Time: **3 hours;** Maximum Marks: **70**

General Instructions:

1. All questions are compulsory. There are 26 questions in all.
2. This question paper has five sections: Section A, Section B, Section, Section D and Section E.
3. Section A contains five questions of one mark each, section B contains five questions of two marks each, section C contains twelve questions of three marks each, section D contains one value based question of four marks and section E contains three questions of five marks each.
4. There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all the three questions of five marks weightage. You have to attempt only one of the choices in such questions.
5. You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^8 \text{ m/s}$

$h = 6.63 \times 10^{-34} \text{ Js}$

$e = 1.6 \times 10^{-19} \text{ C}$

$\mu_0 = 4\pi \times 10^{-7} \text{ T mA}^{-1}$

$\varepsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$

$m_e = 9.1 \times 10^{-31} \text{ kg}$

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = $1.38 \times 10^{-23} \text{ J K}^{-1}$

Section – A

1. Define the term 'mobility' of charge carriers. Write its S.I. unit
2. In a series LCR circuit, $V_L = V_C \neq VR$. What is the value of power factor?
3. The focal length of an equiconvex lens is equal to the radius of curvature of either face. What is the refractive index of the material of the lens?
4. Write a relation for polarization P of a dielectric material in the presence of an external electric field E
5. What happens when a forward bias is applied to a p-n junction?

Section – B

6.

(a) Distinguish between 'Analog' and 'Digital' forms of communication.

(b) Explain briefly two commonly used applications of the 'Internet'.

7. Given the ground state energy E0 = - 13.6 eV and Bohr radius a0 = 0.53 A. Find out how the de Broglie wavelength associated with the electron orbiting in the ground state would change when it jumps into the first excited state.

8. State Bohr's postulate of hydrogen atom which successfully explains the emission lines in the spectrum of hydrogen atom. Use Rydberg formula to determine the wavelength of H_α line.

   [Given: Rydberg constant R = 1.03×10^7 m^{-1}]

9. State the two Kirchhoff's rules used in electric networks. How are there rules justified?

10. Write the important characteristic features by which the interference can be distinguished from the observed diffraction pattern.

    OR

    Explain the basic differences between the construction and working of a telescope and a microscope.

Section – C

11. Light of intensity 'I' and frequency 'ν' is incident on a photosensitive surface and causes photoelectric emission. What will be the effect on anode current when (i) the intensity of light is gradually increased, (ii) the frequency of incident radiation is increased, and (iii) the anode potential is increased? In each case, all other factors remain the same. Explain, giving justification in each case.

12. When is a transistor said to be in active state? Draw a circuit diagram of a p-n-p transistor and explain how it works as a transistor amplifier. Write clearly, why in the case of a transistor (i) the base is thin and lightly doped and (ii) the emitter is heavily doped.

13.

    (a) State three important factors showing the need for translating a low frequency signal into a high frequency wave before transmission.

    (b) Draw a sketch of a sinusoidal carrier wave along with a modulating signal and show how these are superimposed to obtain the resultant amplitude modulated wave.

14. You are given three circuit elements X, Y and Z. When the element X is connected across an a.c. source of a given voltage, the current and the voltage are in the same phase. When the element Y is connected in series with X across the source, voltage is ahead of the current in phase by $\pi/4$. But the current is ahead of the voltage in phase by $\pi/4$ when Z is connected in series with X across the source. Identify the circuit elements X, Y and Z.

    When all the three elements are connected in series across the same source, determine the impedance of the circuit.

Draw a plot of the current versus the frequency of applied source and mention the significance of this plot.

15. Plot a graph showing the variation of current density (j) versus the electric field (E) for two conductors of different materials. What information from this plot regarding the properties of the conducting material, can be obtained which can be used to select suitable materials for use in making (i) standard resistance and (ii) connecting wires in electric circuits?
Electron drift speed is estimated to be of the order of mm s^{-1}. Yet large current of the order of few amperes can be set up in the wire. Explain briefly.

16. State Biot – Savart law. Deduce the expression for the magnetic field at a point on the axis of a current carrying circular loop of radius 'R' distant 'x' from the centre. Hence, write the magnetic field at the centre of a loop.

17. What does a Polaroid consist of? Show, using a simple Polaroid that light waves are transverse in nature. Intensity of light coming out of a Polaroid does not change irrespective of the orientation of the pass axis of the Polaroid. Explain why.

18. How is a Zener diode fabricated? What causes the setting up of high electric field even for small reverse bias voltage across the diode?

    Describe, with the help of a circuit diagram, the working of Zener diode as a voltage regulator.
    OR

    (a) Explain with the help of a diagram, how depletion region and potential barrier are formed in a junction diode.
    (b) If a small voltage is applied to a p-n junction diode, how will the barrier potential be affected when it is (i) forward biased, and (ii) reveres biased?

19. Arrange the following electromagnetic wave in the order of their increasing wavelength:
    (a) γ- rays
    (b) Microwaves
    (c) X-rays
    (d) Radio waves

    How are infra-red waves produced? What role dose infra-red radiation play in (i) maintain the Earth's warmth and (ii) physical therapy?

20. Explain briefly the process of charging a parallel plate capacitor when it is connected across a d.c. battery.

    A capacitor of capacitance 'C' is charged to 'V' volts by a battery. After some time the battery is disconnected and the distance between the plates is doubled. Now a slab of dielectric constant,

$1 < k < 2$, is introduced to fill the space between the plates. How will the following be affected?

(a) The electric field between the plates of the capacitor

(b) The energy stored in the capacitor

Justify your answer by writing the necessary expressions.

