CBSE EXAMINATION PAPER-2025

PHYSICS

(Solved)

Time allowed : 3 hours | Maximum Marks : 82

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **38 questions.** All questions are **compulsory.**

ii. This question paper is divided into **5 sections.**

iii. **Section A** – questions number **1 to 2** are case based questions

iv. **Section B** – questions number **3 to 18** are multiple choice questions

v. **Section C** – questions number **19 to 24** are very short answer

vi. **Section D** – questions number **25 to 32** are short answer

vii. **Section E** – questions number **33 to 38** are long answer

viii. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.

ix. Use of calculator is NOT allowed.

Section A

Question 1.

In a metallic conductor, an electron, moving due to thermal motion, suffers collisions with the heavy fixed ions but after collision, it will emerge out with the same speed but in random directions. If we consider all the electrons, their average velocity will be zero. When an electric field is applied, electrons move with an average velocity, known as drift velocity (v_d). The average time between successive collisions is known as relaxation time (τ). The magnitude of drift velocity per unit electric field is called mobility (μ).

An expression for current through the conductor can be obtained in terms of drift velocity, number of electrons per unit volume (n), electronic charge (-e), and the cross-sectional area (A) of the conductor. This expression leads to an expression between current density (J) and the electric field (□□). Hence, an expression for resistivity (ρ) of a metal is obtained. This expression helps us to understand increase in resistivity of a metal with increase in its temperature, in terms of change in the relaxation time (τ) and change in the number density of electrons (n).

(1)

Consider two cylindrical conductors A and B, made of the same metal connected in series to a battery. The length and the radius of B are twice that of A. If μ_A and μ_B are the mobility of electrons in A and B respectively, then μ_B/μ_A is:

(A) 1/2 (B) 1/4

(C) 2 (D) 1

[1 Marks]

Answer: Since conductors A and B are made of the same metal and mobility (mu) depends on the material's properties and relaxation time (t), the mobility of electrons in A and B remains the same. Hence, mu_B/mu_A = 1.
Mobility is independent of conductor's dimensions like length and radius as per the case paragraph.

Key Points: Mobility depends on material properties and relaxation time - Mobility is independent of conductor's length and radius - mu_B/mu_A equals 1 for same material

(2)

A wire of length 0.5 m and cross-sectional area 1.0×10^{-7} m^2 is connected to a battery of 2 V that maintains a current of 1.5 A in it. The conductivity of the material of the wire (in Ω^{-1} m^{-1}) is:

(A) 2·5 *10⁴ (B) 3·0 *10⁵

(C) 3·75 *10⁶ (D) 5·0 *10⁷

[1 Marks]

Answer: Using the given data, conductivity \u03c3 = current density / electric field = (I / A) / (V / L) = (I * L) / (A * V). Substituting values, \u03c3 = (1.5 * 0.5) / (1.0 * 10-7 * 2) = 3.75 * 10 6 \u03a9-1 m-1. So, the conductivity of the wire is 3.75 * 10 6 \u03a9-1 m-1, matching option (C). This uses the relation from the case passage linking current, cross-sectional area, and electric field.

Key Points: Conductivity formula \u03c3 = (I * L) / (A * V) - Calculate current density and electric field - Substitute given values to find conductivity - Result is 3.75 * 10 6 \u03a9-1 m-1 - Matches option (C)

(3)

The temperature coefficient of resistance of nichrome is 1·70 *10^{-4} C^{-1}. In order to increase resistance of a nichrome wire by 8·5%, the temperature of the wire should be increased by :

(A) 250°C (B) 500°C

(C) 850°C (D) 1000°C

[1 Marks]

Answer: The increase in resistance (\u0394R/R) is related to temperature change (\u0394T) by the formula \u0394R/R = \u03b1 \u03b4T, where \u03b1 is the temperature coefficient of resistance. Given \u03b1 = 1.70 *10-4 C-1 and \u0394R/R = 8.5% = 0.085, so \u03b4T = 0.085 / 1.70 *10-4 = 500 C. Therefore, the temperature should be increased by 500 degrees Celsius (Option B). This is consistent with the case passage explaining that resistance increases with temperature because atoms vibrate more, hindering electron flow.

Key Points: Resistance increases with temperature - Use formula \u0394R/R = \u03b1 \u03b4T - Calculate \u03b4T as 500 C

(4)

(a) Consider the contribution of the following two factors I and II in resistivity of a metal :

I. Relaxation time of electrons

II. Number of electrons per unit volume

The resistivity of a metal increases with increase in its temperature because :

(A) I decreases and II increases.

(B) I increases and II is almost constant.

(C) Both I and II increase.

(D) I decreases and II is almost constant.

[1 Marks]

Answer: Answer: The resistivity of a metal increases with temperature mainly because the relaxation time (I) decreases due to more frequent collisions of electrons, while the number of electrons per unit volume (II) remains almost constant. Thus, option **(D)** is correct as explained in the case passage where relaxation time \u03c4 decreases with temperature, increasing resistivity.

Key Points: Resistivity depends on relaxation time and electron density - Relaxation time decreases with temperature - Electron number density remains almost constant with temperature

(5)

A steady current flows in a copper wire of non-uniform cross-section. Consider the following three physical quantities :

I. Electric field

II. Current density

III. Drift speed

Then at the different points along the wire :

(A) II and III change, but I is constant.

(B) I and II change, but III is constant.

(C) I and III change, but II is constant.

(D) All I, II and III change.

[1 Marks]

Answer: In a wire with non-uniform cross-section, the current (I) is constant but the area changes so current density (J = I/A) changes. The electric field (I) varies to drive different current densities, and hence drift speed (III) also changes. So, both electric field and current density change, but drift speed changes too, therefore option (D) is correct.

> **Key Points: Current is constant in steady state - Current density changes with area - Electric field and drift speed vary along the wire**

Question 2.

When light travels from an optically denser medium to an optically rarer medium, at the interface it is partly reflected back into the same medium and partly refracted to the second medium. The angle of incidence corresponding to an angle of refraction 90° is called the critical angle (i_c) for the given pair of media. This angle is related to the refractive index of medium 1 with respect to medium 2. Refraction of light through a prism involves refraction at two plane interfaces. A relation for the refractive index of the material of the prism can be obtained in terms of the refracting angle of the prism and the angle of minimum deviation. For a thin prism, this relation reduces to a simple equation. Laws of refraction are also valid for refraction of light at a spherical interface. When an object is placed in front of a spherical surface separating two media, its image is formed. A relation between object and image distance, in terms of refractive indices of two media and the radius of curvature of

the spherical surface can be obtained. Using this relation for two surfaces of a lens, 'lens maker formula' is obtained.

