CBSE EXAMINATION PAPER-2025

PHYSICS

(Solved)

Time allowed : 3 hours

Maximum Marks : 50

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **22 questions.** All questions are **compulsory.**
ii. This question paper is divided into **4 sections.**
iii. **Section A** – questions number **1 to 9** are multiple choice questions Each question carries **1 marks.**
iv. **Section B** – questions number **10 to 13** are very short answer Each question carries **2 marks.**
v. **Section C** – questions number **14 to 19** are short answer Each question carries **3 marks.**
vi. **Section D** – questions number **20 to 22** are long answer Each question carries **5 marks.**
vii. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.
viii. Use of calculator is NOT allowed.

Section A

Question 1.

A particle having charge +q enters a uniform magnetic field B as shown in the figure. The particle will describe:

[1 Marks]

(A) a circular path in XZ plane

(B) a helical path with its axis parallel to Y-axis

(C) a semicircular path in YZ plane

(D) a semicircular path in XY plane

Explanation: The correct answer is 'a circular path in XZ plane'. When a charged particle moves perpendicular to a uniform magnetic field, it experiences a magnetic force acting as a centripetal force, causing it to move in a circular path that is perpendicular to the direction of the magnetic field. As stated in the context, if the velocity is perpendicular to the magnetic field, the charged particle will execute circular motion in a plane normal to the magnetic field.

Question 2. Which one out of the following materials is not paramagnetic?

[1 Marks]

(A) Aluminium

(B) Sodium Chloride

(C) Calcium

(D) Copper Chloride

Explanation: Sodium Chloride is the correct answer as it is classified as a diamagnetic material, meaning it has a negative susceptibility and develops a net magnetic moment in the opposite direction to the applied magnetic field. In contrast, aluminium, calcium, and copper chloride are all paramagnetic materials.

Question 3.

An ammeter connected in series in an ac circuit reads 10 A. The maximum value of current at any instant in the circuit is:

[1 Marks]

(A) $10\sqrt{2}$ A

(B) $10/\sqrt{2}$ A

(C) $10/\sqrt{2}\pi$ A

(D) $10/\pi$ A

Explanation: The correct answer is $10\sqrt{2}$ A. In an AC circuit, the reading of an ammeter typically represents the root mean square (rms) value of the current. The relationship between the rms current (I_{rms}) and the maximum (peak) current (I_{max}) is given by the formula $I_{max} = I_{rms} \times \sqrt{2}$. Therefore, if the ammeter reads 10 A, the maximum current at any instant is $10 \text{ A} \times \sqrt{2}$, which equals $10\sqrt{2}$ A.

Question 4.

The amplitude of electric field in an electromagnetic wave in free space is 1000 Vm^{-1}. The amplitude of the magnetic field in this electromagnetic wave is:

[1 Marks]

(A) $3{\cdot}33 \times 10^{-8}$ T

(B) $3{\cdot}0 \times 10^{-11}$ T

(C) $3{\cdot}0 \times 10^{-3}$ T

(D) $3{\cdot}33 \times 10^{-6}$ T

Explanation: The relationship between the electric field amplitude (E0) and the magnetic field amplitude (B0) in an electromagnetic wave is given by the equation B0 = E0/c, where c is the speed of light (approximately 3 × 10^8 m/s). Substituting E0 = 1000 Vm^{-1}, we get B0 = 1000 / (3 × 10^8) = 3.33×10^{-6} T. Therefore, the correct answer is $3{\cdot}33 \times 10^{-6}$ T.

Question 5. Choose the correct statement:

[1 Marks]

(A) Photons of light show diffraction whereas electrons do not show diffraction.

(B) Electrons have momentum whereas photons do not have momentum.

(C) All electromagnetic radiations do not have photons.

(D) Photons of light and electrons both exhibit dual nature.

Explanation: The correct answer is 'Photons of light and electrons both exhibit dual nature.' This is correct because the context explains that both light (as electromagnetic radiation) and particles like electrons demonstrate wave-particle duality, where they can exhibit characteristics of both waves and particles depending on the circumstances.

Question 6. Which of the following is an electrical conductor at room temperature?

[1 Marks]

(A) Mica

(B) Sn

(C) Si

(D) C

Explanation: The correct answer is Sn (tin), as it is a metal with a resistivity in the low range (10–2 to 10–8 Ω·m), making it a good electrical conductor at room temperature. The other options, Mica (an insulator), Si (a semiconductor with higher resistivity), and C (diamond, which is also an insulator), do not qualify as conductors.

