

Question Paper

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 Hours

Maximum Marks: 70

General Instructions

- (i) This edition contains **37 numbered questions**, including the subparts and alternatives supplied in the source.
- (ii) Original question numbering is retained. Answer the alternatives according to the OR labels and instructions within each question.
- (iii) The available questions follow the original Sections A, B, C, D.

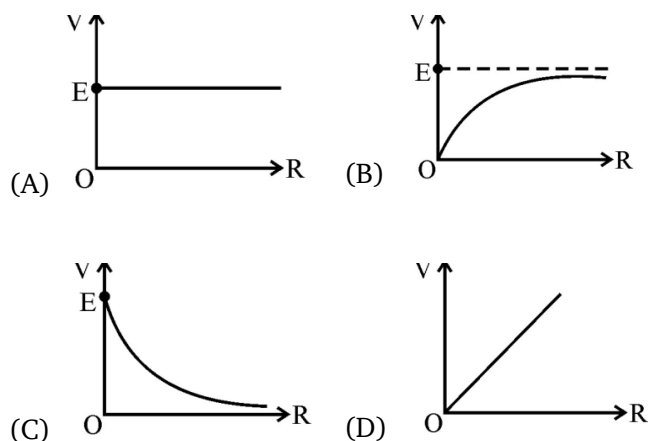
You may use the following values of physical constants wherever necessary:

$$\begin{aligned}c &= 3 \times 10^8 \text{ m/s} \\h &= 6.63 \times 10^{-34} \text{ Js} \\e &= 1.6 \times 10^{-19} \text{ C} \\\mu_0 &= 4\pi \times 10^{-7} \text{ T m A}^{-1} \\\epsilon_0 &= 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \\\frac{1}{4\pi\epsilon_0} &= 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}\end{aligned}$$

$$\begin{aligned}\text{Mass of electron } (m_e) &= 9.1 \times 10^{-31} \text{ kg} \\\text{Mass of neutron} &= 1.675 \times 10^{-27} \text{ kg} \\\text{Mass of proton} &= 1.673 \times 10^{-27} \text{ kg} \\\text{Avogadro's number} &= 6.023 \times 10^{23} \text{ per gm mole} \\\text{Boltzmann constant} &= 1.38 \times 10^{-23} \text{ JK}^{-1}\end{aligned}$$

Section A

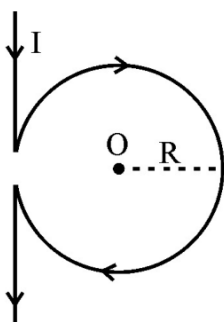
1. A cell of emf (E) and internal resistance r is connected across a variable external resistance R . The graph of terminal potential difference V as a function of R is —



2. A uniform wire of resistance $2R$ is bent in the form of a circle. The effective resistance between the ends of any diameter of the circle is:

- (A) $2R$ (B) R
(C) $\frac{R}{2}$ (D) $\frac{R}{4}$

3. A current I flows through a long straight conductor which is bent into a circular loop of radius R in the middle as shown in the figure. The magnitude of the net magnetic field at point O will be



- (A) Zero (B) $\frac{\mu_0 I}{2R} \left(1 + \frac{1}{\pi}\right)$
(C) $\frac{\mu_0 I}{4\pi R}$ (D) $\frac{\mu_0 I}{2R} \left(1 - \frac{1}{\pi}\right)$

4. A circular loop of radius r , carrying a current I lies in y - z plane with its centre at the origin. The net magnetic flux through the loop is:

- (A) directly proportional to r (B) zero
(C) inversely proportional to r (D) directly proportional to I

5. The kinetic energy of a proton and that of an α -particle are 4 eV and 1 eV, respectively. The ratio of the de-Broglie wavelengths associated with them, will be

- (A) 2 : 1 (B) 1 : 1
(C) 1 : 2 (D) 4 : 1

6. A photocell connected in an electrical circuit is placed at a distance d from a source of light. As a result, current I flows in the circuit. What will be the current in the circuit when the distance is reduced to $d/2$?

