

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 **27 questions**. All questions are **compulsory**.
- (ii) The question paper is divided into Sections A, B, C, D.
- (iii) Section A - Questions 1 to 5 carry 1 mark each.
- (iv) Section B - Questions 6 to 12 carry 2 marks each.
- (v) Section C - Questions 13 to 24 carry 3 marks each.
- (vi) Section D - Questions 25 to 27 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. Define the term "threshold frequency", in the context of photoelectric emission.

OR

1. Define the term "Intensity" in photon picture of electromagnetic radiation.

2. When unpolarised light is incident on the interface separating the rarer medium and the denser medium, Brewster angle is found to be 60° . Determine the refractive index of the denser medium.

3. In sky wave mode of propagation, why is the frequency range of transmitting signals restricted to less than 30 MHz?

OR

3. On what factors does the range of coverage in ground wave propagation depend?

4. When a potential difference is applied across the ends of a conductor, how is the drift velocity of the electrons related to the relaxation time?

5. Draw the equipotential surfaces due to an isolated point charge.

Section B

6. Explain with the help of Einstein's photoelectric equation any two observed features in photoelectric effect which cannot be explained by wave theory.

7. A deuteron and an alpha particle having same momentum are in turn allowed to pass through a magnetic field $\vec{B}$, acting normal to the direction of motion of the particles. Calculate the ratio of the radii of the circular paths described by them.

8. Two bulbs are rated (P_1, V) and (P_2, V) . If they are connected (i) in series and (ii) in parallel across a supply V , find the power dissipated in the two combinations in terms of P_1 and P_2 .

9. Calculate the radius of curvature of an equi-concave lens of refractive index 1.5, when it is kept in a medium of refractive index 1.4, to have a power of -5 D .

OR

9. An equilateral glass prism has a refractive index 1.6 in air. Calculate the angle of minimum deviation of the prism, when kept in a medium of refractive index $\frac{4\sqrt{2}}{5}$.

10. State Bohr's quantization condition of angular momentum. Calculate the shortest wavelength of the Brackett series and state to which part of the electromagnetic spectrum does it belong.

OR

10. Calculate the orbital period of the electron in the first excited state of hydrogen atom.

11. Plot a graph showing variation of de Broglie wavelength (λ) associated with a charged particle of mass m , versus $\frac{1}{\sqrt{V}}$, where V is the potential difference through which the particle is accelerated. How does this graph give us the information regarding the magnitude of the charge of the particle?

11(b). An electron, a proton and an alpha particle have the same kinetic energy. Which one has the shortest wavelength?

12. Why a signal transmitted from a TV tower cannot be received beyond a certain distance? Write the expression for the optimum separation between the receiving and the transmitting antenna.

Section C

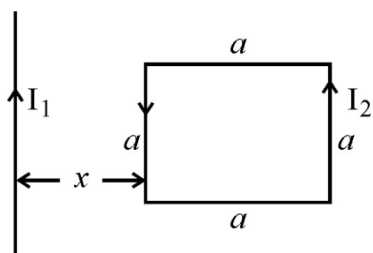
13(a). State the underlying principle of a moving coil galvanometer.

13(b). Give two reasons to explain why a galvanometer cannot as such be used to measure the value of the current in a given circuit.

13(c). Define the terms: (i) voltage sensitivity and (ii) current sensitivity of a galvanometer.

14(a). Define mutual inductance and write its S.I. unit.

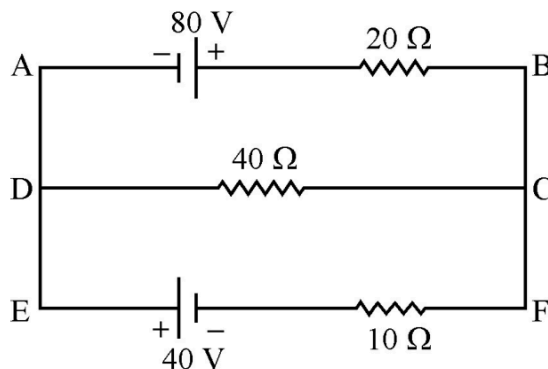
14(b). A square loop of side ' a ' carrying a current I_2 is kept at distance x from an infinitely long straight wire carrying a current I_1 as shown in the figure. Obtain the expression for the resultant force acting on the loop.



15(a). Draw equipotential surfaces corresponding to the electric field that uniformly increases in magnitude along with the z -direction.

15(b). Two charges $-q$ and $+q$ are located at points $(0, 0, -a)$ and $(0, 0, a)$. What is the electrostatic potential at the points $(0, 0, +z)$ and $(x, y, 0)$?

16. Using Kirchhoff's rules, calculate the current through the $40\ \Omega$ and $20\ \Omega$ resistors in the following circuit:



OR

16. What is end error in a metre bridge? How is it overcome? The resistances in the two arms of the metre bridge are $R = 5\ \Omega$ and S respectively. When the resistance S is shunted with an equal resistance, the new balance length is found to be $1.5 l_1$, where l_1 is the initial balancing length. Calculate the value of S .

17(a). Write the relation between half life and average life of a radioactive nucleus.

17(b). In a given sample two isotopes A and B are initially present in the ratio of $1 : 2$. Their half lives are 60 years and 30 years respectively. How long will it take so that the sample has these isotopes in the ratio of $2 : 1$?