Question 7. A long straight wire is held vertically and carries a steady current in upward direction. The shape of magnetic field lines produced by the current-carrying wire are:

[1 Marks]

(A) horizontal straight lines directed radially out from the wire.

(B) straight lines parallel to the current-carrying wire.

(C) concentric horizontal circles around the wire.

(D) coaxial helixes around the wire.

Explanation: The correct option is 'concentric horizontal circles around the wire.' According to the right-hand rule, if the thumb of the right hand points in the direction of the current (upward), the fingers will curl around the wire in concentric circles, indicating that the magnetic field lines form closed loops that are horizontal and circular around the wire.

Question 8.

Assertion (A): In double slit experiment if one slit is closed, diffraction pattern due to the other slit will appear on the screen.

Reason (R): For interference, at least two waves are required.

[1 Marks]

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

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

Explanation: Assertion (A) is true because when one slit is closed, the remaining slit produces a diffraction pattern due to the wave nature of light. Reason (R) is also true but does not serve as an explanation for Assertion (A) because the diffraction pattern occurs from a single slit and does not require two waves; interference specifically requires two waves.

Question 9.

Assertion (A): For monochromatic incident radiation, the emitted photoelectrons from a given metal have speed ranging from zero to a certain maximum value.

Reason (R): Each metal has a definite work function.

[1 Marks]

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

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

Explanation: Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). The assertion correctly states that emitted photoelectrons have a range of speeds up to a maximum due to differences in energy absorption related to the work function. However, the reason provided does not explain why photoelectrons have varying speeds; it merely states that each metal has a definite work function.

Section B

Question 10.

In the given figure, three identical bulbs P, Q and S are connected to a battery.

(i) Compare the brightness of bulbs P and Q with that of bulb S when key K is closed.

(ii) Compare the brightness of the bulbs S and Q when the key K is opened.

Justify your answer in both cases.

[2 Marks]

Answer: When key K is closed, bulbs P and Q are in series, and bulb S is in parallel. Therefore, bulbs P and Q will have lower brightness compared to bulb S because the voltage across S is higher, allowing it to shine brighter. When key K is opened, S is in series with Q, leading to less power and brightness in both. Thus, bulb S will be brighter than bulb Q when K is open due to the changed circuit configuration.

Question 11. Two cells of emf 10 V each, two resistors of 20 Ω and 10 Ω and a bulb B of 10 Ω resistance are connected together as shown in the figure. Find the current that flows through the bulb.

[2 Marks]

Answer: To find the current flowing through the bulb B, we first calculate the total emf in the circuit. Since the cells are in series, their emfs add up: 10 V + 10 V = 20 V. The total resistance in the circuit includes the resistors and the bulb, giving 20 Ω + 10 Ω + 10 Ω = 40 Ω. Using Ohm's Law (I = V/R), the current I is 20 V / 40 Ω = 0.5 A.

Question 12. Find the angle of diffraction (in degrees) for first secondary maximum of the pattern due to diffraction at a single slit. The width of the slit and wavelength of light used are 0.55 mm and 550 nm, respectively.

[2 Marks]

Answer: To find the angle of diffraction for the first secondary maximum in a single slit diffraction pattern, we use the formula: θ = (n + 1/2) λ / a. Here, n = 0 for the first maximum, λ = 550 nm (which is 550 x 10^-9 m), and a = 0.55 mm (which is 0.55 x 10^-3 m). Substituting values, θ = (0 + 1/2) (550 x 10^-9) / (0.55 x 10^-3) = 0.5 x 0.001 = 0.0005 radians. Converting to degrees, θ ≈ 0.029 degrees.

Question 13. An equiconvex lens is made of glass of refractive index 1.55. If the focal length of the lens is 15.0 cm, calculate the radius of curvature of its surfaces.

[2 Marks]

Answer: To calculate the radius of curvature of an equiconvex lens, we use the lens maker's formula: 1/f = (n - 1) (1/R1 - 1/R2). For an equiconvex lens, R1 = R and R2 = -R. Substituting values, we have 1/15 = (1.55 - 1)(1/R - 1/(-R)). Solving gives R = 30 cm.

Section C

Question 14.

(i) Derive an expression for the resistivity of a conductor in terms of number density of free electrons and relaxation time.

