

Question Paper

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 Hours

Maximum Marks: 70

General Instructions

- (i) This edition contains **27 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. Two identical conducting balls A and B have charges $-Q$ and $+3Q$ respectively. They are brought in contact with each other and then separated by a distance d apart. Find the nature of the Coulomb force between them.

OR

A metallic spherical shell has an inner radius R_1 and outer radius R_2 . A charge Q is placed at the centre of the shell. What will be the surface charge density on the (i) inner surface, and (ii) outer surface of the shell?

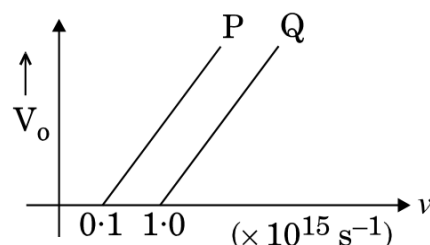
2. Under what condition will the current in a wire be the same when connected in series and in parallel of n identical cells each having internal resistance r and external resistance R ?

3. The small ozone layer on top of the stratosphere is crucial for human survival. Why?

OR

Illustrate by giving suitable examples, how you can show that electromagnetic waves carry both energy and momentum.

4. The figure shows the variation of stopping potential V_s with the frequency ν of the incident radiations for two photosensitive metals P and Q. Which metal has smaller threshold wavelength? Justify your answer.



5. Why is ground wave transmission of signals restricted to a frequency of 1500 kHz?

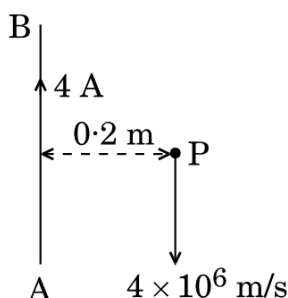
Section B

6. Apply Gauss's law to show that for a charged spherical shell, the electric field outside the shell is, as if the entire charge were concentrated at the centre.

OR

Two large parallel plane sheets have uniform charge densities $+\sigma$ and $-\sigma$. Determine the electric field (i) between the sheets, and (ii) outside the sheets.

7. A long straight wire AB carries a current of 4 A. A proton P travels at $4 \times 10^6 \text{ m s}^{-1}$ parallel to the wire 0.2 m from it and in a direction opposite to the current as shown in the figure. Calculate the force which the magnetic field due to the current carrying wire exerts on the proton. Also specify its direction.



8. A parallel plate capacitor of plate area A each and separation d , is being charged by an ac source. Show that the displacement current inside the capacitor is the same as the current charging the capacitor.

9. A beam of light converges at a point P. Now a convex lens is placed in the path of the convergent beam at 15 cm from P. At what point does a beam converge if the convex lens has a focal length 10 cm?

OR

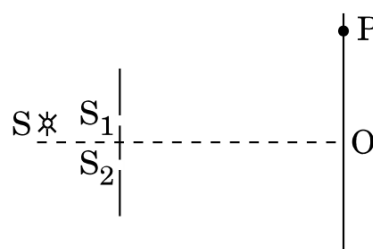
An object is kept in front of a concave mirror of focal length 15 cm. The image formed is real and three times the size of the object. Calculate the distance of the object from the mirror.

10. Explain giving reason, how the resolving power of a compound microscope depends on the
(a) frequency of the incident light.
(b) focal length of the objective lens.

11. The figure shows a modified Young's double slit experimental set-up. Here $SS_1 - SS_2 = \lambda/4$.

(a) Write the condition for constructive interference.

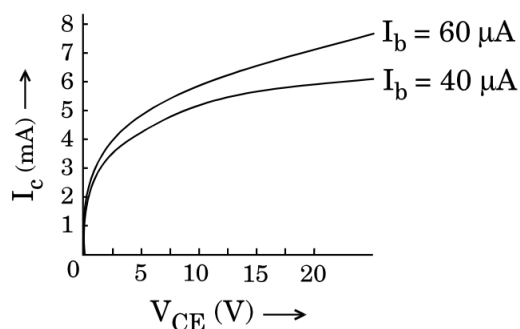
(b) Obtain an expression for the fringe width.



12. A certain n-p-n transistor has the common emitter output characteristics as shown in the figure.

(a) Find the emitter current at $V_{CE} = 12.5 \text{ V}$ and $I_B = 60 \mu\text{A}$, and

(b) Current gain ' β ' at this point.



Section C

13. (a) Draw a graph showing the variation of current versus voltage in an electrolyte when an external resistance is also connected.

(b) (i) The graph between resistance (R) and temperature (T) for Hg is shown in figure (a). Explain the behaviour of Hg near 4 K.

(ii) In which region of the graph shown in figure (b) is the resistance negative and why?