(1)

A small bulb is placed at the bottom of a tank containing a transparent liquid (refractive index n) to a depth H. The radius of the circular area of the surface of liquid, through which light from the bulb can emerge out, is R. Then (R/H) is:

(A)1/√n²-1

(B)/√n²-1

(C)1/√n²+1

(D)/√n²+1

[1 Marks]

Answer: When light travels from an optically denser medium (liquid) to a rarer medium (air), it bends away from the normal and total internal reflection happens at the critical angle i_c where refraction angle is 90 deg (from case). Using geometry, (R/H) = 1 / sqrt(n^2 - 1), so the correct option is (A).

Key Points: Light bends when moving from denser to rarer medium - Critical angle defines the limit of refraction - (R/H) = 1 / sqrt(n^2 - 1) from geometry of light paths

(2)

(a) A parallel beam of light is incident on a face of a prism with refracting angle 60°. The angle of minimum deviation is found to be 30°. The refractive index of the material of the prism is close to : (A) 1·3 (B) 1·4

(C) 1·5 (D) 1·6

[1 Marks]

Answer: The refractive index n of the prism is given by n = sin((A + D_m)/2)/sin(A/2), where A = 60deg and D_m = 30deg. So, n = sin(45deg)/sin(30deg) = (sqrt(2)/2)/(1/2) = sqrt(2) = 1.414 approx. Therefore, the refractive index is close to 1.4, option (B). This uses the relation explained in the case passage about refraction through a prism and angle of minimum deviation.

Key Points: Refractive index formula for prism - Use of angles A and D_m - Calculation leads to refractive index approx 1.4

(3)

A double-convex lens, made of glass of refractive index 1.5, has a focal length of 10 cm. The radius of curvature of its each face is:

(A) 10 cm (B) 15 cm

(C) 20 cm (D) 40 cm

[1 Marks]

Answer: Using lens maker formula 1/f = (n-1)(1/R1 - 1/R2) and given that focal length f = 10 cm and refractive index n = 1.5, for a double convex lens R1 = R2 = R. Substituting we get 1/10 = (1.5 - 1)(2/R) which gives R = 20 cm. Hence, the radius of curvature of each face is 20 cm, so option (C) is correct.

Key Points: Lens maker formula relates focal length with refractive index and radius of curvature - Given n = 1.5 and f = 10 cm, apply formula for double convex lens - Radius of curvature of each face calculated as 20 cm

(4)

An object is placed in front of a convex spherical glass surface (n = 1.5 and radius of curvature R) at a distance of 4R from it. As the object is moved slowly close to the surface, the image formed is:

(A) always real (B) always virtual

(C) first real and then virtual (D) first virtual and then real

[1 Marks]

Answer: Answer: (C) first real and then virtual.
Explanation: When the object is far at 4R from the convex spherical glass surface, a real image is formed on the opposite side. As the object moves closer to the surface, the image shifts and can become virtual. This is because refraction at a spherical interface depends on object distance and radius of curvature, as described in the case passage.

Key Points: Refraction at spherical interface forms image - Image nature depends on object distance - For object far, image is real; when moved closer, image becomes virtual

(5)

The angle of minimum deviation for a ray of light incident on a thin prism, made of crown glass (n = 1·52) is D_m. If the prism was made of dense flint glass (n = 1·62) instead of crown glass, the angle of minimum deviation will :

(A) decrease by 4% (B) increase by 4%

(C) decrease by 19% (D) increase by 19%

[1 Marks]

Answer: The angle of minimum deviation (D_m) is related to the refractive index (n) of the prism material. As per the case passage, a higher refractive index means greater bending of light, thus a greater deviation angle. Since dense flint glass has a higher refractive index (1.62) than crown glass (1.52), the angle of minimum deviation will increase. The increase is approximately 4%, so the correct answer is (B) increase by 4%.

Key Points: Angle of minimum deviation relates to refractive index - Higher refractive index gives higher deviation - Dense flint glass has higher n than crown glass thus higher D_m

Section B

Question 3. Two horizontal plates, separated by 1 cm, are arranged one above the other. A particle of mass 5 mg and charge 2 nC is released in air between the plates. The potential difference that should be applied to the plates so that the particle remains suspended between them, is:

[1 Marks]

(A) 250 V

(B) 200 V

(C) 100 V

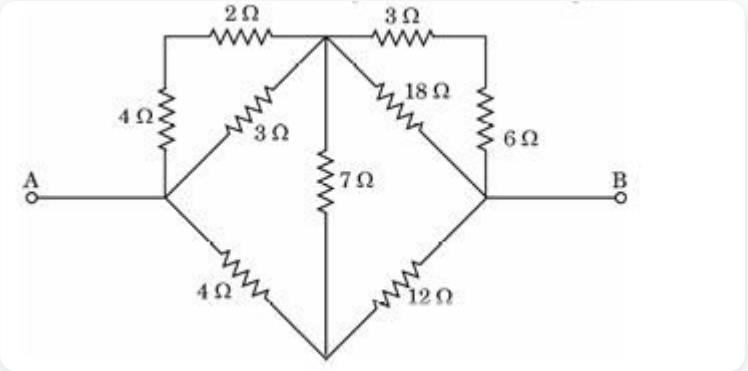
(D) 50 V

Explanation: To keep the particle suspended between the plates, the gravitational force must be balanced by the electric force. The weight of the particle is given by W = mg = 5 mg * 9.81 m/s² = 49.05 * 10^-3 N. The electric force due to the electric field E is given by F = qE = q(V/d). Setting these equal allows us to solve for V, leading to the correct option of 200 V.

Question 4.

The effective resistance between points A and B in the given circuit is:

[1 Marks]



(A) 6 Ω

(B) 8/3 Ω

(C) 2 Ω

(D) 16/3 Ω

Explanation: The correct answer is 8/3 Ω. In the provided context, the circuit arrangement suggests that the internal resistances and the setup allow for a calculation of equivalent resistance using the formulas given in the mentioned equations. By combining resistances in parallel, the effective resistance between points A and B can be determined, resulting in 8/3 Ω.

Question 5.

A rectangular coil of area A is kept in a uniform magnetic field □□ such that the plane of the coil makes an angle **α** with □□. The magnetic flux linked with the coil is:

[1 Marks]

(A) BA

(B) zero

(C) BA sin α

(D) BA cos α

Explanation:

The magnetic flux (ΦB) through the coil is given by the formula ΦB = BA cos Θ, where Θ is the angle between the magnetic field (B) and the area vector (A). Since the plane of the coil makes an angle α with the magnetic field, the correct expression for the magnetic flux is BA cos α.