(ii) The figure shows the plot of current through a cross-section of wire over two different time intervals. Compare the charges (Q_1 and Q_2) that pass through the cross-section during these time intervals.

[3 Marks]

Answer: (i) The resistivity (ρ) of a conductor can be derived using the relation $J = nqv_d$, where J is the current density, n is the number density of free electrons, q is the charge of an electron, and v_d is the average drift velocity. The current I is related by $I = J \cdot A$, where A is the cross-sectional area. By expressing drift velocity in terms of relaxation time τ, we get $v_d = \frac{eE\tau}{m}$. Substituting this into the expression for current, we can find that resistivity is given by $\rho = m/(nq^2\tau)$. \n(ii) The figures likely show two different current plots over time intervals Δt_1 and Δt_2. The areas under the current-time graphs represent the total charge Q that passes through the cross-section of the wire. If Q_1 is the area under one time interval and Q_2 is that under another, the comparison will reveal how the currents in different intervals affect the charge passed. For intervals with higher current, more charge passes due to higher current density.

Question 15.

(a) Write vector form of Biot-Savart law.

(b) Two insulated long straight wires, each carrying 2·0 A current are kept along xx' and yy' axis as shown in the figure. Find the magnitude and direction of resultant magnetic field at point P (4m, 5m).

[3 Marks]

Answer: The vector form of the Biot-Savart law is expressed as: \n\n$dB = (\mu_0/4\pi) * (I * dl \times \hat{r}) / r^2$ \n\nwhere dB is the infinitesimal magnetic field produced at point P by the element dl, μ_0 is the permeability of free space, I is the current through the conductor, and $\hat{r}$ is the unit vector from the current element to the observation point P. \n\nFor finding the magnetic field at point P due to each wire, we can break the contributions of each wire down. From the wire along the x-axis and the one along the y-axis, both producing fields that can be calculated and combined vectorially to get the resultant magnetic field at point P.

Question 16.

(a) State any three characteristics of electromagnetic waves.

(b) Briefly explain how and where the displacement current exists during the charging of a capacitor.

[3 Marks]

Answer: Electromagnetic waves exhibit several crucial characteristics. Firstly, they consist of oscillating electric and magnetic fields that are perpendicular to each other and the direction of propagation. Secondly, they can travel through a vacuum at the speed of light (approximately 3×10^8 m/s), showcasing their ability to propagate in the absence of a medium. Thirdly, they encompass a wide spectrum, ranging from gamma rays with very short wavelengths to radio waves with long wavelengths, illustrating their diverse applications. \n\nDuring the charging of a capacitor, the displacement current arises in the region between the capacitor plates where an electric field changes over time. This changing electric field creates a displacement current, allowing the flow of electric charges via electromagnetic waves, despite the absence of a physical current in the dielectric medium. The magnitude of this displacement current is quantitatively expressed by the equation $i_d = \varepsilon_0 (d\Phi_E/dt)$, indicating its direct relationship with the rate of change of the electric flux over time.

Question 17.

A double slit set-up was initially placed in a tank filled with water and the interference pattern was obtained using a laser light. When water is replaced by a transparent liquid of refractive index $n > n_{water}$, what will be the effect on the following ?

(a) Speed, frequency and wavelength of the light of laser beam.

(b) The fringe width, shape of interference fringes and shift in the position of central maximum.

[3 Marks]

Answer: When the water in the double slit experiment is replaced by a transparent liquid with a greater refractive index, the speed of light in the liquid decreases due to the higher refractive index, while the frequency remains constant since it only depends on the source. Consequently, the wavelength of the light also decreases because the relationship between speed, frequency and wavelength is given by the equation $v = f\lambda$. For part (b), the fringe width decreases because the fringe width is inversely proportional to the refractive index. The shape of the interference fringes may slightly change as they become more compressed, and the central maximum shifts in position due to the changes in wavelength, which affects the angle of diffraction.

Question 18.

(a) Explain briefly the formation of diffusion current and drift current in a p-n junction diode.

(b) What are majority and minority charge carriers of p-type and n-type semiconductors?

[3 Marks]

Answer: In a p-n junction diode, diffusion current is formed due to the movement of charge carriers from high to low concentration. Holes from the p-side diffuse to the n-side while electrons from the n-side diffuse to the p-side. This results in an initial large diffusion current. However, as the diffusion continues, the space-charge region creates an electric field that opposes further diffusion, generating a drift current. Drift current occurs as charge carriers, influenced by the electric field, move toward regions of majority carriers. In an n-type semiconductor, electrons are the majority carriers while holes are the minority carriers. Conversely, in a p-type semiconductor, holes are the majority carriers and electrons are the minority carriers.

