

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 **27 questions**. All questions are **compulsory**.
- (ii) The question paper is divided into Sections A, B, C, D.
- (iii) Section A - Questions 1 to 5 carry 1 mark each.
- (iv) Section B - Questions 6 to 12 carry 2 marks each.
- (v) Section C - Questions 13 to 24 carry 3 marks each.
- (vi) Section D - Questions 25 to 27 carry 5 marks each.
- (vii) There is no overall choice. Where an internal choice is provided, attempt only one of the alternatives.
- (viii) Use of calculators is not permitted.

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

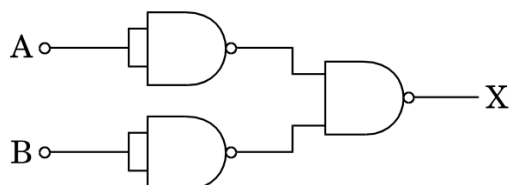
$$\begin{aligned}c &= 3 \times 10^8 \text{ m/s} \\h &= 6.63 \times 10^{-34} \text{ Js} \\e &= 1.6 \times 10^{-19} \text{ C} \\\mu_0 &= 4\pi \times 10^{-7} \text{ T m A}^{-1} \\\epsilon_0 &= 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \\\frac{1}{4\pi\epsilon_0} &= 9 \times 10^9 \text{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

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

Section A

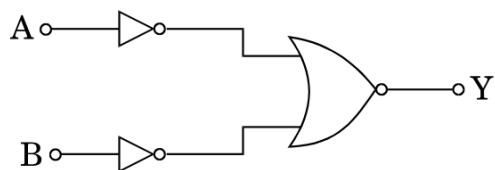
1. Plot a graph of de-Broglie wavelength associated with an electron as a function of its kinetic energy.

2. Identify the equivalent gate for the circuit of a combination of gates shown in the figure. Write its symbol.



OR

Draw the logic symbol of the gate shown by the combination of gates and write its name.



3. Write one important property of a paramagnetic material.

OR

Do the diamagnetic substances have resultant magnetic moment in an atom in the absence of external magnetic field?

4. Why can the interior of a conductor have no excess charge in the static situation?

5. When a p-n junction diode is forward biased, how will its barrier potential be affected?

Section B

6. Draw a block diagram of a generalized communication system and write the functions of (i) a transmitter, and (ii) a receiver.

7. (a) Obtain the conditions under which an electron does not suffer any deflection while passing through a magnetic field.

(b) Two protons P and Q moving with the same speed pass through the magnetic fields $\vec{B}_1$ and $\vec{B}_2$ respectively, at right angles to the field directions. If $|\vec{B}_1| > |\vec{B}_2|$, which of the two protons will describe the circular path of smaller radius? Explain.

8. Two coils P and Q of radius R and 2R are lying in the same plane with their centres coinciding. Find the magnitude and direction of the resultant magnetic field at the common centre if they respectively carry currents $3I$ and $2I$ in opposite directions.

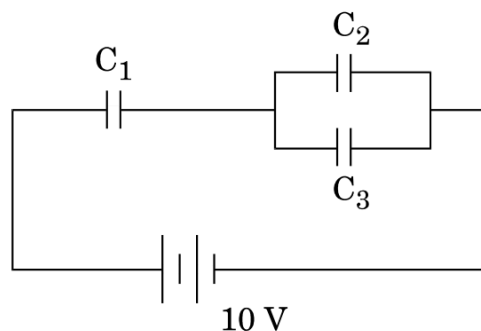
9. A wire of resistance R , length l and uniform area of cross-section A is stretched till its length becomes double. It is then cut into three pieces of equal length which are connected in parallel. Find the net resistance of the combination in terms of the resistance R .

10. Derive an expression for the torque acting on an electric dipole of dipole moment $\vec{p}$ placed in a uniform electric field $\vec{E}$. Write the direction along which the torque acts.