Question 6.

An alternating current is given by $I = I_0 \cos(100\pi)t$. The least time the current takes to decrease from its maximum value to zero will be:

[1 Marks]

(A) (1/150) s

(B) (1/100) s

(C) (1/50) s

(D) (1/200) s

Explanation: The current $I = I_0 \cos(100\pi t)$ reaches its maximum value when $\cos(100\pi t) = 1$, and it becomes zero when $\cos(100\pi t) = 0$. The first instance of this occurs at t = 1/(200) seconds, as the frequency component 100π in the cosine function indicates that the period of the function is $T = 2\pi/(100\pi) = 0.02$ seconds. Consequently, the current takes a quarter of the period ($T/4 = 0.02/4 = 0.005$ seconds) to go from maximum to zero. Hence, the least time the current takes to decrease from its maximum value to zero is (1/200) s.

Question 7.

A capacitor and an inductor are connected in series across an ac source of voltage of variable frequency. The frequency is increased continuously. The nature of the circuit before and after the resonance will be:

[1 Marks]

(A) inductive only

(B) inductive and capacitive respectively

(C) capacitive only

(D) capacitive and inductive respectively

Explanation: The correct answer is 'inductive and capacitive respectively'. Before resonance occurs, at low frequencies, the circuit behaves predominantly capacitively (current leads voltage), while after resonance, at high frequencies, the circuit behaves predominantly inductively (voltage leads current). Resonance occurs when the inductive reactance (XL) equals the capacitive reactance (XC), resulting in the circuit being purely resistive at that point.

Question 8.

A metal rod of length 50 cm is held vertically and moved with a velocity of 10 m/s towards east. The horizontal component of the earth's magnetic field at the place is 0.4 G. The emf induced across the

ends of the rod is:

[1 Marks]

(A) 0.8 mV

(B) 0.2 mV

(C) 1.6 mV

(D) 0.1 mV

Explanation: The induced emf (ε) can be calculated using the formula ε = Blv. Here, B (the magnetic field) is 0.4 G, which is equivalent to 0.4 × 10^-4 T (since 1 G = 10^-4 T), l (the length of the rod) is 0.5 m (converted from 50 cm), and v (the velocity) is 10 m/s. Plugging in the values, we get ε = (0.4 × 10^-4 T) × (0.5 m) × (10 m/s) = 0.2 mV. Therefore, the correct answer is 0.2 mV.

Question 9.

The frequency of a photon of energy 1.326 eV is:

[1 Marks]

(A) 3.20×10^{14} Hz

(B) 4.80×10^{15} Hz

(C) 4.20×10^{15} Hz

(D) 1.18×10^{14} Hz

Explanation: To find the frequency (ν) of a photon, we can use the formula E = hν, where E is the energy in joules and h is Planck's constant (6.626 x 10^-34 J·s). First, we convert the energy from electronvolts to joules: 1.326 eV = 1.326 × 1.6 × 10^-19 J = 2.1216 × 10^-19 J. Using the formula ν = E/h, we calculate ν = (2.1216 × 10^-19 J) / (6.626 x 10^-34 J·s) = 3.20×10^{14} Hz. Therefore, the correct option is 3.20×10^{14} Hz.

Question 10. Germanium crystal is doped at room temperature with a minute quantity of boron. The charge carriers in the doped semiconductors will be:

[1 Marks]

(A) electrons only

(B) holes and few electrons

(C) holes only

(D) electrons and few holes

Explanation: When germanium, a tetravalent semiconductor, is doped with boron, a trivalent element, it produces a p-type semiconductor. In this situation, boron creates holes, which become the majority charge carriers, while the few remaining electrons from the germanium structure serve as minority carriers. Therefore, the correct answer is 'holes and few electrons.'

Question 11. Out of the four options given, in which transition will the emitted photon have the maximum wavelength?

[1 Marks]

(A) n = 4 to n = 3

(B) n = 3 to n = 2

(C) n = 2 to n = 1

(D) n = 3 to n = 1

Explanation: The emitted photon will have the maximum wavelength in the transition from n = 4 to n = 3. Wavelength is inversely proportional to frequency, which is determined by the energy difference between the two levels. The larger the difference in energy levels, the higher the frequency and the shorter the wavelength of the emitted photon. Therefore, the transition n = 4 to n = 3 has the smallest energy difference, resulting in the longest wavelength among the given options.

Question 12.

The dimensions of 'self-inductance' are:

[1 Marks]

(A) $[M\ L\ T^{-2}\ A^{-2}]$

(B) $[M\ L^{2}\ T^{-1}\ A^{-1}]$

(C) $[M\ L^{2}\ T^{-2}\ A^{-2}]$

(D) $[M\ L^{-1}\ T^{-2}\ A^{-2}]$

Explanation:

The correct option is (D) $[M\ L^{2}\ T^{-2}\ A^{-2}]$. This is because self-inductance has dimensions derived from the relationship between the magnetic flux linked with the coil and the current, which can be represented mathematically as dimensions of flux divided by dimensions of current. According to the provided context, self-inductance is expressed as L, with its dimensions being $[M\ L^{2}\ T^{-2}\ A^{-2}]$.

Question 13.

A p-n junction diode is forward biased. As a result,

[1 Marks]

(A) both the potential barrier height and the width of depletion layer increase.

(B) both the potential barrier height and the width of depletion layer decrease.

(C) the potential barrier height decreases and the width of depletion layer increases.

(D) the potential barrier height increases and the width of depletion layer decreases.

Explanation: When a p-n junction diode is forward biased, the potential barrier height decreases and the width of the depletion layer decreases. This is due to the applied voltage that effectively reduces the barrier height, allowing for increased current flow, as stated in the provided context.

Question 14.

Isotones are the nuclides having :

[1 Marks]

(A) same atomic numbers

(B) same mass numbers

(C) same neutron number, but different atomic number

(D) different neutron number, and different mass number

Explanation: Isotones are defined as nuclides that have the same neutron number (N) but different atomic numbers (Z). This aligns with the context provided, which states that nuclides with the same N but different Z are called isotones.

Question 15.

Assertion (A) : A charged particle is moving with velocity v in x-y plane, making an angle θ ($0 < \theta < \pi/2$) with x-axis. If a uniform magnetic field B is applied in the region, along y-axis, the particle will move in a helical path with its axis parallel to x-axis.

