 2.3}{1.414 \ X \ 9.7 \ X \ 10^{-2}}$

$= \frac{7.227}{13.72}$ X 10^{-5} = 5.267 X 10^{-6}T = 5.267 μT

Answer B

Given:

R = 9.7 cm = 9.7 X 10^{-2}m

I = 2.3 A

Z = 9.7 cm = 9.7 X 10^{-2}m

To find:

Magnetic field

At the centre of the loop

On the axis at a distance

Formulae:

Bc = $\frac{\mu_0 I}{2R}$

Ba= $\frac{\mu_{0IR^2}}{2(z^2 + R^2)^{3/2}}$

Calculation:

Using formula (i),

Bc = $\frac{4\pi X 10^{-7} X 2.3}{2 X 9.7 X 10^{-2}}$

= $\frac{2 X 3.142 X 2.3}{9.7}$ X 10^{-7+2}

= $\frac{4\pi X 10^{-7} X 2.3 X (9.7 X 10-2)-2}{2 X 2^{3/2} X (9.7 X 10^{-2})3}$

= $\frac{\pi X 10^{-7} X 2.3}{2^{1/2} X (9.7 X 10^{-2})}$

= 5.268 X 10^{-6}T

The magnetic field at the centre of 14.9 μT

The magnetic field on the axis at a distance of 9.7 cm from the centre is 5.268 μT

Q.26 Given: R = 20Ω, L = 10 m, E = 1.5 V

K = 1 μV/cm = 1 X ($10^{-6}/10^{-2}$) V/m = 10^{-4} V/m

To find: External resistance (R_E)

Formula: K = V/L

Calculation:

I = $\frac{E}{R+R_E}$

From formula,

K = $\frac{ER}{(R+R_E)L}$

R + R_E = $\frac{ER}{KL}$

∴ R_E = $\frac{1.5 X 20}{10^{-4} X 10}$ – 20 = 30000 – 20

∴ R_E = 29980 Ω

The external resistance should be 29980 Ω.

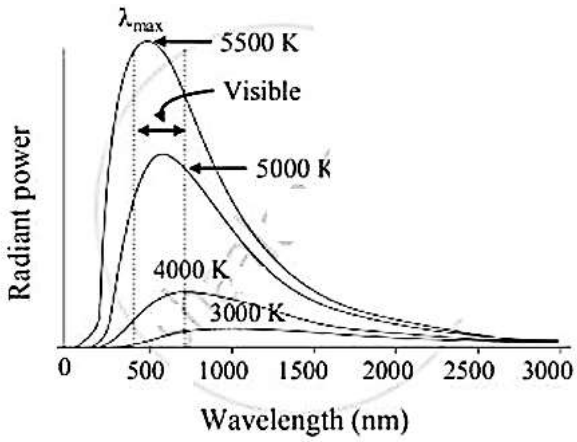
Section – D

Attempt *any three* :

Q.27 i. The rate of emission per unit area or power per unit area of surface is defined as a function of the wavelength λ of the emitted radiation.

ii. Scientists studied the energy distribution of blackbody radiation as a function of wavelength.

iii. By keeping the source of radiation (such as cavity radiator) at different temperatures they measured the radiant power corresponding to different wavelengths. The measurements were represented graphically in the form of curves showing the variation of radiant power per unit area as a function of wavelength λ at different constant temperatures as shown in the figure.



Q.28 Bohr's three postulates are:

i. In a hydrogen atom, the electron revolves around the nucleus in a fixed circular orbit with constant speed.

ii. The radius of the orbit of an electron can only take certain fixed values such that the angular momentum of the electron in these orbits in an integral multiple of h/2π, h being the Planck's constant.

iii. An electron can make a transition from one of its orbits to another orbit having lower energy. In doing so, it emits a photon of energy equal to the difference in its energies in the two orbits.

Expression for the energy of an electron in the nth orbit of Bohr's hydrogen atom:

i. Kinetic energy:

Let m_e = mass of an electron

r_n = radius of nth orbit of Bohr's hydrogen atom

v_n = velocity of electron

-e = charge of an electron

+e = charge of nucleus

Z = a number of electrons in an atom

According to Bohr's first postulate,

$\frac{m_e v_n^2}{r_n} = \frac{1}{4\pi\varepsilon 0} \text{ X } \frac{Ze^2}{r_n^2}$

where ε_0 is permittivity of the free space.

$\therefore m_e v_n^2 = \frac{Z}{4\pi\varepsilon 0} \times \frac{e^2}{r_n} \ldots (1)$

The revolving electron in the circular orbit has linear speed and hence it possess kinetic energy.

