

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. For a fixed potential difference applied across a conductor, the drift speed of free electrons does not depend upon

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|---|-----------------------------------|
| (A) free electron density in the conductor. | (B) mass of the electrons. |
| (C) length of the conductor. | (D) temperature of the conductor. |

2. Ohm's law is obeyed by

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|--------------------------------|---------------------------------|
| (A) extrinsic semiconductors. | (B) intrinsic semiconductors. |
| (C) metals at low temperature. | (D) metals at high temperature. |

3. Electromagnetic waves used as a diagnostic tool in medicine are

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|-------------------------|-----------------------|
| (A) X-rays. | (B) ultraviolet rays. |
| (C) infrared radiation. | (D) ultrasonic waves. |

4. A straight current carrying conductor is placed inside a uniform magnetic field. The force per unit length acting on the conductor is

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|---|---|
| (A) maximum when the conductor is perpendicular to the direction of magnetic field. | (B) maximum when the conductor is along the direction of magnetic field. |
| (C) minimum when the conductor is perpendicular to the direction of magnetic field. | (D) minimum when the conductor makes an angle of 45° with the direction of magnetic field. |

5. In a travelling plane electromagnetic wave, which of the following have zero average value?

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|---|--|
| (A) Magnetic energy and electric energy | (B) Magnetic field and electric field |
| (C) Magnetic energy and magnetic field | (D) Electric energy and electric field |

6. In β^- decay, a

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| (A) neutron converts into a proton emitting antineutrino. | (B) neutron converts into a proton emitting neutrino. |
| (C) proton converts into a neutron emitting antineutrino. | (D) proton converts into a neutron emitting neutrino. |

7. An electron is released from rest in a region of uniform electric and magnetic fields acting parallel to each other. The electron will

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|------------------------------|-----------------------------|
| (A) move in a straight line. | (B) move in a circle. |
| (C) remain stationary. | (D) move in a helical path. |

8. At equilibrium, in a p-n junction diode the net current is

- | | |
|--|--|
| (A) due to diffusion of majority charge carriers. | (B) due to drift of minority charge carriers. |
| (C) zero as diffusion and drift currents are equal and opposite. | (D) zero as no charge carriers cross the junction. |

9. In an n-type semiconductor, the donor energy level lies

- | | |
|--------------------------------------|-------------------------------------|
| (A) at the centre of the energy gap. | (B) just below the conduction band. |
| (C) just above the valance band. | (D) in the conduction band. |

10. When two nuclei ($A < 10$) fuse together to form a heavier nucleus, the

- (A) binding energy per nucleon increases. (B) binding energy per nucleon decreases.
(C) binding energy per nucleon does not change. (D) total binding energy decreases.

11. The potential difference between two points in vacuum is V_0 . If vacuum is replaced by a medium of dielectric constant K , the new value of potential difference will be _____.

12. Unpolarised light passes from a rarer into a denser medium. If the reflected and the refracted rays are mutually perpendicular, the reflected light is linearly polarised _____ to the plane of incidence.

13. The resolving power of a compound microscope can be _____ by using a medium (oil) of higher refractive index than air between the object and the objective lens.

14. In Young's double slit experiment, the path difference between two interfering waves at a point on the screen is $\frac{5\lambda}{2}$, λ being the wavelength of the light used. The _____ dark fringe will lie at this point.

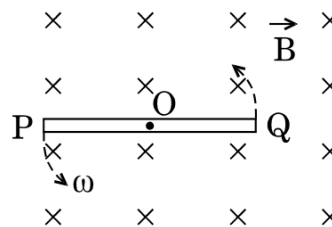
OR

If one of the slits in Young's double slit experiment is fully closed, the new pattern has _____ central maximum in angular size.

15. At sunset or sunrise, the scattered coloured light _____ from the sun reaches our eyes.

16. Define the term 'threshold frequency' in photoelectric emission.

17. A metallic rod PQ of length l is rotated with an angular velocity ω in a magnetic field $\vec{B}$ about an axis passing through the mid-point O of the rod and perpendicular to the plane of paper as shown in the figure. What is the potential difference developed between the points O and Q of the rod?



18. What is the impedance of a capacitor of capacitance C in an ac circuit using source of frequency n Hz?

OR

What is the value of impedance of a resonant series LCR circuit?

19. The threshold frequencies of two photosensitive surfaces are ν_1 and ν_2 , respectively. What is the ratio of the velocities of the photoelectrons emitted from these surfaces when light of frequency ν is incident on them and photoemission occurs?

