Time Allowed : 3 Hours **Maximum Marks : 70**

General Instructions:

1. All questions are compulsory. There are 37 questions in all.
2. This question paper has four sections: Section A, Section B, Section C and Section D.
3. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions of three marks each, and Section D contains three questions of five marks each.
4. There is no overall choice. However, internal choices have been provided in two questions of one mark each, two questions of two marks, one question of three marks and 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 where ever necessary.

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

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

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

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

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

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

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

mass of neutron $= 1.675 \times 10^{-27}$ kg

mass of proton $= 1.673 \times 10^{-27}$ kg

Avogadro's number $= 6.023 \times 10^{23}$ per gram mole

Boltzmann constant $= 1.38 \times 10^{-23}$ JK^{-1}

SECTION - A

Directions (Q.1-10) : ***Select the most appropriate option from those given below each question.***

1. In full wave rectifier, what is the output frequency if the input frequency is 50 Hz?

(a) 50 Hz (b) 75 Hz (c) 100 Hz (d) 125 Hz

2. A half-wave rectifier is being used to rectify an alternating voltage of frequency 50 Hz. The number of pulses of rectified current obtained in one second is

(a) 50 (b) 25 (c) 100 (d) 2000

3. Two beams of light of intensity I_1 and I_2 interfere to give an interference pattern. If the ratio of maximum intensity to that of minimum intensity is 25/9, then I_1/I_2 is

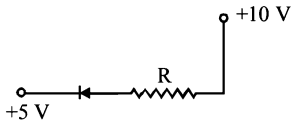
(a) 5/3 (b) 4 (c) 81/625 (d) 16

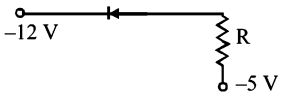
4. What is the particle x in the following nuclear reaction

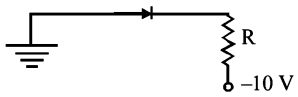
$${}^{9}_{4}\text{Be} + {}^{4}_{2}\text{He} \longrightarrow {}^{12}_{6}\text{C} + \text{x}$$

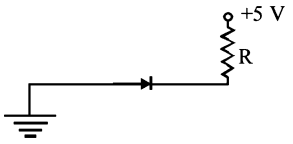
(a) Electron (b) Proton (c) Photon (d) Neutron

5. Of the diodes shown in the following diagrams, which one is reverse biased ?

(a) 

(b) 

(c) 

(d) 

6. Magnetic flux ϕ in weber in a closed circuit of resistance 10Ω varies with time ϕ (sec) as $\phi = 6t^2 - 5t + 1$. The magnitude of induced current at t = 0.25s is

(a) 0.2 A (b) 0.6 A (c) 1.2 A (d) 0.8 A

7. What is the critical angle for a material of refractive index $\sqrt{2}$?

(a) 30° (b) 45° (c) 60° (d) 90°

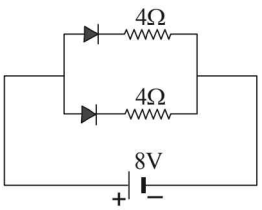
8. Currents flowing in each of the circuits A and B respectively are

(a) 1 A, 2A

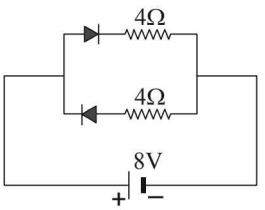
(b) 2A, 1A

(c) 4A, 2A

(d) 2A, 4A



(Circuit A)



(Circuit B)

9. Which of the following is responsible for the earth's magnetic field?

(a) Convective currents in earth's core. (b) Diversive current in earth's core.
(c) Rotational motion of earth. (d) Translational motion of earth.

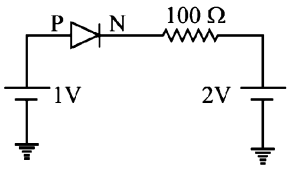
10. The current through an ideal PN-junction shown in the following circuit diagram will be

(a) zero

(b) 1 mA

(c) 10 mA

(d) 30 mA



Directions (Q.11-15) : ***Fill in the blanks with appropriate answer.***

11. Capacitor serves as a block for _____ and offers on easy path to _____.

OR

Capacitive reactance is proportional to _____.