Reason (R) : The direction of the magnetic force acting on a charged particle moving in a magnetic field is along the velocity of the particle.

[1 Marks]

(A) Assertion (A) is true, but Reason (R) is false.

(B) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(C) Both Assertion (A) and Reason (R) are false.

(D) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

Explanation: Assertion (A) is true, but Reason (R) is false. The charged particle will indeed move in a helical path due to the magnetic force acting perpendicular to both the velocity and the magnetic field (which is incorrect in statement R). Thus while A accurately describes the motion, R incorrectly states that the magnetic force is along the velocity.

Question 16.

Assertion (A) : A ray of light is incident normally on the face of a prism. The emergent ray will graze along the opposite face of the prism when the critical angle at glass-air interface is equal to the angle of the prism. Reason (R) : The refractive index of a prism depends on angle of the prism.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(B) Assertion (A) is true, but Reason (R) is false.

(C) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(D) Both Assertion (A) and Reason (R) are false.

Explanation: Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). Assertion (A) correctly describes the behavior of light in relation to the critical angle and the angle of the prism, while Reason (R) states that the refractive index depends on the angle of the prism, which is true. However, Reason (R) does not directly explain why the emergent ray grazes along the opposite face.

Question 17.

Assertion (A) : EM waves do not require a medium for their propagation.

Reason (R) : EM waves are transverse waves.

[1 Marks]

(A) Assertion (A) is true, but Reason (R) is false.

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Both Assertion (A) and Reason (R) are false.

(D) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

Explanation: Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). EM waves indeed do not require a medium for propagation, which is a defining characteristic of electromagnetic waves. While it is also true that electromagnetic waves are transverse waves, this property does not directly explain why they do not require a medium, as transverse waves can exist in certain media, unlike electromagnetic waves.

Question 18.

Assertion (A) : The minimum negative potential applied to the anode in a photoelectric experiment at which photoelectric current becomes zero, is called cut-off voltage.

Reason (R) : The threshold frequency for a metal is the minimum frequency of incident radiation below which emission of photoelectrons does not take place.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are false.

(B) Assertion (A) is true, but Reason (R) is false.

(C) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(D) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

Explanation: Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). The cut-off voltage is correctly defined in Assertion (A), and the threshold frequency defined in Reason (R) is also accurate; however, the threshold frequency does not directly explain what cut-off voltage is.

Section C

Question 19.

A cell of emf E and internal resistance r is connected across a resistor of variable resistance R. Show graphically the variation of

(a) the terminal voltage across the cell

(b) the current supplied by the cell,

with R as it is increased from 0 to the maximum value.

[2 Marks]

Answer: The terminal voltage (V) across the cell is given by the equation V = E - Ir, where I is the current. As R increases, the current I decreases, leading to an increase in terminal voltage. This creates a downward slope on the graph of V against R. The current I, given by I = E/(R + r), starts at a maximum when R is zero and decreases as R increases. This results in a downward trend in the graph of I against R.

Key Points: Terminal voltage V = E - Ir; Current I = E/(R + r); V increases as R increases; I decreases as R increases; Graphs show downward trends.

Question 20.

Using the mirror equation and the formula of magnification, deduce that "the virtual image produced by a convex mirror is always diminished in size and is located between the pole and the focus."

[2 Marks]

Answer: The mirror equation is $1/v + 1/u = 1/f$, where u is negative for convex mirrors. The magnification formula is $m = -v/u$. For a convex mirror, since f is positive and u is negative, v is also positive but less than f. Thus, the image distance v is between the pole and focus, and since $|v| < |u|$, the image is diminished.

Key Points: mirror equation, positive focal length, virtual image, diminished size, location between pole and focus

Question 21.

Write two differences in the patterns of double-slit interference experiment and single-slit diffraction experiment.

light waves from two pinholes illuminated by two sodium lamps do not produce interference patterns. Explain why

[2 Marks]

Answer: (a) In double-slit interference, the pattern consists of bright and dark fringes with equal spacing due to superposition of coherent light waves from two slits. In single-slit diffraction, the central bright fringe is wider and brighter with the intensity gradually decreasing on both sides, caused by the bending of light around a single slit.
(b) Double-slit interference depends on two coherent sources with fixed phase difference, while single-slit diffraction arises from the wave nature of light passing through one slit.
(c) Light waves from two pinholes illuminated by two sodium lamps do not produce interference patterns because the lamps are independent and incoherent sources. Their light waves do not have a constant phase relationship, so the waves do not produce stable constructive or destructive interference. Instead, their intensities simply add, resulting in no visible interference fringes.

Key Points: Difference in fringe pattern - Dependence on coherence - Sodium lamps are incoherent sources

Question 22. Draw energy band diagrams of n-type and p-type semiconductors at temperature T > 0 K. Show the donor/acceptor energy levels with the order of difference of their energies from the bands.

[2 Marks]

Answer: In an n-type semiconductor, the energy band diagram shows the conduction band (Ec) and valence band (Ev) with the donor energy level (Ed) just below Ec. At T > 0 K, electrons from Ed move to the conduction band, indicating increased conductivity. For a p-type semiconductor, Ev is the valence band, and the acceptor energy level (Ea) lies just above Ev. Electrons from the valence band can jump to Ea, creating holes that enhance conductivity.

Key Points: n-type semiconductor shows donor level below conduction band; p-type semiconductor has acceptor level above valence band; both diagrams depict energy levels at temperature T > 0 K

Question 23. Briefly explain how energy is produced in stars, giving two examples of the nuclear reactions involved.

[2 Marks]

Answer: Energy in stars is produced through nuclear fusion, where light nuclei combine to form a heavier nucleus, releasing energy. One example is the fusion of two hydrogen nuclei ($1\ 1\ H + 1\ 1\ H \rightarrow 2\ 1\ H + e+ + \nu$), which generates energy of 0.42 MeV. Another example is the fusion of deuterium ($2\ 1\ H$) nuclei to produce helium ($2\ 1\ H + 2\ 1\ H \rightarrow 3\ 2\ H + n + 3$. In stars, this process occurs at extremely high temperatures, driving stellar energy output.

Key Points: Nuclear fusion; Light nuclei combined; Two examples: H to He; Energy release; High temperatures in stars

Question 24.

A convex lens of focal length 10 cm, a concave lens of focal length 15 cm and a third lens of unknown focal length are placed coaxially in contact. If the focal length of the combination is +12 cm, find the nature and focal length of the third lens, if all lenses are thin. Will the answer change if the lenses were thick ?