20. Draw the graph showing variation of the value of the induced emf as a function of rate of change of current flowing through an ideal inductor.

Section B

21. Which of the following electromagnetic waves has (a) minimum wavelength, and (b) minimum frequency? Write one use of each of these two waves.

Infrared waves, Microwaves, γ -rays and X-rays

22. A circular loop carrying a current 5 A, produces a magnetic field of π mT, at its centre. Find the value of the magnetic moment of the loop.

23. Draw V-I characteristics of a p-n junction diode. Explain, why the current under reverse bias is almost independent of the applied voltage up to the critical voltage.

24. Define the term 'mobility' of charge carriers in a current carrying conductor. Obtain the relation for mobility in terms of relaxation time.

OR

Define the term 'drift velocity' of electrons in a current carrying conductor. Obtain the relationship between the current density and the drift velocity of electrons.

25. An object is placed in front of a convex mirror of focal length 15 cm. It produces an image that is half the size of the object. Find (a) position of the object, (b) nature of the image, and (c) draw the ray diagram of image formation.

26. (a) Write the SI unit of activity of a radioactive substance.

(b) Find the half-life of a radioactive substance if the activity of the substance drops to $\frac{1}{16}$ of its initial value in 15 years.

27. (a) Explain the term 'sharpness of resonance' in ac circuit.

(b) In a series LCR circuit, $V_L = V_C \neq V_R$. What is the value of power factor for this circuit?

OR

An ac source of emf $V = V_0 \sin \omega t$ is connected to a capacitor of capacitance C . Deduce the expression for the current (I) flowing in it. Plot the graph of (i) V vs. ωt , and (ii) I vs. ωt .

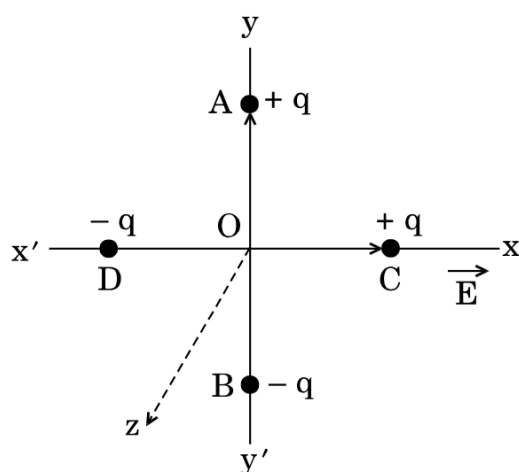
Section C

28. A capacitor of $4\ \mu\text{F}$ is charged by a battery of 12 V. The battery is disconnected and a dielectric slab of dielectric constant 8 is inserted in between the plates of the capacitor to fill the space completely. Find the change in the (a) charge stored in the capacitor, (b) potential difference between the plates of the capacitor, and (c) energy stored in the capacitor.

OR

Two small identical electric dipoles AB and CD, each of dipole moment $\vec{p}$ are kept at an angle of 90° to each other in an external electric field $\vec{E}$ pointing along the x -axis as shown in the figure. Find the

- dipole moment of the arrangement, and
- magnitude and direction of the net torque acting on it.

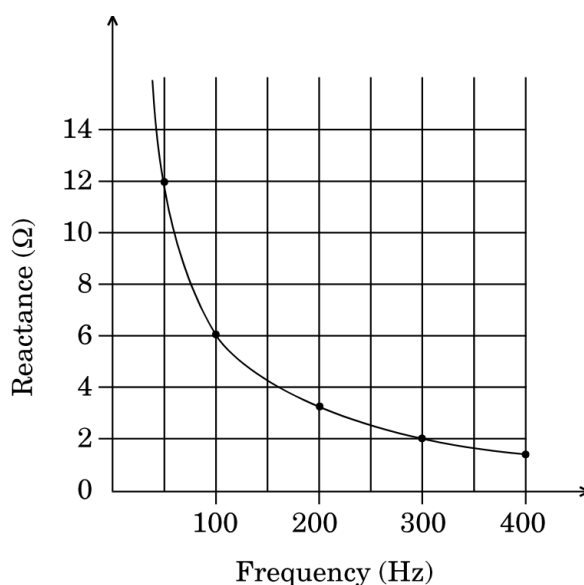


29. What is the difference in the construction of an astronomical telescope and a compound microscope? The focal lengths of the objective and eyepiece of a compound microscope are 1.25 cm and 5.0 cm, respectively. Find the position of the object relative to the objective in order to obtain an angular magnification of 30 when the final image is formed at the near point.

