CBSE EXAMINATION PAPER-2025

PHYSICS

(Solved)

Time allowed : 3 hours | Maximum Marks : 52

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **27 questions.** All questions are **compulsory.**
ii. This question paper is divided into **4 sections.**
iii. **Section A** – questions number **1 to 14** are multiple choice questions Each question carries **1 marks.**
iv. **Section B** – questions number **15 to 19** are very short answer Each question carries **2 marks.**
v. **Section C** – questions number **20 to 25** are short answer Each question carries **3 marks.**
vi. **Section D** – questions number **26 to 27** 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. 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/s^2 = 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 2.

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 3.

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 4.

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 5.

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 6.

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 7. 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 8. 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 9.

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 10.

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 11.

Assertion (A) : A charged particle is moving with velocity v in x-y plane, making an angle **θ** (0 <**θ** < **π/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 12.

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 13.

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 14.

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 B

Question 15.

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.

Question 16.

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.

Question 17. 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.

Question 18. 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 → 2 1 H + e+ + ν), 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 → 3 2 H + n + 3. In stars, this process occurs at extremely high temperatures, driving stellar energy output.

Question 19.

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.

Section C

Question 20.

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.

Question 21.

(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 √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.

Question 22.

(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.

Question 23.

(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.

Question 24.

(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.

Question 25.

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.

Section D

Question 26.

(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.

Question 27.

(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.