

Question Paper

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 Hours

Maximum Marks: 70

General Instructions

- (i) This question paper contains **37 questions**. All questions are **compulsory**.
- (ii) The question paper is divided into Sections A, B, C, D.
- (iii) Section A - Questions 1 to 20 carry 1 mark each.
- (iv) Section B - Questions 21 to 27 carry 2 marks each.
- (v) Section C - Questions 28 to 34 carry 3 marks each.
- (vi) Section D - Questions 35 to 37 carry 5 marks each.
- (vii) There is no overall choice. Where an internal choice is provided, attempt only one of the alternatives.
- (viii) Use of calculators is not permitted.

You may use the following values of physical constants wherever necessary:

$$\begin{aligned}c &= 3 \times 10^8 \text{ m/s} \\h &= 6.63 \times 10^{-34} \text{ Js} \\e &= 1.6 \times 10^{-19} \text{ C} \\\mu_0 &= 4\pi \times 10^{-7} \text{ T m A}^{-1} \\\epsilon_0 &= 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \\\frac{1}{4\pi\epsilon_0} &= 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}\end{aligned}$$

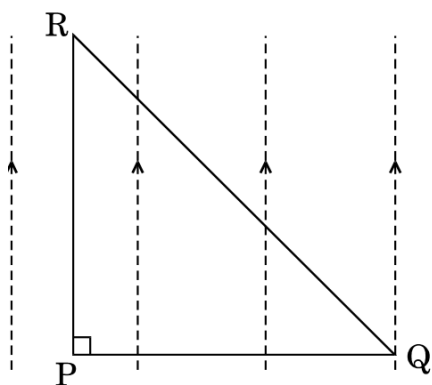
$$\begin{aligned}\text{Mass of electron } (m_e) &= 9.1 \times 10^{-31} \text{ kg} \\\text{Mass of neutron} &= 1.675 \times 10^{-27} \text{ kg} \\\text{Mass of proton} &= 1.673 \times 10^{-27} \text{ kg} \\\text{Avogadro's number} &= 6.023 \times 10^{23} \text{ per gm mole} \\\text{Boltzmann constant} &= 1.38 \times 10^{-23} \text{ JK}^{-1}\end{aligned}$$

Section A

1. A charge Q is kept at the centre of a circle of radius r . A test charge q_0 is carried from a point X to the point Y on this circle such that arc XY subtends an angle of 60° at the centre of the circle. The amount of work done in this process will be

- (A) $\frac{1}{4\pi\epsilon_0} \frac{Qq_0}{2r}$ (B) $\frac{1}{4\pi\epsilon_0} \frac{\sqrt{3} Qq_0}{2r}$
 (C) Zero (D) $\frac{\sqrt{3} Qq_0}{4\pi\epsilon_0 r}$

2. An isosceles right angled current carrying loop PQR is placed in a uniform magnetic field $\vec{B}$ pointing along PR. If the magnetic force acting on the arm PQ is F , then the magnetic force which acts on the arm QR will be



- (A) F (B) $\frac{F}{\sqrt{2}}$
 (C) $\sqrt{2} F$ (D) $-F$

3. An electric dipole consisting of charges $+q$ and $-q$ separated by a distance r , is kept symmetrically at the centre of an imaginary sphere of radius R ($> r$). Another point charge Q is also kept at the centre of the sphere. The net electric flux coming out of the sphere will be

- (A) $\frac{1}{4\pi\epsilon_0} (2q + Q)$ (B) $\frac{Q}{\epsilon_0}$
 (C) $\frac{2q + Q}{\epsilon_0}$ (D) $\frac{2q}{\epsilon_0}$

4. A parallel plate capacitor is charged to V volt by a battery. The battery is disconnected and the separation between the plates is halved. The new potential difference across the capacitor will be

- (A) $\frac{V}{2}$ (B) V
 (C) $2V$ (D) $\frac{V}{4}$

5. A region has a uniform magnetic field in it. A proton enters into the region with velocity making an angle of 45° with the direction of the magnetic field. In this region the proton will move on a path having the shape of a

- (A) straight line (B) circle
 (C) spiral (D) helix

6. n resistors, each of resistance R are connected (a) in series, and (b) in parallel. Each combination is then connected to a source of emf E . The ratio of heat produced per second in the two cases will be

- (A) $n : 1$ (B) $1 : n$
 (C) $n^2 : 1$ (D) $1 : n^2$

7. A zener diode has

- (A) heavily doped p-side and lightly doped n-side. (B) heavily doped n-side and lightly doped p-side.
(C) heavily doped n-side as well as p-side. (D) lightly doped n-side as well as p-side.