12. Impact parameter is proportional to _____.

13. In resistive-inductive circuit, the leading quantity is _____.

14. A coil having an area A_0 is placed in a magnetic field which changes from B_0 to 4 B_0 in time interval t. The _____ is the e.m.f. induced in the coil.

15. On a rainy day, a small oil film on water show brilliant colours. This is due to _____ of light.

Directions (Q.16-20) : ***Answer the following***

16. A resistance R is connected across a cell of emf E and internal resistance r. Now, a potentiometer measures the potential difference between the terminals of the cells as V. Write the expression for r in terms of E, V and R.

17. What do you mean by conduction current?

18. What is expression for λ of an e^- moving under potential difference of 1V?

19. What is the magnifying power of a compound microscope?

20. What is the main condition to produce interference of light?

OR

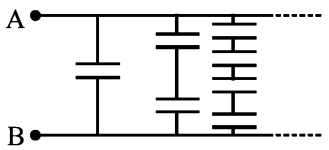
What happens to the energy at distructive interference in interference pattern?

SECTION - B

21. Horizontal and vertical component of magnetic field at a place are 0.22 gauss and 0.38 gauss. Calculate the angle of dip and resultant intensity of magnetic field.

22. Two point electric charges of unknown magnitude and sign are placed at a distance 'd' apart. The electric field intensity is zero at a point, not between the charges but on the line joining them. Write two essential conditions for this to happen.

23. An infinite number of the identical capacitors, each of the capacitance 1 μF, are connected, as shown. Then, what is the equivalent capacitance between the points A and B?



OR

The electric field at point due to a point charge is 20 N/C and the electric potential at that point is 10 J/C. Calculate the distance of the point from the charge and magnitude of the charge.

24. A ray of light passes through an equilateral prism in such a way that the angle of incidence is equal to the angle of emergence and each of these angles is 3/4th the angle of the prism. Determine the (i) angle of deviation and (ii) the refractive index of the prism.

25. How does the mutual inductance of a pair of coils change when:

(i) the distance between the coils is increased?

(ii) the number of turns in each coil is dicreased?

Justify your answer in each case.

OR

How does the self inductance of an air core coil change, when (i) the number of turns in the coil is decreased (ii) an iron rod is introduced in the coil.

26. At what positions, secondary maxima and minima are obtained and, why is the intensity of light at secondary maxima less than that of central maximum in the diffraction pattern.

27. In an intrinsic semiconductor the energy gap E_g is 1.2eV. Its hole mobility is much smaller than electron mobility and independent of temperature. What is the ratio between conductivity at 600K and that at 300K? Assume that the temperature dependence of intrinsic carrier concentration n_i is given by

$n_i = n_0 \exp\left(-\frac{E_g}{2k_B T}\right)$ where n_0 is a constant. $k_B = 8.62 \times 10^{-5}$ eV K^{-1}

SECTION - C

28. Derive the relation, $\delta = (n_{12} - 1)A$.

29. On giving energy to H-atom, transition occurs from energy level n = 1 to n = 4. If the ionisation potential of hydrogen is 13.6 V. Find

(i) energy absorbed in transition

(ii) the wavelength of emitted radiation if the atom comes back to its initial state.

30. Assuming that p^+ and n^0 have equal masses, calculate how many times nuclear matter is denser than water. Take m(nucleon) = 1.67×10^{-27} kg and $R_0 = 1.2 \times 10^{-15}$m.

OR

The Sun is believed to be getting its energy from the fusion of 4 p^+ to form a He nucleus and a pair of positrons. Calculate release of energy per fusion in Mev. m(p^+) = 1.007825 u. m(e^+) = 0.000549 u, m(He) = 4.002603 u, 1 a.m.u = 931.5 MeV.