- (A) I (B) $2I$
(C) $4I$ (D) $\sqrt{2}I$

7. A current of 10 A is flowing from east to west in a long straight wire kept on a horizontal table. The magnetic field developed at a distance of 10 cm due north on the table is:

- (A) 2×10^{-5} T, acting downwards (B) 2×10^{-5} T, acting upwards
(C) 4×10^{-5} T, acting downwards (D) 4×10^{-5} T, acting upwards

8. When a wave undergoes reflection at an interface from rarer to denser medium, adhoc change in its phase is:

- (A) $\frac{\pi}{2}$ (B) 0
(C) π (D) $\frac{\pi}{4}$

9. Paschen series of atomic spectrum of hydrogen gas lies in:

- (A) Infrared region (B) Ultraviolet region
(C) Visible region (D) Partly in ultraviolet
and partly in visible
region

10. In the α -particle scattering experiment, the shape of the trajectory of the scattered α -particles depend upon:

- (A) only on impact parameter. (B) only on the source of α -particles.
(C) both impact parameter and source of α -particles. (D) impact parameter and the screen material of the detector.

11. Fill in the blank with appropriate answer.

Torque acting on an electric dipole placed in an electric field is maximum when the angle between the electric field and the dipole moment is _____.

12. Fill in the blank with appropriate answer.

A proton released from rest in an electric field, will start moving towards a region of _____ potential in the field.

13. Fill in the blank with appropriate answer.

To minimize the percentage error in the determination of unknown resistance of a conductor in meter bridge experiment, the balance point is adjusted near _____ of the wire.

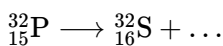
OR

In potentiometer, a long uniform wire is used to _____ potential gradient along the wire.

14. Fill in the blank with appropriate answer.

Unpolarised light of intensity I_0 is incident on two crossed polaroids. The intensity of light transmitted by the combination will be _____.

15. Name the particle emitted spontaneously in the following nuclear reaction:



16. The work done in moving a charged particle between two points in a uniform electric field does not depend on the path followed by the particle. Why?

17. Define 'magnetic declination' at a place on earth.

18. An A.C. source with variable frequency is connected to a parallel plate capacitor. How will the displacement current be affected with the decrease in frequency of the source?

19. An astronomical telescope may be a refracting type or a reflecting type. Which of the two produces image of better quality? Justify your answer.

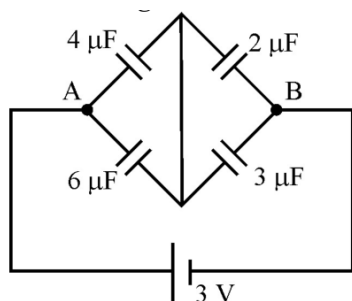
20. Can a slab of p-type semi-conductor be physically joined to another n-type semiconductor slab to form p-n junction? Justify your answer.

OR

In a p-n junction diode the forward bias resistance is low as compared to the reverse bias resistance. Give reason.

Section B

21. Find the total charge stored in the network of capacitors connected between A and B as shown in figure:



22. A wire of length L_1 has a resistance R_1 . It is gradually stretched till its length becomes $2L_1$.

(a) Plot a graph showing variation of its resistance R with its length l during stretching.

(b) What will be its resistance when its length becomes $2L_1$?

23. A resistor R and an inductor L are connected in series to a source of voltage $V = V_0 \sin \omega t$. The voltage is found to lead current in phase by $\pi/4$. If the inductor is replaced by a capacitor C , the voltage lags behind current in phase by $\pi/4$.

When L , C and R are connected in series with the same source, find the:

- (i) average power dissipated and
- (ii) instantaneous current in the circuit.

24. Light of same wavelength is incident on three photo-sensitive surfaces A , B and C . The following observations are recorded.

- (i) From surface A , photo electrons are not emitted.
- (ii) From surface B , photo electrons are just emitted.
- (iii) From surface C , photo electrons with some kinetic energy are emitted.

Compare the threshold frequencies of the three surfaces and justify your answer.

OR

If the frequency of light incident on the cathode of a photo-cell is increased, how will the following be affected? Justify your answer.

- (i) Energy of the photo electrons.
- (ii) Photo current.

25. Briefly explain how a potential barrier is set up across a p-n junction as a result of diffusion and drift of the charge carriers.

26. (a) Why is a photo diode operated under reverse bias condition?

(b) Draw V - I characteristic curves of photo diode for incident light of intensities I_1 and I_2 ($I_2 > I_1$).

OR

(a) State the level of doping and biasing condition used in light emitting diode (LED).

(b) Write any two advantages of LED over the conventional low power lamps.

27. (a) Explain the formation of energy bands in crystalline solids.

(b) Draw the energy band diagrams of (i) a metal and (ii) a semiconductor.

Section C

28. A hollow conducting sphere of inner radius r_1 and outer radius r_2 has a charge Q on its surface. A point charge $-q$ is also placed at the centre of the sphere.