30. What is the function of a solar cell? Briefly explain its working and draw its I-V characteristic curve.

31. The maximum kinetic energy of the photoelectrons emitted is doubled when the wavelength of light incident on the photosensitive surface changes from λ_1 to λ_2 . Deduce expressions for the threshold wavelength and work function for the metal surface in terms of λ_1 and λ_2 .

32. The figure shows the graphical variation of the reactance of a capacitor with frequency of ac source.



- Find the capacitance of the capacitor.
- An ideal inductor has the same reactance at 100 Hz frequency as the capacitor has at the same frequency. Find the value of inductance of the inductor.
- Draw the graph showing the variation of the reactance of this inductor with frequency.

33. (a) Draw the graph of radius of orbit (r_n) in hydrogen atom as a function of orbit number (n).
 (b) In a hydrogen atom, find the ratio of the time taken by the electron to complete one revolution in the first excited and in the second excited states.

34. (a) Derive the condition of balance for Wheatstone bridge.
 (b) Draw the circuit diagram of a meter bridge to explain how it is based on Wheatstone bridge.

Section D

35. (a) Derive lens maker's formula for a biconvex lens.

(b) A point object is placed at a distance of 12 cm on the principal axis of a convex lens of focal length 10 cm. A convex mirror is placed coaxially on the other side of the lens at a distance of 10 cm. If the final image coincides with the object, sketch the ray diagram and find the focal length of the convex mirror.

OR

(a) What is a wavefront? How does it propagate? Using Huygens' principle, explain reflection of a plane wavefront from a surface and verify the laws of reflection.

(b) A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is obtained on a screen 1 m away. If the first minimum is formed at a distance of 2.5 mm from the centre of the screen, find the (i) width of the slit, and (ii) distance of first secondary maximum from the centre of the screen.

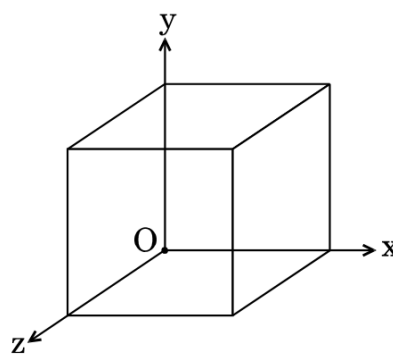
36. (a) Use Gauss's law to show that due to a uniformly charged spherical shell of radius R , the electric field at any point situated outside the shell at a distance r from its centre is equal to the electric field at the same point, when the entire charge on the shell were concentrated at its centre. Also plot the graph showing the variation of electric field with r , for $r < R$ and $r \geq R$.

(b) Two point charges of $+1 \mu\text{C}$ and $+4 \mu\text{C}$ are kept 30 cm apart. How far from the $+1 \mu\text{C}$ charge on the line joining the two charges, will the net electric field be zero?

OR

(a) Two point charges q_1 and q_2 are kept r distance apart in a uniform external electric field $\vec{E}$. Find the amount of work done in assembling this system of charges.

(b) A cube of side 20 cm is kept in a region as shown in the figure. An electric field $\vec{E}$ exists in the region such that the potential at a point is given by $V = 10x + 5$, where V is in volt and x is in m.



Find the (i) electric field $\vec{E}$, and (ii) total electric flux through the cube.

37. (a) A circular loop of radius R carries a current I . Obtain an expression for the magnetic field at a point on its axis at a distance x from its centre.

(b) A conducting rod of length 2 m is placed on a horizontal table in north-south direction. It carries a current of 5 A from south to north. Find the direction and magnitude of the magnetic force acting on the rod. Given that the Earth's magnetic field at the place is 0.6×10^{-4} T and angle of dip is $\frac{\pi}{6}$.

OR

(a) Obtain the expression for the deflecting torque acting on the current carrying rectangular coil of a galvanometer in a uniform magnetic field. Why is a radial magnetic field employed in the moving coil galvanometer?

(b) Particles of mass 1.6×10^{-27} kg and charge 1.6×10^{-19} C are accelerated in a cyclotron of dee radius 40 cm. It employs a magnetic field 0.4 T. Find the kinetic energy (in MeV) of the particle beam imparted by the accelerator.

- End of Question Paper -