31. A straight horizontal conduction rod of length 0.45 m and mass 60 g is suspended by two vertical wires at its ends. A current of 5.0 A is set up in the rod through the wires.

(a) What magnetic field should be set up normal to the conductor in order that the tension in the wires is zero?

(b) What will be the total tension in the wires if the direction of current is reversed keeping the magnetic field same as before?

[Ignore the mass of the wires and g = 9.8 m s^{-2}]

32. Define an equipotential surface. Draw equipotential surfaces :

(i) in the case of a single point charge and

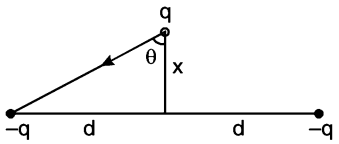
(ii) in a constant electric field in Z-direction.

Why the equipotential surfaces about a single charge are not equidistant ?

(iii) Can electric field exist tangential to an equipotential surface ? Give reason.

33. Two charge $-q$ each are fixed separated by distance $2d$. A third charge q of mass m placed at the mid-point is displaced slightly by x ($x << d$) perpendicular to the line joining the two fixed charged as shown in Fig. Show that q will perform simple harmonic oscillation of time period.

$$T = \left[\frac{8\pi^3 \varepsilon_0 m d^3}{q^2}\right]^{1/2}$$



34. Show that the electron revolving around the nucleus in a radius 'r' with orbital speed 'v' has magnetic moment $evr/2$. Hence, using Bohr's postulate of the quantization of angular momentum obtain the expression for the magnetic moment of hydrogen atom in its ground state.

SECTION - D

35. (a) Derive the prism formula, $n_{12} = \dfrac{\sin\dfrac{(A+\delta_m)}{2}}{\text{Sin}\dfrac{A}{2}}$

(b) Draw the graph showing the variation of the angle of deviation with angle of incidence, through a prism.

OR

(a) Define magnifying power of a telescope. Write its expression.

(b) A small telescope has an objective lens of focal length 150 cm and an eyepiece of focal length 5 cm. If this telescope is used to view a 100 m high tower 3 km away, find the height of the final image when it is formed 25 cm away from the eyepiece.

36. Define capacitance of a capacitor. Give its S.I. unit. Prove that the total electrostatic energy stored in a parallel plate capacitor is $\frac{1}{2}CV^2$. Hence derive the expression for the energy density of a capacitor.

OR

Derive an expression for the energy stored in a parallel plate capacitor.

A parallel plate capacitor with air as dielectric is charged by a d.c. source to a potential V. Without disconnecting the capacitor from the source, air is replaced by another dielectric medium of dielectric constant 10. State with reason, how does

(i) electric field between the plates and

(ii) energy stored in the capacitor change.

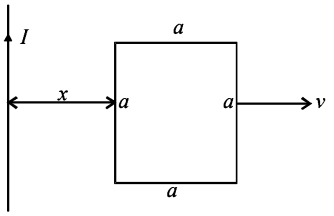
37. (a) A wheel with 10 metallic spokes each 0.5 m long is rotated with a speed of 120 rev/min in a plane normal to the Earth's magnetic field at the place. If the magnitude of the field is 0.4 G, what is the induced emf between the axle and the rim of the wheel?

(b) A circular coil having 20 turns, each of radius 8 cm, is rotating about its vertical diameter with an angular speed of 50 radians s^{-1} in a uniform horizontal magnetic field of magnitude 30 mT. Obtain the maximum, average and r.m.s. values of the emf induced in the coil.

If the coil forms a closed loop of resistance 10 Ω, how much power is dissipated as heat in it?

OR

(a) Obtain an expression for mutual inductance between a long straight wire and a square loop of side a as shown in figure.



(b) Assume that the straight wire carries a current of 50 A and the loop is moved to the right with a constant velocity v = 10 ms^{-1}. Calculate the induced emf in the loop at the instant when x = 0.2 m. Take a = 0.1m and assume that the loop has a large resistance.