[2 Marks]

Answer: To find the focal length of the third lens, we use the formula for the combination of thin lenses: $1/f = 1/f_1 + 1/f_2 + 1/f_3$. Given $f_1 = 10$ cm (convex) and $f_2 = -15$ cm (concave) with the combination focal length $f = 12$ cm, we substitute: $1/12 = 1/10 - 1/15 + 1/f_3$. Solving this gives us $f_3 = 30$ cm, which is a convex lens. If the lenses were thick, the effective focal length would require different calculations due to additional lens thickness considerations.

Key Points: Use thin lens formula; Combination of focal lengths; Solve for the third lens; Determine if the lens is convex/concave; Discuss impact of thickness on calculations.

Section D

Question 25.

Three cells A, B and C of emfs 2 V, 3 V and 5 V respectively are connected in parallel to each other. Their internal resistances are 5**Ω, 5Ω** and 1**Ω** respectively. Calculate the currents flowing through the cells A, B and C.

[3 Marks]

Answer: To find the currents flowing through each cell, we first determine the equivalent voltage (V_eq) across the cells and then apply Ohm's law. For cells in parallel, the voltage across each cell is the same. The total current is the sum of the individual currents through each cell, given by I = E/R. For cell A, I_A = (2 V) / (5 Ω) = 0.4 A; for cell B, I_B = (3 V) / (5 Ω) = 0.6 A; for cell C, I_C = (5 V) / (1 Ω) = 5 A. Therefore, the currents are I_A = 0.4 A, I_B = 0.6 A, and I_C = 5 A.

Key Points: Use of Ohm's law-I=E/R-equivalent voltage across parallel cells-individual currents calculation

Question 26.

(i) Write Biot-Savart's law in vector form.

(ii) Two identical circular coils A and B, each of radius R, carrying currents I and √3 I respectively, are placed concentrically in XY and YZ planes respectively. Find the magnitude and direction of the net

magnetic field at their common centre.

[3 Marks]

Answer: The Biot-Savart Law in vector form states that the magnetic field dB at a point in space due to an infinitesimal current element Idl is given by $dB = (\mu_0/4\pi) * (I\, dl \times \hat{r}) / r^2$, where $\hat{r}$ is the unit vector pointing from the current element to the field point and r is the distance from the current element to the point. For the two coils, Coil A, with current I, produces a magnetic field at the center $B_1 = (\mu_0 I)/(2R)$. Coil B, with current $\sqrt{3}$ I, produces $B_2 = (\mu_0\sqrt{3}I)/(2R)$. Since they are oriented perpendicular, the net magnetic field will be $B_net = B_1 + B_2$, directed along the axis defined by their orientation.

Key Points: Biot-Savart Law expression; Current contributions from Coil A and Coil B; Calculation of magnetic fields B_1 and B_2; Direction of net magnetic field.

Question 27.

(a) State Faraday's law of electromagnetic induction and explain the role of negative sign in its expression.

(b) Explain, with an example, thet Lenz's law is consistent with the law of conservation of energy.

[3 Marks]

Answer: Faraday's law of electromagnetic induction states that the induced electromotive force (emf) in a circuit is directly proportional to the rate of change of magnetic flux through that circuit. Mathematically, this is expressed as $\varepsilon = -d\Phi B/dt$. The negative sign indicates the direction of induced emf, which opposes the change in magnetic flux, in accordance with Lenz's law. For example, when a magnet approaches a conducting loop, the induced current flows in a direction that opposes the magnet's motion, demonstrating conservation of energy, as it prevents energy depletion by opposing external changes.

Key Points: Faraday's law states induced emf is proportional to rate of change of magnetic flux; negative sign shows direction opposes change; Lenz's law example involves magnet approaching loop; energy conservation demonstrated by induced current opposing external change.

Question 28.

(a) Differentiate between 'conduction current' and 'displacement current', giving one similarity and one dissimilarity between them.

(b) Explain the existence of electromagnetic waves in free space, using the concept of displacement current.

[3 Marks]

Answer: Conduction current refers to the flow of charge carriers (like electrons) in a conducting medium, resulting in the creation of a magnetic field. Displacement current, on the other hand, arises from time-varying electric fields in regions where there are no physical charge carriers but still generates a magnetic field. A similarity between the two is that both contribute to the continuity equation of electric fields and magnetic fields. However, a key dissimilarity is that conduction current occurs in conducting materials, while displacement current occurs in non-conducting spaces, such as the gap between capacitor plates during charging. The concept of displacement current allows us to demonstrate electromagnetic waves; as an accelerating charge produces a varying electric field, it results in a changing magnetic field, propagating energy as electromagnetic waves through free space.

Key Points: Conduction current involves physical charge movement; Displacement current is related to changing electric fields; Both contribute to magnetic fields; Conduction occurs in conductors, displacement in non-conductors; Maxwell's equations include displacement current for wave propagation.

Question 29.

(a) Define 'work function' of a metal. How can its value be determined from a graph between stopping potential and frequency of the incident radiation ? (b) The work function of a metal is 2·4 eV. A stopping potential of 0·6 V is required to reduce the photocurrent to zero, in a photoelectric experiment. Calculate the wavelength of light used.

[3 Marks]

Answer: The work function (Φ) of a metal is the minimum energy required for an electron to escape from its surface, typically measured in electronvolts (eV). This energy directly correlates with the threshold frequency needed for photoelectric emission. By plotting a graph of stopping potential versus the frequency of incident radiation, we can determine the value of the work function—the y-intercept of the linear graph will give the work function in eV. In part (b), using the formula, E = hf, where h is Planck's constant (4.14 × 10^-15 eV. s) and f is the frequency derived from the stopping potential, we calculate the wavelength (λ) of light using the relation λ = c/f, giving us approximately 520 nm.

Key Points: 1. Definition of work function (minimum energy for electron emission) 2. Relation between stopping potential and frequency on a graph 3. Use of formula E = hf and λ = c/f to determine wavelength

Question 30.

Write the mathematical forms of three postulates of Bohr's theory of the hydrogen atom. Using them prove that, for an electron revolving in the nth orbit,

(a) the radius of the orbit is proportional to n^2, and

(b) the total energy of the atom is proportional to $(1/n^2)$

[3 Marks]

Answer: Bohr's Postulates:
(i) The electron revolves around the nucleus in certain stable orbits without emitting energy. These orbits are called stationary orbits.
(ii) The angular momentum of the electron in these orbits is quantised and given by mvr = n(h/2pi), where m is the mass of the electron, v is its velocity, r is the radius of the orbit, h is Planck's constant, and n is a positive integer (n=1,2,3...).
(iii) The energy is emitted or absorbed when an electron jumps from one allowed orbit to another, and the energy difference is given by E = hf, where f is the frequency of radiation.

