

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 **26 questions**. All questions are **compulsory**.
- (ii) The question paper is divided into Sections A, B, C, D, E.
- (iii) Section A - Questions 1 to 5 carry 1 mark each.
- (iv) Section B - Questions 6 to 10 carry 2 marks each.
- (v) Section C - Questions 11 to 22 carry 3 marks each.
- (vi) Section D - Question 23 carries 4 marks.
- (vii) Section E - Questions 24 to 26 carry 5 marks each.
- (viii) There is no overall choice. Where an internal choice is provided, attempt only one of the alternatives.

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. What is the amount of work done in moving a point charge Q around a circular arc of radius r at the centre of which another point charge q is located?

2. Define mobility of a charge carrier. What is its relation with relaxation time?

3. What can be the cause of helical motion of a charged particle?

4. Why can't we see clearly through fog? Name the phenomenon responsible for it.

5. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. What are the frequencies of the side bands produced?

Section B

6. When 5 V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is 2.5×10^{-4} m/s. If the electron density in the wire is $8 \times 10^{28} \text{ m}^{-3}$, calculate the resistivity of the material of wire.

7. A proton and an α particle are accelerated through the same potential difference. Which one of the two has (i) greater de-Broglie wavelength, and (ii) less kinetic energy? Justify your answer.

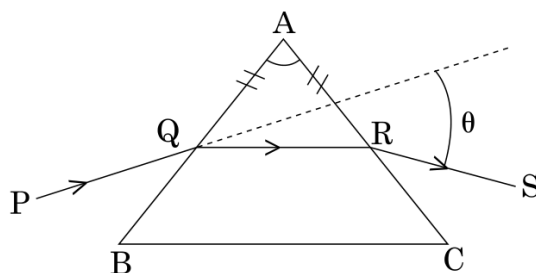
8. When is H_α line in the emission spectrum of hydrogen atom obtained? Calculate the frequency of the photon emitted during this transition.

OR

8. Calculate the wavelength of radiation emitted when electron in a hydrogen atom jumps from $n = \infty$ to $n = 1$.

9. Why is base band signal not transmitted directly? Give any two reasons.

10. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in the figure and emerges from the other refracting face AC as RS such that $AQ = AR$. If the angle of prism $A = 60^\circ$ and refractive index of material of prism is $\sqrt{3}$, calculate angle θ .



Section C

11. Find the electric field intensity due to a uniformly charged spherical shell at a point (i) outside the shell and (ii) inside the shell. Plot the graph of electric field with distance from the centre of the shell.

12. Two identical cells of emf 1.5 V each joined in parallel supply energy to an external circuit consisting of two resistances of $7\ \Omega$ each joined in parallel. A very high resistance voltmeter reads the terminal voltage of cells to be 1.4 V. Calculate the internal resistance of each cell.

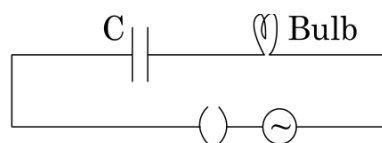
13. State Ampere's circuital law. Use this law to find magnetic field due to straight infinite current carrying wire. How are the magnetic field lines different from the electrostatic field lines?

OR

13. State the principle of a cyclotron. Show that the time period of revolution of particles in a cyclotron is independent of their speeds. Why is this property necessary for the operation of a cyclotron?

14. (i) When an AC source is connected to an ideal capacitor, show that the average power supplied by the source over a complete cycle is zero.

(ii) A bulb is connected in series with a variable capacitor and an A.C. source as shown. What happens to the brightness of the bulb when the key is plugged in and capacitance of the capacitor is gradually reduced?



15. How are electromagnetic waves produced? What is the source of energy of these waves? Write mathematical expressions for electric and magnetic fields of an electromagnetic wave propagating along the z -axis. Write any two important properties of electromagnetic waves.

16. (i) Derive Snell's law on the basis of Huygen's wave theory when light is travelling from a denser to a rarer medium.

(ii) Draw the sketches to differentiate between plane wavefront and spherical wavefront.

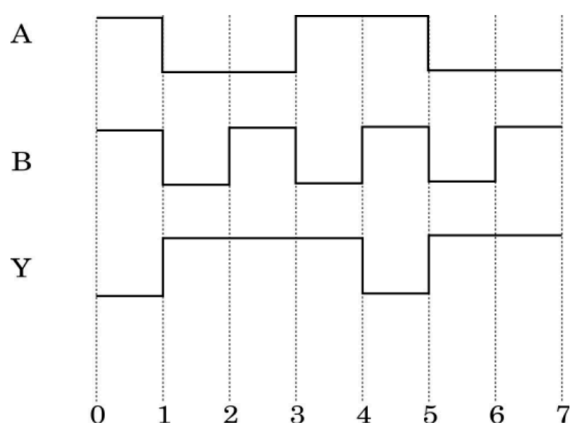
17. State two important properties of photon which are used to write Einstein's photoelectric equation. Define (i) stopping potential and (ii) threshold frequency, using Einstein's equation and drawing necessary plot between relevant quantities.

18. (i) Name two important processes that occur during the formation of a pn junction.

(ii) Draw the circuit diagram of a full wave rectifier along with the input and output waveforms. Briefly explain how the output voltage/current is unidirectional.

19. (i) Distinguish between a conductor and a semi conductor on the basis of energy band diagram.

(ii) The following figure shows the input waveforms (A , B) and the output waveform (Y) of a gate. Identify the gate, write its truth table and draw its logic symbol.