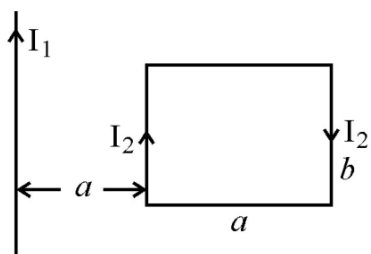
18. Define the term wavefront. Using Huygens' wave theory, verify the law of reflection.

OR

18. Define the term, "refractive index" of a medium. Verify Snell's law of refraction when a plane wavefront is propagating from a denser to a rarer medium.

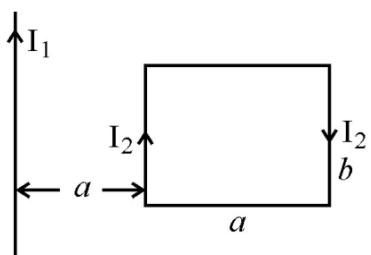
19. (a) Define the term 'self inductance' of a coil. Write its S.I. unit.

(b) A rectangular loop of sides a and b carrying current I_2 is kept at a distance ' a ' from an infinitely long straight wire carrying a current I_1 as shown in the figure. Obtain the expression for the resultant force acting on the loop.



19(a). Define the term 'self inductance' of a coil. Write its S.I. unit.

19(b). A rectangular loop of sides a and b carrying current I_2 is kept at a distance ' a ' from an infinitely long straight wire carrying current I_1 as shown in the figure. Obtain an expression for the resultant force acting on the loop.



20(a). Describe briefly the functions of the three segments of n-p-n transistor.

20(b). Draw the circuit arrangement for studying the output characteristics of n-p-n transistor in CE configuration. Explain how the output characteristics is obtained.

OR

20. Draw the circuit diagram of a full wave rectifier and explain its working. Also, give the input and output waveforms.

21(a). If A and B represent the maximum and minimum amplitudes of an amplitude modulated wave, write the expression for the modulation index in terms of A & B .

21(b). A message signal of frequency 20 kHz and peak voltage 10 V is used to modulate a carrier of frequency 2 MHz and peak voltage of 15 V. Calculate the modulation index. Why the modulation index is generally kept less than one?

22(a). State Gauss's law for magnetism. Explain its significance.

22(b). Write the four important properties of the magnetic field lines due to a bar magnet.

OR

22. Write three points of differences between para-, dia- and ferro-magnetic materials, giving one example for each.

23(a). Identify the part of the electromagnetic spectrum used in (i) radar and (ii) eye surgery. Write their frequency range.

23(b). Prove that the average energy density of the oscillating electric field is equal to that of the oscillating magnetic field.

24(a). Three photo diodes D_1 , D_2 and D_3 are made of semiconductors having band gaps of 2.5 eV, 2 eV and 3 eV respectively. Which of them will not be able to detect light of wavelength 600 nm?

24(b). Why photodiodes are required to operate in reverse bias? Explain.

Section D

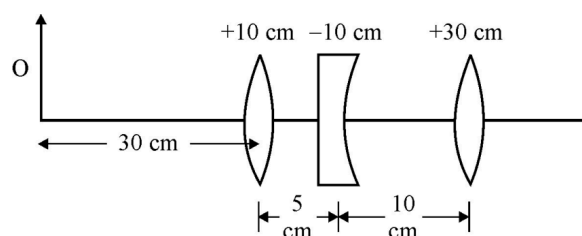
25(a). Describe any two characteristic features which distinguish between interference and diffraction phenomena. Derive the expression for the intensity at a point of the interference pattern in Young's double slit experiment.

25(b). In the diffraction due to a single slit experiment, the aperture of the slit is 3 mm. If monochromatic light of wavelength 620 nm is incident normally on the slit, calculate the separation between the first order minima and the 3rd order maxima on one side of the screen. The distance between the slit and the screen is 1.5 m.

OR

25(a). Under what conditions is the phenomenon of total internal reflection of light observed? Obtain the relation between the critical angle of incidence and the refractive index of the medium.

25(b). Three lenses of focal lengths +10 cm, –10 cm and +30 cm are arranged coaxially as in the figure given below. Find the position of the final image formed by the combination.



26(a). Describe briefly the process of transferring the charge between the two plates of a parallel plate capacitor when connected to a battery. Derive an expression for the energy stored in a capacitor.

26(b). A parallel plate capacitor is charged by a battery to a potential difference V . It is disconnected from battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor.

OR

26(a). Derive an expression for the electric field at any point on the equatorial line of an electric dipole.

26(b). Two identical point charges, q each, are kept 2 m apart in air. A third point charge Q of unknown magnitude and sign is placed on the line joining the charges such that the system remains in equilibrium. Find the position and nature of Q .

27(a). In a series LCR circuit connected across an ac source of variable frequency, obtain the expression for its impedance and draw a plot showing its variation with frequency of the ac source.

27(b). What is the phase difference between the voltages across inductor and the capacitor at resonance in the LCR circuit?

27(c). When an inductor is connected to a 200 V dc voltage, a current of 1 A flows through it. When the same inductor is connected to a 200 V, 50 Hz ac source, only 0.5 A current flows. Explain, why? Also, calculate the self inductance of the inductor.

OR

27(a). Draw the diagram of a device which is used to decrease high ac voltage into a low ac voltage and state its working principle. Write four sources of energy loss in this device.

27(b). A small town with a demand of 1200 kW of electric power at 220 V is situated 20 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5Ω per km. The town gets the power from the line through a 4000-220 V step-down transformer at a sub-station in the town. Estimate the line power loss in the form of heat.

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