8. In Bohr's model of hydrogen atom, the total energy of the electron in n^{th} discrete orbit is proportional to

- (A) n (B) $\frac{1}{n}$
(C) n^2 (D) $\frac{1}{n^2}$

9. $\text{m}^2 \text{V}^{-1} \text{s}^{-1}$ is the SI unit of which of the following?

- (A) Drift velocity (B) Mobility
(C) Resistivity (D) Potential gradient

10. The electric flux emerging out from 1 C charge is

- (A) $\frac{1}{\epsilon_0}$ (B) 4π
(C) $\frac{\epsilon_0}{4\pi}$ (D) ϵ_0

11. In Young's double slit experiment, when the monochromatic source is replaced by a source of white light, the central fringe becomes _____.

12. In photoelectric effect, the number of emitted photoelectrons is proportional to _____ of incident light.

OR

Light of frequency ν is incident on a photosensitive surface of threshold frequency ν_0 ($\nu > \nu_0$). The value of kinetic energy of the emitted photoelectrons will be _____.

13. The phase difference between the two points on the same wavefront is _____.

14. The refractive index of the material of a converging lens is 1.5. If air is replaced by a medium of refractive index 1.6, then the lens will now behave as a _____ lens.

15. The value of Brewster's angle for air-glass interface is $\frac{\pi}{3}$; hence the refractive index of glass is _____.

16. A circuit element is connected across an ac source. It is observed that the voltage across the element leads the current flowing through it by a phase angle $\frac{\pi}{2}$. Identify the circuit element.

17. Write the impedance of a series LCR resonant circuit in terms of L , C and R .

18. Mention the contribution of Indian physicist J.C. Bose in the production of electromagnetic waves.

19. In an ac circuit, the applied voltage and flowing current are $E = E_0 \sin \omega t$ and $I = I_0 \sin \left(\omega t + \frac{\pi}{2} \right)$ respectively. What is the average power consumed in one cycle in this circuit?

OR

What happens when a block of metal is kept in a varying magnetic field?

20. Which physical quantity associated with an electromagnetic wave does not change when it propagates from one medium into another medium?

Section B

21. A battery of emf 12 V and internal resistance $4\ \Omega$ is connected to an external resistance R . If the current in the resistance is 0.5 A, calculate the value of (a) R , and (b) the terminal voltage of the battery.

22. A converging lens of focal length f_1 is placed coaxially in contact with a diverging lens of focal length f_2 ($f_1 > f_2$). Determine the power and nature of the combination in terms of f_1 and f_2 .

OR

How is the resolving power of a compound microscope affected if (a) wavelength of light used is decreased, and (b) the diameter of its objective lens is increased? Justify your answers.

23. The energy stored in a solenoid of inductance L is U . The number of turns per unit length of the solenoid is doubled. Keeping the current and all other factors same, find (a) change in inductance of the solenoid, and (b) the final energy stored in the inductor.

24. A hydrogen atom is in its third excited state.

(a) How many spectral lines can be emitted by it before coming to the ground state? Show these transitions in the energy level diagram.

(b) In which of the above transitions will the spectral line of shortest wavelength be emitted?

25. Two identical bars, one of paramagnetic material and other of diamagnetic material are kept in a uniform external magnetic field parallel to it. Draw diagrammatically the modifications in the magnetic field pattern in each case.

26. The de Broglie wavelengths associated with an electron and a proton are equal. Prove that the kinetic energy of the electron is greater than that of the proton.

27. How does an oscillating charge radiate an electromagnetic wave? Give the relation between the frequency of radiated wave and the frequency of oscillating charge.

OR

(a) Explain briefly the fact that electromagnetic waves carry energy.

(b) Why do we not feel the pressure due to sunshine?

Section C

28. (a) Write the relationship between mobility and drift velocity in a current carrying conductor.