It is given by KE = ½ $m_e v_n^2$

$\therefore$ K.E. = ½ × $\left(\frac{Z}{4\pi\varepsilon 0} \times \frac{e^2}{r_n}\right)$ . . from equation (1)

$\therefore$ K.E. = $\frac{ze^2}{8\pi\varepsilon 0 r_n}$ . . . (2)

ii. Potential energy:

The potential energy of an electron is given by P.E. = V(-e) where,

V = electric potential at any point due to charge on the nucleus

-e = charge on electron.

In this case,

P.E. = $\frac{1}{4\pi\varepsilon 0} \text{ X } \frac{e^2}{r_n^2}$ X (-Ze)

$\therefore$ P.E. = $\frac{1}{4\pi\varepsilon 0} \text{ X } \frac{-Ze^2}{r_n^2}$

$\therefore$ P.E. = $\frac{-Ze^2}{4\pi\varepsilon 0\, r_n^2}$ . . . (3)

iii. Total energy:

The total energy of the electron in any orbit is its sum of PE and KE.

$\therefore$ T.E. = K.E. + P.E.

= $\frac{Z}{8\pi\varepsilon 0}\frac{e^2}{r_n} + \frac{-Ze^2}{4\pi\varepsilon 0\, r_n^2}$ . . . from equations (2) and (3)

$\therefore$ T.E. = $\frac{Z}{8\pi\varepsilon 0}\frac{e^2}{r_n}$ . . . (4)

iv. But, $r_n = (\frac{\varepsilon 0 h^2}{\pi meZe^2})$ X n^2

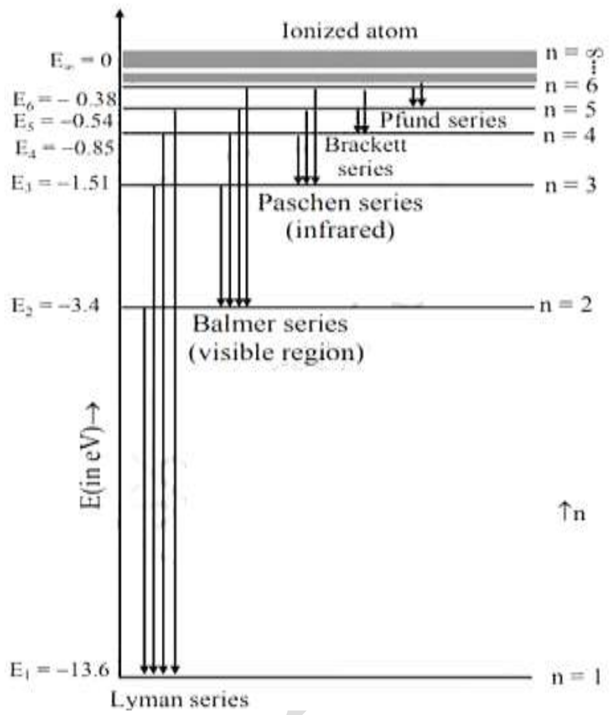
Substituting for r_n in equation (4),

T.E. = $\frac{-1}{8\pi\varepsilon 0}$ X $\frac{Ze2}{\left(\frac{\varepsilon 0 h^2}{\pi meZe^2}\right)Xn^2}$

= - $\frac{1}{8\pi\varepsilon 0}$ X $\frac{m_e Z^2 e^4}{8\varepsilon_0^2 h^2}$ X $\frac{1}{n^2}$ . . (5)

$\rightarrow$ T.E. $\alpha \frac{1}{n^2}$

Q.29 i. Energy levels and transition between them for hydrogen atom:



ii. Data: r = 5.3 X 10^{-11} m, v = 2 X 10^6 m/s

e = 1.6 X 10^{-19} C, m_e = 9.1 X 10^{-31} kg

The orbital magnetic moment of the electron is:

$M_0 = \frac{1}{2}$ evr

= $\frac{1}{2}$ (1.6 X 10^{-19}) (2 X 10^6) (5.3 X 10^{-11})

= 8.48 X 10^{-24} A.m^2

= The angular momentum of the electron is

$L_0 = m_e vr$

= (9.1 X 10^{-31}) (2 X 10^6) (5.3 X 10^{-11})

= 96.46 X 10^{-36} = 9.646 X 10^{-35} kg.m^2/ s

Answer B:

r = 5.3 X 10^{-11} m,

v = 2 X 10^6 ms-1

e = 1.6 10^{-19} C

m_e = 9.1 X 10^{-31} kg

To find:

i. Orbital magnetic moment (m_{orb})

ii. Angular momentum of electron

Formulae:

i. $m_{orb} = \frac{evr}{2}$

ii. L = mvr

Calculation:

From formula (i),

$m_{orb} = (1.6\ X\ 10 - 19\ X\ 2\ X\ 106\ X\ 5.3\ X\ 10 - 11)\ /\ 2$

= 1.6 X 5.3 X 10^{-24}

= 8.48 X 10^{-24} Am^2

From formula (ii),

L = 9.1 X 10^{-31} X 2 X 10^6 X 5.3 X 10^{-11}

= 96.46 X 10^{-36}

∴ L ≅ 9.646 X 10^{-35} kgm^2/s

i. Orbital magnetic moment is 8.48 X 10^{-24} Am^2

ii. Angular momentum of electron is 9.646 X 10^{-35} kgm^2/s

Q.30 (i) The ratio of magnetic moment to the volume of the material is called as magnetization.

ii. Unit: Am^{-1} in SI system.

iii. Dimensions: $[M^0L^{-1}T^0I^1]$

iv. Relation between magnetic field (H) and magnetization (M):

Consider a magnetic material (rod) placed in a magnetic field (solenoid with n turns per unit length and carrying current I)

The magnetic field inside the solenoid is given by,

$B_0 = \mu_0 nI$ . . . (1)

Where,

μ_0 is permeability of free space

The magnetic field inside the rod is given as

$B_m = \mu_0 M$. . . (2)

Where, M is magnetization of the material.

The net magnetic field inside the rod is expressed as:

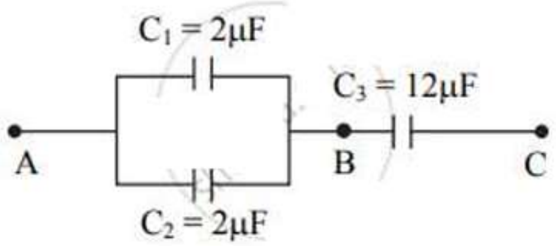
$B = B_0 + B_m$ . . . (3)

$B = \mu_0 nI + \mu_0 M$

∴ $B = \mu_0 H + \mu_0 M$ . . . (4)

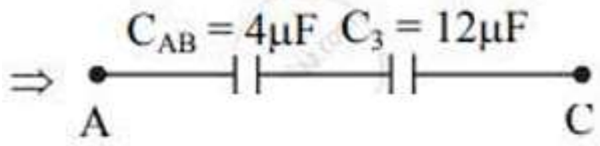
Equation (4) shows that the magnetic field B induced in the material depends on magnetic field intensity (H) and magnetization (M).

(ii)



Here, C1 and C2 are in parallel.

∴ C_{AB} = C1 + C2 = 2μF + 2μF = 4μF



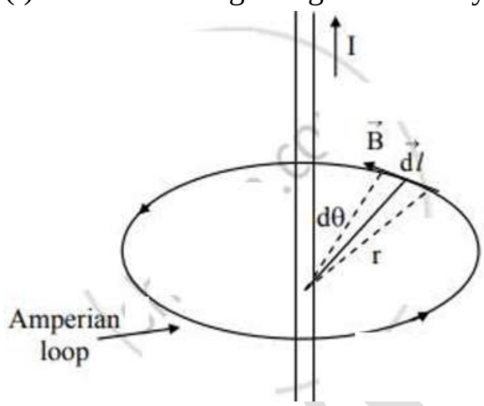
Here, C_{AB} and C3 are in series,

∴ $\frac{1}{C_{AC}} = \frac{1}{4\mu} + \frac{1}{12\mu}$

∴ C_{AC} = 3 μF

The equivalent capacity of the system is 3 μF.

Q.31 (i) Consider a long straight wire carrying a current I as shown in the figure:



$\vec{B}$ and $\vec{dl}$ are tangential to the Amperian loop which in this case is a circle.

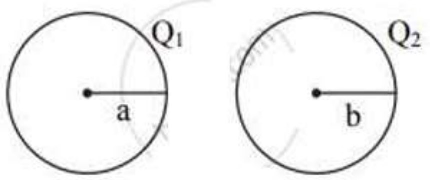
∴ $\vec{B}.\vec{dl}$ = B.dl

= B r dθ

ii. The field $\vec{B}$ at a distance r from the wire is given by

$B = \frac{\mu 0}{2\pi} . \frac{I}{r}$

$\therefore \oint_c \vec{B}.\vec{dl} = \int_0^{2\pi} \frac{\mu 0 I}{2\pi r} r \, d\theta = \mu_0 I$



(ii)

As the electric potential is the same, $\frac{1}{4\pi\varepsilon 0}\frac{Q1}{a} = \frac{1}{4\pi\varepsilon 0}\frac{Q2}{b}$

$\therefore \frac{Q1}{Q2} = \frac{a}{b}$

But, σ1 = $\frac{Q1}{4\pi a^2}$ and σ2 = $\frac{Q2}{4\pi b^2}$

$\therefore \frac{\sigma 1}{\sigma 2} = \frac{Q1}{Q2} \text{ X } \frac{b^{2}}{a^{2}} = \frac{a}{b} \text{ X } \frac{b^{2}}{a^{2}} = \frac{b}{a}$

The ratio of the surface charge densities of A and B is b : a.