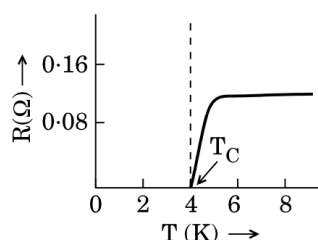


Figure (a)

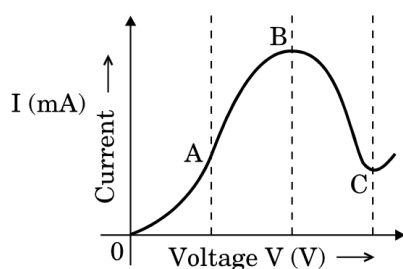


Figure (b)

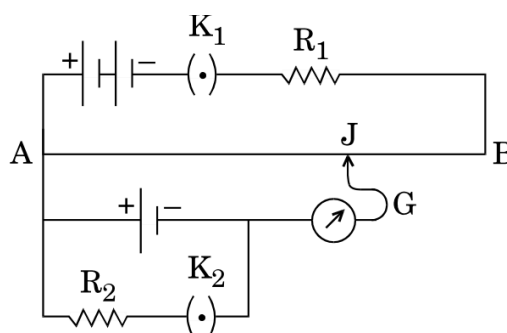
14. (a) For the circuit shown in the figure, how would the balancing length be affected, if

(i) R_1 is decreased,

(ii) R_2 is increased,

the other factors remaining the same in the circuit? Justify your answer in each case.

(b) Why is a potentiometer preferred over a voltmeter? Give reason.



OR

State the underlying principle of meter bridge. Draw the circuit diagram and explain how the unknown resistance of a conductor can be determined by this method.

15. A proton, a deuteron and an alpha particle, are accelerated through the same potential difference and then subjected to a uniform magnetic field $\vec{B}$, perpendicular to the direction of their motions. Compare (i) their kinetic energies, and (ii) if the radius of the circular path described by proton is 5 cm, determine the radii of the paths described by deuteron and alpha particle.

16. (a) Briefly explain how a galvanometer is converted into an ammeter.

(b) A galvanometer coil has a resistance of $15\ \Omega$ and it shows full scale deflection for a current of 4 mA. Convert it into an ammeter of range 0 to 6 A.

OR

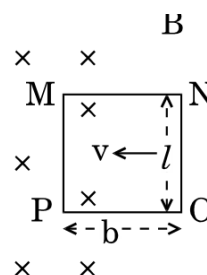
(a) Briefly explain how a galvanometer is converted into a voltmeter.

(b) A voltmeter of a certain range is constructed by connecting a resistance of $980\ \Omega$ in series with a galvanometer. When the resistance of $470\ \Omega$ is connected in series, the range gets halved. Find the resistance of the galvanometer.

17. The figure shows a rectangular conducting frame MNOP of resistance R placed partly in a perpendicular magnetic field $\vec{B}$ and moved with velocity $\vec{v}$ as shown in the figure. Obtain the expressions for the

(a) force acting on the arm 'ON' and its direction, and

(b) power required to move the frame to get a steady emf induced between the arms MN and PO.



18. Draw a ray diagram to show the image formation of a distant object by a refracting telescope. Write the expression for its angular magnification in terms of the focal lengths of the lenses used. State the important considerations required to achieve large resolution and their consequent limitations.

OR

(a) Plot a graph for angle of deviation as a function of angle of incidence for a triangular prism.

(b) Derive the relation for the refractive index of the prism in terms of the angle of minimum deviation and angle of prism.

19. (a) State briefly, with what purpose was Davisson and Germer experiment performed and what inference was drawn from this.

(b) Obtain an expression for the ratio of the accelerating potentials required to accelerate a proton and an α -particle to have the same de-Broglie wavelength associated with them.

OR

(a) An electron and a proton are accelerated through the same potential. Which one of the two has

(i) greater value of de-Broglie wavelength associated with it, and

(ii) lesser momentum?

Justify your answer in each case.

(b) How is the momentum of a particle related with its de-Broglie wavelength? Show the variation on a graph.

20. (a) Using Bohr's postulates, derive the expression for the orbital period of the electron moving in the n^{th} orbit of hydrogen atom.

(b) Write Rydberg's formula for wavelengths of the spectral lines of hydrogen atom spectrum. Mention to which series in the emission spectrum of hydrogen, H_β line belongs.

21. Draw a graph showing the variation of binding energy per nucleon with mass number of different nuclei. Write any two salient features of the curve. How does this curve explain the release of energy both in the processes of nuclear fission and fusion?

22. Draw the energy band diagram of (i) n-type, and (ii) p-type semiconductors at temperature $T > 0\text{ K}$.

In the case of n-type Si-semiconductor, the donor energy level is slightly below the bottom of conduction band whereas in p-type semiconductor, the acceptor energy level is slightly above the top of valence band. Explain, giving examples, what role do these energy levels play in conduction and valence bands.