Proof:
(a) From the Coulomb's force providing centripetal force: (ke^2)/r^2 = m v^2 / r, so ke^2 / r = m v^2 ... (1)
From quantisation of angular momentum: m v r = n h / 2pi, so v = n h / (2pi m r) ... (2)
Substitute v from (2) into (1): ke^2 / r = m [n h / (2pi m r)]^2 = n^2 h^2 / (4 pi^2 m r^2)
Multiply both sides by r^2: ke^2 r = n^2 h^2 / (4 pi^2 m)
Thus, r = (n^2 h^2) / (4 pi^2 m k e^2), which shows r is proportional to n^2.

(b) The total energy E = Kinetic Energy + Potential Energy = (1/2) m v^2 - k e^2 / r
From (1), m v^2 = k e^2 / r, so kinetic energy = (1/2) k e^2 / r
Potential energy = - k e^2 / r
Therefore, total energy E = (1/2) k e^2 / r - k e^2 / r = - (1/2) k e^2 / r
Putting r from part (a), E = - (1/2) k e^2 * (4 pi^2 m k e^2) / (n^2 h^2) = - (2 pi^2 m k^2 e^4) / (n^2 h^2)
Hence, total energy E is proportional to 1/n^2.

Key Points: Bohr's three postulates - expression for angular momentum quantization - derivation showing radius proportional to n squared - derivation showing total energy proportional to 1 over n squared

Question 31.

Explain the process of formation of 'depletion layer' and 'potential barrier' in a p-n junction region of a diode, with the help of a suitable diagram. Which feature of junction diode makes it suitable for its use as a rectifier ?

[3 Marks]

Answer: In a p-n junction, when p-type and n-type semiconductors are joined, electrons from the n-side diffuse into the p-side and recombine with holes, leading to the formation of a depletion layer. This layer consists of immobile ion-cores, creating a localized region devoid of charge carriers. The

potential barrier is established due to this depletion layer, which prevents further diffusion of charge carriers until sufficient voltage is applied. Junction diodes permit current flow primarily during forward bias, making them ideal rectifiers since they allow current to flow efficiently in one direction.

Key Points: Formation of depletion layer; Movement of electrons and holes; Creation of immobile ion-cores; Establishment of potential barrier; Characteristics of rectifier; Current flow in forward bias

Question 32.

(i) A rectangular loop of sides l and b carries a current I clockwise. Write the magnetic moment □□of the loop and show its direction in a diagram.

(ii) The loop is placed in a uniform magnetic field □□ and is free to rotate about an axis which is perpendicular to □□. Prove that the loop experiences no net force, but a torque □□= □□ * □□.

[3 Marks]

Answer: (i) The magnetic moment $\vec{m}$ of a rectangular current loop is given by $\vec{m} = I imes A \hat{n}$, where I is the current, $A = l imes b$ is the area of the loop, and $\hat{n}$ is a unit vector perpendicular to the plane of the loop. For a clockwise current, by the right-hand rule, $\vec{m}$ points into the plane of the loop.

(ii) When the loop is placed in a uniform magnetic field $\vec{B}$ and is free to rotate about an axis perpendicular to $\vec{B}$, the forces on opposite sides of the loop are equal in magnitude and opposite in direction, so the net force is zero. However, these forces create a torque $\vec{ au} = \vec{m} imes \vec{B}$ given by $\vec{ au} = \vec{m} imes \vec{B}$ which tends to align $\vec{m}$ with $\vec{B}$, causing the loop to rotate.

Diagram: Draw a rectangular loop with sides labeled l and b. Current arrows show clockwise direction. The magnetic moment vector $\vec{m}$ is shown perpendicular to the loop, directed inside the plane. The magnetic field vector $\vec{B}$ is shown perpendicular to the axis of rotation. The torque $\vec{ au} = \vec{m} imes \vec{B}$ causes rotation about the axis perpendicular to both $\vec{m}$ and $\vec{B}$.

Key Points: Magnetic moment m = I * l * b with direction by right-hand rule - No net force on loop in uniform magnetic field - Torque on loop is m cross B causing rotation

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Section E

Question 33.

(i) A parallel plate capacitor with plate area A and plate separation d has a capacitance C_0 . A slab of dielectric constant K having area A and thickness (d/4) is inserted in the capacitor, parallel to the plates. Find the new value of its capacitance.

(ii) You are provided with a large number of 1 **μ**F identical capacitors and a power supply of 1200 V. The dielectric medium used in each capacitor can withstand up to 200 V only. Find the minimum number of capacitors and their arrangement, required to build a capacitor system of equivalent capacitance of 2 **μ**F for use with this supply.

[5 Marks]

Answer: (i) Given a parallel plate capacitor with capacitance $C_0 = \varepsilon_0 * A / d$. When a dielectric slab of dielectric constant K, thickness d/4 and area A is inserted, it divides the capacitor into two capacitors in series: one with dielectric of thickness d/4 and capacitance $C1 = K * \varepsilon_0 * A / (d/4) = 4 * K * \varepsilon_0 * A / d$ and another with air of thickness 3d/4 and capacitance $C2 = \varepsilon_0 * A / (3d/4) = 4 * \varepsilon_0 * A / (3d)$. The total capacitance C is given by $1 / C = 1 / C1 + 1 / C2 = d/(4 * K * \varepsilon_0 * A) + 3d/(4 * \varepsilon_0 * A) = d/(4 * \varepsilon_0 * A) * (1/K + 3)$. Thus, $C = 4 * \varepsilon_0 * A / d / (1/K + 3) = 4 * C_0 / (1/K + 3)$.

(ii) Each capacitor has capacitance 1 μF and maximum voltage rating 200 V. The supply voltage is 1200 V. To prevent capacitor damage, at least n capacitors should be connected in series so that voltage per capacitor is <= 200 V. Thus, n >= 1200 / 200 = 6 capacitors in series. The equivalent capacitance of n capacitors in series is C_series = 1 μF / n = 1/6 μF. To get 2 μF equivalent capacitance, we need m such series sets in parallel so that m * C_series = 2 μF => m = 2 / (1/6) = 12.

Minimum number of capacitors = n * m = 6 * 12 = 72 capacitors. Arrangement: 12 groups of 6 capacitors in series connected in parallel to achieve 2 μF at 1200 V safely.