21. Write symbolically the nuclear β^+ decay process of $^{11}6C$. Is the decayed product X an isotope or isobar of ($^{11}6C$)? Given the mass values m ($^{11}6C$) = 11.011434 u and m (X) = 11.009305 u. Estimate the Q-value in this process.

22. An object is placed 15 cm in front of a convex lens of focal length 10 cm. Find the nature and position of the image formed. Where a concave mirror of radius of curvature 20 cm should be placed so that the final image is formed at the position of the object itself?

Section – D

23. Ajit had a high tension tower erected on his farm land. He kept complaining to the authorities to remove it as it was occupying a large portion of his land. His uncle, who was a teacher, explained to him the need for erecting these towers for efficient transmission of power. As Ajit realized its significance, he stopped complaining.

Answer the following questions:

(a) Why is it necessary to transport power at high voltage?

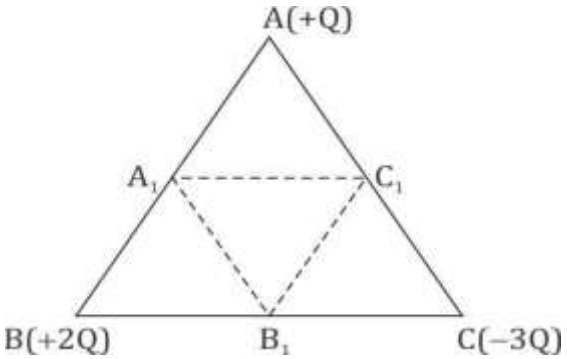
(b) A low power factor implies large power loss. Explain.

(c) Write two values each displayed by Ajit and his uncle.

24.

(a) Deduce the expression for the potential energy of a system of two charges q1 and q2 located r1 and r2, respectively, in an external electric field.

(b) Three point charges, + Q + 2Q and – 3Q are placed at the vertices of an equilateral triangle ABC of side l. If these charges are displaced to the mid-point A_1, B_1 and C_1, respectively, find the amount of the work done in shifting the charges to the new locations.



OR

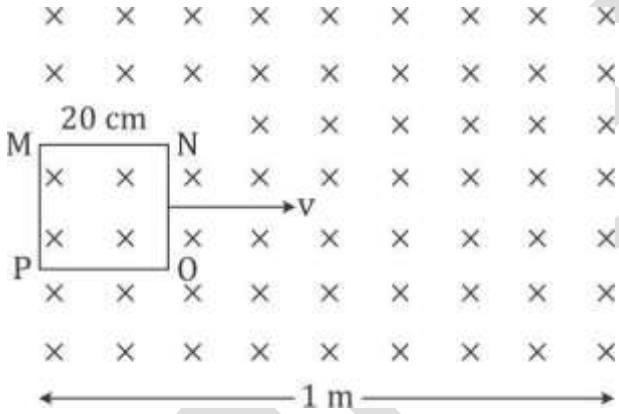
Define electric flux. Write its S.I unit.

State and explain Gauss's law. Find out the outward flux to a point charge +q placed at the center of a cube of side 'a'. Why is it found to be independent of the size and shape of the surface enclosing it? Explain.

25.

(a) Define self-inductance of a coil. Obtain an expression for the energy stored in a solenoid of self-inductance 'L' when the current though it grows from zero to 'I'.

(b) A square loop MNOP of side 20 cm is placed horizontally in a uniform magnetic field acting vertically downwards as shown in the figure. The loop is pulled with a constant velocity of 20 cm s^{-1} till it goes out of the field.



(i) Depict the direction of the induced current in the loop as it goes out of the field. For how long would the current in the loop persist?

(ii) Plot a graph showing the variation of magnetic flux and induced emf as a function of time.

OR

(a) Draw the magnetic field lines due to a circular loop area A carrying current I. Show that it acts as a bar magnet of magnetic moment m = I A .

(b) Derive the expression for the magnetic field due to a solenoid of length '2l', radius 'a' having 'n' number of turns per unit length and carrying a steady current 'I' at a point on the axial line, distance 'r' from the center of the solenoid. How does this expression compare with the axial magnetic field due to a bar magnet of magnetic moment 'm'?

26.

(a) In young's double slit experiment, deduce the conditions for obtaining constructive and destructive interference fringes. Hence, deduce the expression for the fringe width.

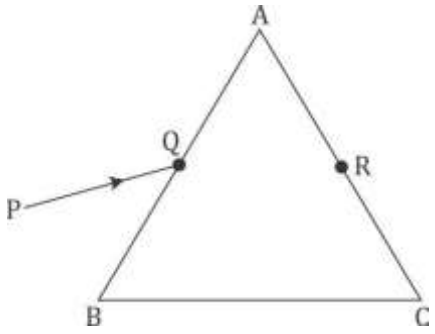
(b) Show that the fringe pattern on the screen is actually a superposition of slit diffraction from each slit.

(c) What should be the width of each slit to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern, for green light of wavelength 500 nm, if the separation between two slits is 1 mm?

OR

(a) Two thin convex lenses L1 and L2 of focal lengths f1 and f2, respectively, are placed coaxially in contact. An object is placed at a point beyond the focus of lens L1. Draw a ray diagram to show the image formation by the combination and hence derive the expression for the focal length of the combined system.

(b) A ray PQ incident on the face AB of a prism ABC, as shown in the figure, emerges from the face AC such that AQ = AR.



Draw the ray diagram showing the passage of the ray through the prism. If the angle of the prism is 60^0 and refractive index of the material of prism is $\sqrt{3}$, determine the values of angle of incidence and angle of deviation.