- (a) What is the surface charge density on the (i) inner and (ii) outer surface of the sphere?
(b) Use Gauss' law of electrostatics to obtain the expression for the electric field at a point lying outside the sphere.

OR

- (a) An infinitely long thin straight wire has a uniform linear charge density λ . Obtain the expression for the electric field E at a point lying at a distance x from the wire, using Gauss' law.
(b) Show graphically the variation of this electric field E as a function of distance x from the wire.

29. (a) Explain the principle of working of a potentiometer.

- (b) In a potentiometer, a standard source of emf 5 V and negligible internal resistance maintains a steady current through the potentiometer wire of length 10 m. Two primary cells of emf E_1 and E_2 are joined together in a series with (i) same polarity and (ii) opposite polarity. The combination is connected to the potentiometer circuit in each case. The balancing length of the wire in the two cases are found to be 700 cm and 100 cm, respectively. Find the values of emf of the two cells.

30. (a) Differentiate between self inductance and mutual inductance.

- (b) The mutual inductance of two coaxial coils is 2 H. The current in one coil is changed uniformly from zero to 0.5 A in 100 ms. Find the:

- (i) change in magnetic flux through the other coil.
(ii) emf induced in the other coil during the change.

31. Explain with the help of a diagram, the working of a step-down transformer. Why is a laminated iron core used in a transformer?

32. Name the electro-magnetic waves with their frequency range, produced in

- (a) some radioactive decay
(b) sparks during electric welding
(c) TV remote

33. Two coherent light waves of intensity $5 \times 10^{-2} \text{ W m}^{-2}$ each super-impose and produce the interference pattern on a screen. At a point where the path difference between the waves is $\lambda/6$, λ being the wavelength of the wave, find the

- (a) phase difference between the waves.
(b) resultant intensity at the point.
(c) resultant intensity in terms of the intensity at the maximum.

34. Two objects P and Q when placed at different positions in front of a concave mirror of focal length 20 cm, form real images of equal size. Size of object P is three times size of object Q . If the distance of P is 50 cm from the mirror, find the distance of Q from the mirror.

Section D

35. (a) Show that a current carrying solenoid behaves like a small bar magnet. Obtain the expression for the magnetic field at an external point lying on its axis.

(b) A steady current of 2 A flows through a circular coil having 5 turns of radius 7 cm. The coil lies in X - Y plane with its centre at the origin. Find the magnitude and direction of the magnetic dipole moment of the coil.

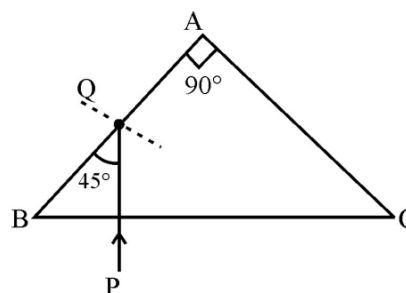
OR

(a) Derive the expression for the force acting between two long parallel current carrying conductors. Hence, define 1 A current.

(b) A bar magnet of dipole moment 3 A m^2 rests with its centre on a frictionless pivot. A force F is applied at right angles to the axis of the magnet, 10 cm from the pivot. It is observed that an external magnetic field of 0.25 T is required to hold the magnet in equilibrium at an angle of 30° with the field. Calculate the value of F . How will the equilibrium be effected if F is withdrawn?

36. (a) Draw the ray diagram showing refraction of ray of light through a glass prism. Derive the expression for the refractive index μ of the material of prism in terms of the angle of prism A and angle of minimum deviation δ_m .

(b) A ray of light PQ enters an isosceles right angled prism ABC of refractive index 1.5 as shown in figure.



- (i) Trace the path of the ray through the prism.
- (ii) What will be the effect on the path of the ray if the refractive index of the prism is 1.4?

OR

(a) Two thin lenses are placed coaxially in contact. Obtain the expression for the focal length of this combination in terms of the focal lengths of the two lenses.

(b) A converging lens of refractive index 1.5 has a power of 10 D. When it is completely immersed in a liquid, it behaves as a diverging lens of focal length 50 cm. Find the refractive index of the liquid.

37. (a) Derive the law of radioactive decay $N = N_0 e^{-\lambda t}$.

(b) The half life of ^{238}U undergoing α -decay is 4.5×10^9 years. Find its mean life.

(c) What fraction of the initial mass of a radioactive substance will decay in five half-life periods?

OR

(a) State the postulates of Bohr's model of hydrogen atom and derive the expression for Bohr radius.

(b) Find the ratio of the longest and the shortest wavelengths amongst the spectral lines of Balmer series in the spectrum of hydrogen atom.

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