Key Points: Dielectric slab divides capacitor into two capacitors in series - Use formula for capacitors in series to find new capacitance - Voltage division in series capacitors limits the number in series - Calculate equivalent capacitance of series and parallel combinations - Minimum capacitors found by voltage rating and desired capacitance

Question 34.

(i) With the help of a labelled diagram, explain the principle of working of a moving coil galvanometer. Write the purpose of using (i) radial magnetic field, and (ii) soft iron core, in it.

(ii) Define current sensitivity of a galvanometer. "Increasing the current sensitivity may not necessarily increase the voltage sensitivity." Given reason.

[5 Marks]

Answer: (i) A moving coil galvanometer works on the principle that a current-carrying coil placed in a magnetic field experiences a torque. The coil, suspended between the poles of a permanent magnet, carries current which produces a magnetic field that interacts with the magnet's field causing the coil to rotate. This rotation is opposed by a spring that provides restoring torque. The angle of deflection is proportional to the current flowing through the coil.
Purpose of radial magnetic field: The radial magnetic field ensures that the coil experiences a constant torque for every position of the coil, making the deflection directly proportional to the current.
Purpose of soft iron core: The soft iron core increases the magnetic field strength, making the galvanometer more sensitive.

(ii) Current sensitivity of a galvanometer is defined as the deflection produced in the galvanometer needle per unit current passing through the coil. Mathematically, current sensitivity = deflection / current.
Increasing the current sensitivity may not necessarily increase the voltage sensitivity because voltage sensitivity depends on both current sensitivity and the resistance of the galvanometer. Even if current sensitivity increases, if the resistance remains high, the voltage sensitivity may not improve accordingly. Voltage sensitivity = current sensitivity * resistance of the galvanometer.

Key Points: Principle: current-carrying coil in magnetic field experiences torque - Radial magnetic field provides uniform torque - Soft iron core increases magnetic field strength and sensitivity - Current sensitivity = deflection per unit current - Voltage sensitivity depends on current sensitivity and galvanometer resistance

Question 35.

(i) Explain with the help of a labelled ray diagram the formation of final image by an astronomical telescope at infinity. Write the expression for its magnifying power.

(ii) The total magnification produced by a compound microscope is 20. The magnification produced by the eyepiece is 5. When the microscope is focussed on a certain object, the distance between the objective and eyepiece is observed to be 14 cm. Calculate the focal lengths of the objective and the eyepiece. (Given that the least distance of distinct vision = 25 cm)

[5 Marks]

Answer: (i) An astronomical telescope is designed to observe distant objects. When the final image is formed at infinity, the rays from a distant object come in parallel and enter the objective lens. The objective lens converges these rays to form a real and inverted image at its focal point, which acts as the object for the eyepiece. The eyepiece then magnifies this image to form a virtual image at infinity, allowing comfortable viewing. The magnification power (m) is given by the formula m = (L/f0) * (L/fe), where L is the distance between the focal points of the lenses, f0 is the focal length of the objective, and fe is the focal length of the eyepiece. (ii) For the compound microscope, the total magnification (M) is 20 and the eyepiece magnification (me) is 5. The formula for total magnification can be

expressed as M = mo * me, where mo is the magnification of the objective. Thus, mo = M/me = 20/5 = 4. Given the distance (L) between the objective and eyepiece is 14 cm and the least distance of distinct vision (d) is 25 cm, we can relate this to the focal lengths: L = f0 + fe, giving us f0 + fe = 14 cm. The equation for total magnification can also be written as M = (L/f0) + (d/fe). Substituting known values, we get 20 = (14/f0) + (25/fe). By solving these two equations simultaneously, we can find the values of f0 and fe.

Key Points: Ray diagram showing objective, eyepiece, and image; Image formation at focus of eyepiece; Magnifying power formula derivation; Total magnification relationship; Calculation setup for focal lengths; Simultaneous equations for f0 and fe.

Question 36.

(i) An electric dipole of dipole moment p consists of point charges q and -q, separated by 2a. Derive an expression for electric potential in terms of its dipole moment at a point at a distance x (>> a) from its centre and lying

(I) along its axis, and (II) along its bisector line.

(ii) An electric dipole of dipole moment □□ = $(0.8\hat{i}+0.6\hat{j}) \times 10^{-29}$ cm is placed in an electric field □□=$1.0\times10^{7}\hat{k}$ V/m. Calculate the magnitude of the torque acting on it and the angle it makes with the x-axis, at this instant.

[5 Marks]

Answer: (i) **Derivation of electric potential**

Consider an electric dipole with charges +q and -q separated by a distance 2a along the x-axis. The dipole moment is p = q * 2a and points from -q to +q.

(I) Electric potential at point along the axis of dipole (distance x >> a)

Let the point be at distance x on the axis of the dipole. Potential due to +q is $V_+ = k * q / (x - a)$ and due to -q is $V_- = -k * q / (x + a)$, where $k = 1 / (4\pi\varepsilon_0)$. Total potential $V = V_+ + V_- = kq [(1/(x - a)) - (1/(x + a))]$.

For x >> a, use binomial approximation: $1/(x \pm a) \approx 1/x \mp a/x^2$.

So, $V \approx kq [(1/x + a/x^2) - (1/x - a/x^2)] = kq (2a / x^2) = k (2aq) / x^2$.

Since p = 2aq, $V = k p / x^2$.

(II) Electric potential at a point along the bisector line (perpendicular bisector at distance x)

Here, distance from each charge to the point is $r = \sqrt{x^2 + a^2}$. Potential at the point is V = kq / r - kq / r = 0, but considering x >> a, the potential satisfies $V = -k p / x^2 \cos\theta$ where θ = 90 deg, so cos θ = 0, so potential is zero at the bisector axis exactly. However, the exact formula is $V = k p \cos\theta / r^2$ for any point.

(ii) **Calculation of torque and angle**

Given dipole moment vector P = $(0.8\,\hat{i} + 0.6\,\hat{j}) * 10^{-29}$ C.m and electric field E = $1.0 * 10^{7}\,\hat{k}$ V/m.

Magnitude of torque $\tau = |P| * |E| * \sin\theta$, where θ is the angle between P and E.

$|P| = \text{sqrt}(0.8^2 + 0.6^2) * 10^{-29} = 1.0 * 10^{-29}$ C.m.

$|E| = 1.0 * 10^{7}$ V/m.

Since E is along $\hat{k}$ and P lies in xy-plane, $\theta = 90$ degrees, so $\sin\theta = 1$.

Therefore, $\tau = 1.0 * 10^{-29} * 1.0 * 10^{7} * 1 = 1.0 * 10^{-22}$ N.m.