23. With what considerations in view is a photodiode fabricated? Explain its working with the help of a suitable diagram. With the help of V-I characteristics, state how photodiode is used to detect optical signals.

24. (a) What is amplitude modulation? Draw a diagram showing an amplitude modulated wave obtained by modulation of a carrier sinusoidal wave on a modulating signal.

(b) Define the terms (i) modulation index, and (ii) side bands. Mention the significance of side bands.

Section D

25. (a) When a parallel plate capacitor is connected across a dc battery, explain briefly how the capacitor gets charged.

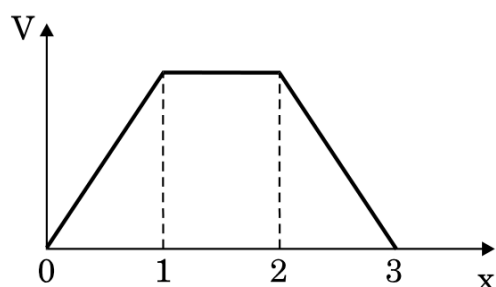
(b) A parallel plate capacitor of capacitance ' C ' is charged to ' V ' volt by a battery. After some time the battery is disconnected and the distance between the plates is doubled. Now a slab of dielectric constant $1 < k < 2$ is introduced to fill the space between the plates. How will the following be affected?

(i) The electric field between the plates of the capacitor.

(ii) The energy stored in the capacitor.

Justify your answer in each case.

(c) The electric potential as a function of distance ' x ' is shown in the figure. Draw a graph of the electric field E as a function of x .



OR

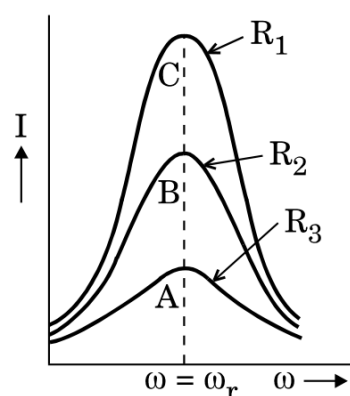
(a) Derive an expression for the potential energy of an electric dipole in a uniform electric field. Explain conditions for stable and unstable equilibrium.

(b) Is the electrostatic potential necessarily zero at a point where the electric field is zero? Give an example to support your answer.

26. (a) What do you understand by 'sharpness of resonance' for a series LCR resonant circuit? How is it related with the quality factor ' Q ' of the circuit? Using the graphs given in the diagram, explain the factors which affect it. For which graph is the resistance (R) minimum?

(b) A $2\ \mu\text{F}$ capacitor, $100\ \Omega$ resistor and $8\ \text{H}$ inductor are connected in series with an ac source. Find the frequency of the ac source for which the current drawn in the circuit is maximum.

If the peak value of emf of the source is $200\ \text{V}$, calculate the (i) maximum current, and (ii) inductive and capacitive reactance of the circuit at resonance.



OR

(a) Draw a schematic diagram of an ac generator. Explain its working and obtain the expression for the instantaneous value of the emf in terms of the magnetic field B , number of turns N of the coil of area A rotating with angular frequency ω . Show how an alternating emf is generated by a loop of wire rotating in a magnetic field.

(b) A circular coil of radius $10\ \text{cm}$ and 20 turns is rotated about its vertical diameter with angular speed of $50\ \text{rad s}^{-1}$ in a uniform horizontal magnetic field of $3.0 \times 10^{-2}\ \text{T}$.

(i) Calculate the maximum and average emf induced in the coil.

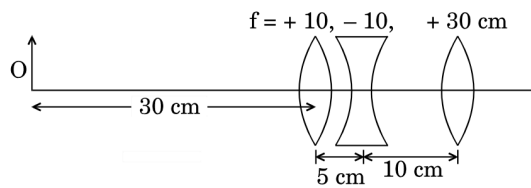
(ii) If the coil forms a closed loop of resistance $10\ \Omega$, calculate the maximum current in the coil and the average power loss due to Joule heating.

27. (a) Using the ray diagram for a system of two lenses of focal lengths f_1 and f_2 in contact with each other, show that the two lens system can be regarded as equivalent to a single lens of focal length f , where

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}.$$

Also write the relation for the equivalent power of the lens combination.

(b) Determine the position of the image formed by the lens combination given in the figure.



OR

(a) Explain, using a suitable diagram, how unpolarized light gets linearly polarized by scattering.

(b) Describe briefly the variation of the intensity of transmitted light when a polaroid sheet kept between two crossed polaroids is rotated. Draw the graph depicting the variation of intensity with the angle of rotation. How many maxima and minima would be observed when θ varies from 0 to π ?

- End of Question Paper -