(b) Two aluminium wires have their lengths in the ratio 2 : 3 and radii in the ratio 1 : 3. These are connected in parallel across a battery of emf E and of negligible internal resistance. Find the ratio of drift velocities of the electrons in the two wires.

29. (a) Why is an intrinsic semiconductor deliberately converted into an extrinsic semiconductor by adding impurity atoms?

(b) Explain briefly the two processes that occur in p-n junction region to create a potential barrier.

30. (a) The density of the nuclear matter is tremendously larger than the physical density of the material. Explain.

(b) The nuclear forces are not coulomb forces between nucleons. Explain.

(c) Draw a plot of the potential energy between a pair of nucleons as a function of distance between them inside a nucleus.

31. What are matter waves? Find the ratio of de Broglie wavelengths associated with proton and alpha particles when both particles

(a) are accelerated through the same potential difference.

(b) have same velocity.

32. (a) Using the necessary ray diagram, derive the mirror formula for a concave mirror.

(b) In the magnified image of a measuring scale (with equidistant markings) lying along the principal axis of a concave mirror, the markings are not equidistant. Explain.

33. With the help of a circuit diagram, explain how two p-n junction diodes along with a centre tapped transformer can be used as a full wave rectifier.

34. A series LCR ac circuit has $L = 2.0 \text{ H}$, $C = 32 \mu\text{F}$ and $R = 10 \Omega$.

(a) At what angular frequency of ac will it resonate?

(b) Calculate the Q value of the circuit.

OR

An ideal inductor of 5 H inductance is connected to a 200 V, 50 Hz ac supply.

(a) Calculate the rms and peak value of current in the inductor.

(b) What is the phase difference between current through the inductor and the applied voltage? How will it change if a small resistance is connected in series with this inductor in the circuit?

Section D

35. (a) Derive the expression for the force acting per unit length between two long straight parallel current carrying conductors. Hence define one ampere.

(b) Two long parallel straight conductors are placed 12 cm apart in air. They carry equal currents of 3 A each. Find the magnitude and direction of the magnetic field at a point midway between them (drawing a figure) when the currents in them flow in opposite directions.

OR

(a) Draw the schematic sketch of a cyclotron. Explain the shape of the path on which charged particle moves when the particle is accelerated by it.

(b) To convert a given galvanometer into a voltmeter of ranges $2V$, V and $\frac{V}{2}$ volt, resistances R_1 , R_2 and R_3 ohm respectively, are required to be connected in series with the galvanometer. Obtain the relationship between R_1 , R_2 and R_3 .

36. (a) What is meant by plane polarised light? An unpolarised light is incident at an angle θ on the surface of glass of refractive index μ . If the reflected and refracted rays are perpendicular to each other, then obtain the relationship between μ and θ .

(b) Two polaroids P_1 and P_2 are placed in a crossed position. Unpolarised light of intensity I_0 is incident on P_1 . If P_2 is rotated through an angle θ about the direction of propagation of light, keeping P_1 fixed, plot the graph of intensity of light for $0^\circ \leq \theta \leq 360^\circ$ which is (i) transmitted by P_1 , and (ii) transmitted by P_2 .

OR

(a) Briefly describe the Young's double slit experiment of interference of light. Derive the expression for fringe width in the pattern.

(b) Monochromatic light of wavelength 588 nm is incident from air to water interface. Find the wavelength and speed of the refracted light. The refractive index of water is $\frac{4}{3}$.

37. (a) An electric dipole of dipole moment $\vec{P}$ is placed in a uniform electric field $\vec{E}$ at an angle θ with it. Derive the expression for torque ($\vec{\tau}$) acting on it. Find the orientation of the dipole relative to the electric field for which torque on it is (i) maximum, and (ii) half of maximum.

(b) Two point charges $q_1 = +1 \mu\text{C}$ and $q_2 = +4 \mu\text{C}$ are placed 2 m apart in air. At what distance from q_1 along the line joining the two charges, will the net electric field be zero?

OR

(a) Derive an expression for the energy stored in a parallel plate capacitor of capacitance C when charged up to voltage V . How is this energy stored in the capacitor?

(b) A capacitor of capacitance $1 \mu\text{F}$ is charged by connecting a battery of negligible internal resistance and emf 10 V across it. Calculate the amount of charge supplied by the battery in charging the capacitor fully.

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