Question 19.

Two coils '1' and '2' are placed close to each other as shown in the figure. Find the direction of induced current in coil '1' in each of the following situations, justifying your answers :

(a) Coil '2' is moving towards coil '1'.

(b) Coil '2' is moving away from coil '1'.

(c) The resistance connected with coil '2' is increased keeping both the coils stationary.

[3 Marks]

Answer: In coil '1', the direction of induced current depends on the relative motion of coil '2'. (a) When coil '2' moves towards coil '1', the magnetic flux through coil '1' increases. According to Lenz's Law, to oppose this, induced current flows in such a way as to create a magnetic field opposing the increase, resulting in a current in the direction that produces a north pole on coil '1'. (b) When coil '2' moves away, the magnetic flux through coil '1' decreases, and induced current flows in a direction to oppose the decrease, creating a magnetic field that retains flux, hence flowing opposite to the previous direction. (c) Increasing resistance in coil '2' does not change the current flowing through it immediately; therefore, no change in magnetic flux occurs through coil '1', resulting in no induced current.

Section D

Question 20.

(i) Show that Gauss's theorem is consistent with Coulomb's law. Using it, derive an expression for the electric field due to a uniformly charged thin spherical shell of radius r at a point at a distance y from the center of the shell such that (I) $y > r$, and (II) $y < r$.

(ii) A point charge of +2 nC is kept at the origin of a three-dimensional coordinate system. Find the type and magnitude of the charge which should be kept at (0, 0, -6m) so that the potential due to the system becomes zero at (0, 0, 2m).

[5 Marks]

Answer: (i) **Gauss's theorem and Coulomb's law consistency:** According to Coulomb's law, the electric field E due to a point charge is radial and its magnitude varies as $1/y^2$. Gauss's theorem states that the net electric flux through a closed surface is proportional to the charge enclosed. For a spherically symmetric charge distribution, Gauss's law gives the electric field as E times the surface area of the sphere equals the enclosed charge divided by epsilon zero.

For a uniformly charged thin spherical shell of radius r and total charge Q:
(I) When $y > r$ (outside the shell): The Gaussian surface encloses the entire charge Q. By Gauss's law, $E * 4 \pi y^2 = Q / \epsilon_0$. Therefore, $E = (1 / 4 \pi \epsilon_0) * (Q / y^2)$. This matches Coulomb's law for a point charge, showing consistency.

(II) When $y < r$ (inside the shell): The Gaussian surface encloses no charge, so enclosed charge = 0. Hence, $E * 4 \pi y^2 = 0$ leading to $E = 0$. So, the electric field inside the spherical shell is zero.

(ii) Let the charge at (0,0,-6m) be q. The potential at point (0,0,2m) due to +2 nC at origin is $V1 = (1 / 4 \pi \epsilon_0) * (2 * 10^{-9} C / 2)$. The distance from charge q to point (0,0,2m) is 8 m. The potential due to q at that point is $V2 = (1 / 4 \pi \epsilon_0) * (q / 8)$. The total potential $V = V1 + V2 = 0$.
Therefore, $(2 / 2) + (q / 8) = 0$ (in units of $(1 / 4 \pi \epsilon_0)$. Multiply both sides by 8: $8*(2/2) + q = 0 \rightarrow 8 * 1 + q = 0 \rightarrow q = -8$ nC.

The charge to be kept at (0,0,-6m) should be negative with magnitude 8 nC to make the potential zero at (0,0,2m).

Question 21.

(i) An object is placed 30 cm from a thin convex lens of focal length 10 cm. The lens forms a sharp image on a screen. If a thin concave lens is placed in contact with the convex lens, the sharp image on the screen is formed when the screen is moved by 45 cm from its initial position. Calculate the focal length of the concave lens.

(ii) Calculate the angle of minimum deviation of an equilateral prism. The refractive index of the prism is √3. Calculate the angle of incidence for this case of minimum deviation also.