20. What is space wave propagation? State the factors which limit its range of propagation. Derive an expression for the maximum line of sight distance between two antennas for space wave propagation.

21. (a) Derive the mathematical expression for law of radioactive decay for a sample of a radioactive nucleus.

(b) How is the mean life of a given radioactive nucleus related to the decay constant?

22. (i) A screen is placed at a distance of 100 cm from an object. The image of the object is formed on the screen by a convex lens for two different locations of the lens separated by 20 cm. Calculate the focal length of the lens used.

(ii) A converging lens is kept coaxially in contact with a diverging lens - both the lenses being of equal focal length. What is the focal length of the combination?

23. Seema's uncle was advised by his doctor to have an MRI (Magnetic Resonance Imaging) scan of his brain. Her uncle felt it to be expensive and wanted to postpone it.

When Seema learnt about this, she took the help of her family and also approached the doctor, who also offered a substantial discount. She then convinced her uncle to undergo the test to enable the doctor to know the condition of his brain. The information thus obtained greatly helped the doctor to treat him properly.

Based on the above paragraph, answer the following questions:

- (a) What according to you are the values displayed by Seema, her family and the doctor?
- (b) What could be the possible reason for MRI test to be so expensive?
- (c) Assuming that MRI test was performed using a magnetic field of 0.1 T, find the minimum and maximum values of the force that the magnetic field could exert on a proton (charge = 1.6×10^{-19} C) moving with a speed of 10^4 m/s.

Section E

24. (a) Distinguish, with the help of a suitable diagram, the difference in the behaviour of a conductor and a dielectric placed in an external electric field. How does polarised dielectric modify the original external field?

(b) A capacitor of capacitance C is charged fully by connecting it to a battery of emf E . It is then disconnected from the battery. If the separation between the plates of the capacitor is now doubled, how will the following change?

- (i) charge stored by the capacitor.
- (ii) field strength between the plates.
- (iii) energy stored by the capacitor.

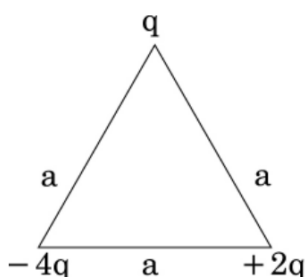
Justify your answer in each case.

OR

24. (a) Explain why, for any charge configuration, the equipotential surface through a point is normal to the electric field at that point.

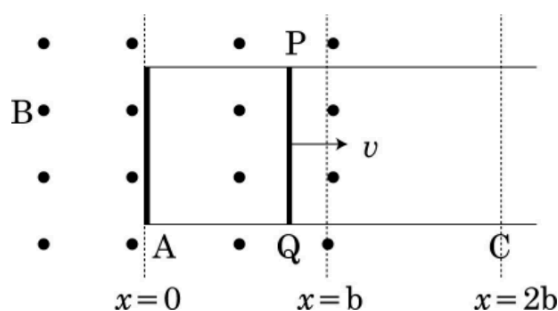
Draw a sketch of equipotential surfaces due to a single charge ($-q$), depicting the electric field lines due to the charge.

(b) Obtain an expression for the work done to dissociate the system of three charges placed at the vertices of an equilateral triangle of side a as shown below.



25. (a) When a bar magnet is pushed towards (or away) from the coil connected to a galvanometer, the pointer in the galvanometer deflects. Identify the phenomenon causing this deflection and write the factors on which the amount and direction of the deflection depends. State the laws describing this phenomenon.

(b) Sketch the change in flux, emf and force when a conducting rod PQ of resistance R and length l moves freely to and fro between A and C with speed v on a rectangular conductor placed in uniform magnetic field as shown in the figure.



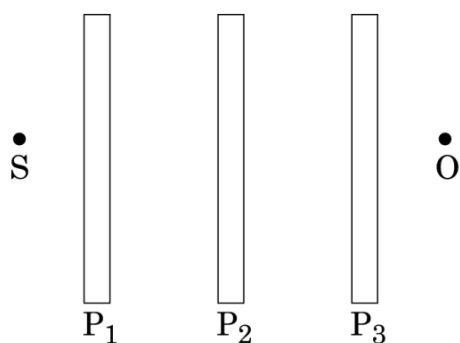
OR

25. In a series LCR circuit connected to an a.c. source of voltage $v = v_m \sin \omega t$, use phasor diagram to derive an expression for the current in the circuit. Hence obtain the expression for the power dissipated in the circuit. Show that power dissipated at resonance is maximum.

26. (a) Why does unpolarised light from a source show a variation in intensity when viewed through a polaroid which is rotated? Show with the help of a diagram, how unpolarised light from sun gets linearly polarised by scattering.

(b) Three identical polaroid sheets P_1 , P_2 and P_3 are oriented so that the pass axis of P_2 and P_3 are inclined at angles of 60° and 90° respectively with the pass axis of P_1 . A monochromatic source S of unpolarized light of intensity I_0 is kept in front of the polaroid sheet P_1 as shown in the figure.

Determine the intensities of light as observed by the observer at O , when polaroid P_2 is rotated with respect to P_1 at angles $\theta = 30^\circ$ and 60° .



OR

26. (a) Derive an expression for path difference in Young's double slit experiment and obtain the conditions for constructive and destructive interference at a point on the screen.

(b) The intensity at the central maxima in Young's double slit experiment is I_0 . Find out the intensity at a point where the path difference is $\frac{\lambda}{6}$, $\frac{\lambda}{4}$ and $\frac{\lambda}{3}$.

- End of Question Paper -