Angle made by P with x-axis:

$\tan\varphi$ = (component along $\hat{j}$) / (component along $\hat{i}$) = 0.6 / 0.8 = 0.75.

So, $\varphi = \arctan(0.75) \approx 37$ deg.

Final answers:

(i) (I) $V = (1 / 4\pi\varepsilon_0) * p / x^2$ along the axis; (II) V = 0 along the perpendicular bisector for x >> a.

(ii) Torque magnitude = $1.0 * 10^{-22}$ N.m, angle with x-axis ≈ 37 degrees.

Key Points: Definition of electric dipole and dipole moment - Expression for potential along axis using binomial approximation - Potential along bisector is zero for distant points - Torque calculated using cross product magnitude formula - Angle found using arctan of vector components

Question 37.

(i) (I) Write Ampere's cricuital law in mathematical form and explain the terms used.

(II) As the current carrying solenoid is made longer, the magnetic field produced outside it approaches zero. Why ?

(III) A flexible loop of irregular shape carrying current when located in an external magnetic field, changes to a circular shape. Give reason.

(ii) A galvanometer of resistance G is converted into a voltmeter to measure up to V volts, by connecting a resistance R_1 in series with the coil. If R_1 is replaced by R_2, then it can only measure up to V/2 volt. Find the value of the resistance R_3 (in terms of R_1 and R_2) needed to convert it into a voltmeter that can read up to 2 V.

[5 Marks]

Answer: (i) (I) Ampere's Circuital Law states that the line integral of the magnetic field B around any closed path is equal to the permeability of free space mu_0 times the net current I_{enc} enclosed by the path. Mathematically, integral of B . dl = mu_0 I_{enc}. Here, B is the magnetic field, dl is an infinitesimal length element of the closed path, mu_0 is permeability of free space,

and I_{enc} is the total current enclosed by the path.

(ii) When the solenoid carrying current is made longer, the magnetic field lines inside become more uniform and concentrated, while those outside spread apart and weaken. Therefore, the magnetic field produced outside approaches zero as the length increases because the external field contributions cancel out.

(iii) A flexible current carrying loop in an external magnetic field changes to a circular shape because the loop experiences a magnetic force that minimizes magnetic energy. The circular shape produces uniform tension and magnetic forces balance, thus the loop assumes a shape of least energy which is a circle.

(ii) Let the galvanometer resistance be G, and series resistance R_1 converts it to a voltmeter of range V volts. Then the total resistance for V volts is $R_{T1} = G + R_1$. When replaced by R_2, the voltmeter range is V/2 volts, with total resistance $R_{T2} = G + R_2$. Since voltage V is proportional to current * total resistance, the relation is $(G + R_1) * I = V$ and $(G + R_2) * I = V/2$. From this, $(G + R_2) = (G + R_1)/2$.

To convert the galvanometer to measure up to 2 V, let the series resistance be R_3, so total resistance $R_{T3} = G + R_3$. Similarly, the voltage is double, so $(G + R_3) = 2 (G + R_1)$. Using the earlier relation, substitute $G = (G + R_1) - R_1$. After substituting from the relation $(G + R_2) = (G + R_1)/2$ and simplifying, the expression for R_3 in terms of R_1 and R_2 is $R_3 = 4 R_1 - 3 R_2$. Therefore, the resistance needed for 2 V range is $R_3 = 4 R_1 - 3 R_2$.

> **Key Points: Ampere's circuital law mathematical form - Magnetic field outside solenoid weakens as length increases - Flexible current loop changes to circle to minimize energy - Voltmeters made by adding series resistance to galvanometer - Formula derivation for new resistance R3 in terms of R1 and R2**

Question 38.

(i) Two coherent light waves, each of intensity I_o superpose each other and produce interference pattern on a screen. Obtain the expression for the resultant intensity at a point where the phase difference between the waves is φ. Write its maximum and minimum possible values.

(ii) In a single slit diffraction experiment, the aperture of the slit is 3 mm and the separation between the slit and the screen is 1·5 m. A monochromatic light of wavelength 600 nm is normally incident on the slit. Calculate the distance of (I) first order minimum, and (II) second order maximum, from the centre of the screen.

[5 Marks]

Answer: (i) Intensity due to two coherent waves:

Given each wave has intensity I_o, amplitude a = sqrt(I_o). When two waves of the same frequency and amplitude interfere with phase difference φ, the resultant amplitude is A = 2a

cos(φ/2).

Resultant intensity, $I = A^2 = (2a\cos(\varphi/2))^2 = 4a^2\cos^2(\varphi/2) = 4I_o\cos^2(\varphi/2)$.

Maximum intensity occurs when $\cos^2(\varphi/2) = 1$ i.e. $\varphi = 0, \pm 2\pi, \ldots$

Max $I = 4I_o$.

Minimum intensity occurs when $\cos^2(\varphi/2) = 0$ i.e. $\varphi = \pm\pi, \pm 3\pi, \ldots$

Min I = 0.

(ii) Single slit diffraction:

Width of slit, a = 3 mm = 3*10 -3 m.

Distance between slit and screen, D = 1.5 m.

Wavelength, λ = 600 nm = 600 * 10 -9 m.

Condition for minima (dark fringes): a sin θ = m λ (m = 1,2,3 ...)

For first order minimum, m = 1

sin θ = λ / a = (600 * 10 -9) / (3 * 10 -3) = 2 * 10 -4

Distance y from centre to first minimum on screen, y = D tan θ ≈ D sin θ = 1.5 * 2 * 10 -4 = 3 * 10 -4 m = 0.3 mm.

Condition for maxima (bright fringes) in single slit diffraction is complex; however, secondary maxima occur approximately between minima.

Approximate position of second order maximum lies between m = 2 and m = 3 minima.

For m = 2 minima, sin θ = 2λ / a = 4 * 10 -4

For m = 3 minima, sin θ = 3λ / a = 6 * 10 -4

The second order maximum is roughly near 0.5*(4*10 -4 + 6*10 -4) = 5 * 10 -4

Distance y = D sin θ = 1.5 * 5 * 10 -4 = 7.5 * 10 -4 m = 0.75 mm.

Final answers:

(I) Distance of first order minimum = 0.3 mm.

(II) Distance of second order maximum ≈ 0.75 mm from centre of the screen.

> Key Points: Resultant intensity formula I = 4I0 cos2(φ/2) - Maximum intensity = 4I0, Minimum intensity = 0 - Single slit minima condition a sin θ = m λ - Distance calculation y = D sin θ for minima and maxima