[5 Marks]

Answer: (i) Given: Object distance u = -30 cm (since object is in front of the lens), focal length of convex lens f_1 = +10 cm.
Using lens formula 1/f = 1/v - 1/u, for convex lens:
1/10 = 1/v - 1/(-30) => 1/10 = 1/v + 1/30 => 1/v = 1/10 - 1/30 = (3 - 1)/30 = 2/30 => v = 15 cm.
So, image is formed at 15 cm on the other side.
Now, when a concave lens of focal length f_2 is placed in contact with convex lens, the combination focal length f is such that the final image forms on the screen moved by 45 cm.
Initial image distance = 15 cm, so new image distance = 15 + 45 = 60 cm.
Using lens formula for combination: 1/f = 1/v - 1/u = 1/60 - 1/(-30) = 1/60 + 1/30 = (1 + 2)/60 = 3/60 = 1/20 => f = 20 cm.
For lenses in contact, 1/f = $1/f_1$ + $1/f_2$ => 1/20 = 1/10 + $1/f_2$ => $1/f_2$ = 1/20 - 1/10 = (1 - 2)/20 = -1/20 => f_2 = -20 cm.
Thus, focal length of concave lens is -20 cm.

(ii) Given: Refractive index of prism, n = sqrt(3), prism angle A = 60 deg (equilateral prism).
Using the formula for refractive index n = sin((A + D_{min})/2) / sin(A/2).
Let D_{min} be angle of minimum deviation.
sin((60 + D_{min})/2) = n * sin(30) = sqrt(3) * 1/2 = sqrt(3)/2 ≈ 0.866.
Therefore, (60 + D_{min})/2 = 60 deg (since sin 60 deg = 0.866). So, (60 + D_{min}) = 120 deg => D_{min} = 60 deg.

Angle of minimum deviation D_{min} = 60 deg.
Also, angle of incidence i for minimum deviation is given by:
i = (A + D_{min})/2 = (60 + 60)/2 = 60 deg.

Hence,
Angle of minimum deviation = 60 deg
Angle of incidence for minimum deviation = 60 deg.

Question 22.

(i) A physics teacher wants to demonstrate interference with the help of double slit experiment using a laser beam of 633 nm wavelength. Since the hall is large enough, interference pattern is formed on the wall 5·0 m from the slits. For clear and comfortable view by all the students they want the fringe width 5 mm.

(I) Find the slit separation for obtaining the desired interference pattern.

(II) How far will the first minimum be from the central maximum ?

(ii) A parallel beam of light of wavelength 650 nm passes through a slit of width 0·6 mm. The diffraction pattern is obtained on a screen kept 60 cm away from the slit. Find the distance between first order minima on both sides of the central maximum.

[5 Marks]

Answer: (i) (I) Given:
Wavelength, $\lambda = 633\ extnm = 633imes10^{-9}\ extm$
Distance to screen, $D = 5.0\ extm$
Desired fringe width, $\beta = 5\ extmm = 5imes10^{-3}\ extm$

The fringe width β in double slit experiment is given by:
$\beta = \frac{\lambda D}{d}$, where d is slit separation.
Rearranging, $d = \frac{\lambda D}{\beta} = \frac{633imes10^{-9}imes5}{5imes10^{-3}} = 6.33imes10^{-4}\ extm = 0.633\ extmm$

(II) The first minimum in a double slit interference occurs at an angle $heta$ where:
$d \sin heta = \lambda$
For small angles, $\sin heta \approx anheta = y/D$, where y is the distance of the first minimum from central maximum.
So,
$y = \frac{\lambda D}{d} = \beta = 5\ extmm$
Therefore, the first minimum is 5 mm from the central maximum.

(ii) Given:
Wavelength, $\lambda = 650\ extnm = 650imes10^{-9}\ extm$
Slit width, $a = 0.6\ extmm = 0.6imes10^{-3}\ extm$
Screen distance, $D = 60\ extcm = 0.6\ extm$

In single slit diffraction, the position of minima is given by:
$a \sin heta = m\lambda$, where m = 1,2,...
For small angle $\sin heta \approx y/D$, so:
$y = \frac{m\lambda D}{a}$
For first order minima (m=1), distance from central maximum to first minima on one side:
$y = \frac{1imes650imes10^{-9}imes0.6}{0.6imes10^{-3}} = 6.5imes10^{-4}\ extm = 0.65\ extmm$
Distance between first order minima on both sides:
$2y = 2imes0.65 = 1.3\ extmm$

Final answers :
(i)(I) Slit separation $d = 0.633\ extmm$
(i)(II) Distance of first minimum from central maximum = 5 mm
(ii) Distance between first order minima on both sides = 1.3 mm