OR

Derive an expression for the electric field at a point on the axis of an electric dipole of dipole moment $\vec{p}$. Also write its expression when the distance $r \gg$ the length ' a ' of the dipole.

11. The figure shows a network of three capacitors $C_1 = 2 \mu F$; $C_2 = 6 \mu F$ and $C_3 = 3 \mu F$ connected across a battery of 10 V. If a charge of $6 \mu C$ is acquired by the capacitor C_3 , calculate the charge acquired by C_1 .



12. The frequencies of two side bands in an amplitude modulated wave are 640 kHz and 660 kHz respectively. Find the frequencies of the carrier and the modulating signals. Also obtain the value of the bandwidth required in amplitude modulation.

OR

A sinusoidal carrier voltage is amplitude modulated by a sinusoidal voltage of 10 kHz with modulation index 0.3. If the carrier frequency is 10 MHz and its amplitude is 40 V, calculate the frequency and amplitude of the two sidebands.

Section C

13. A screen is placed 90 cm from an object. The image of the object on the screen is formed by a convex lens at two different positions separated by 20 cm. Calculate the focal length of the lens.

OR

A convex lens of focal length 20 cm and a concave lens of focal length 15 cm are kept 30 cm apart with their principal axes coincident. When an object is placed 30 cm in front of the convex lens, calculate the position of the final image formed by the combination. Would this result change if the object were placed 30 cm in front of the concave lens? Give reason.

14. (a) Good quality sunglasses made of polaroids are preferred over ordinary coloured glasses. Explain why.

(b) How is plane polarized light defined?

(c) A beam of plane polarised light is passed through a polaroid. Show graphically, variation of the intensity of the transmitted light with angle of rotation of the polaroid.

15. State the principle of a moving coil galvanometer. Explain its working and obtain the expression for the deflection produced due to the current passed through the coil. Define current sensitivity.

OR

Explain how a galvanometer can be converted into an ammeter of a given range. Derive an expression for shunt resistance and current for full scale deflection. Find the effective resistance of the ammeter.

16. Draw the phasor diagram of a series LCR connected across an ac source $V = V_m \sin \omega t$. Hence, derive the expression for the impedance of the circuit. Obtain the conditions for the phase angle under which the current is (i) maximum, and (ii) minimum.

17. Answer the following questions:

(a) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band?

(b) How is the width of the central maximum changed when red light is replaced by blue?

(c) In what way is diffraction from each slit related to the interference pattern in a double slit experiment?

18. A charge Q is distributed over the surfaces of two concentric hollow spheres of radii r and R ($R \gg r$), such that their surface charge densities are equal. Derive the expression for the potential at the common centre.

OR

Three concentric metallic shells A, B and C of radii a , b and c ($a < b < c$) have surface charge densities $+\sigma$, $-\sigma$ and $+\sigma$ respectively.

(a) Obtain the expressions for the potential of the three shells A, B and C.

(b) If shells A and C are at the same potential, obtain the relation between a , b and c .

19. Write Einstein's photoelectric equation using the quantum picture of radiation. Explain briefly the three characteristic features observed in photoelectric effect which can be explained by Einstein's equation and not by the wave theory of light.

20. (a) Distinguish between isotopes and isobars, giving one example for each.

(b) Why is the mass of a nucleus always less than the sum of the masses of its constituents? Write one example to justify your answer.

OR

(a) Classify the following six nuclides into (i) isotones, (ii) isotopes, and (iii) isobars: $^{12}_6\text{C}$, ^3_2He , $^{198}_{80}\text{Hg}$, ^3_1H , $^{197}_{79}\text{Au}$, $^{14}_6\text{C}$.

(b) How does the size of a nucleus depend on its mass number? Hence explain why the density of nuclear matter should be independent of the size of the nucleus.

21. (a) Differentiate between three segments of an n-p-n transistor on the basis of their size and level of doping.

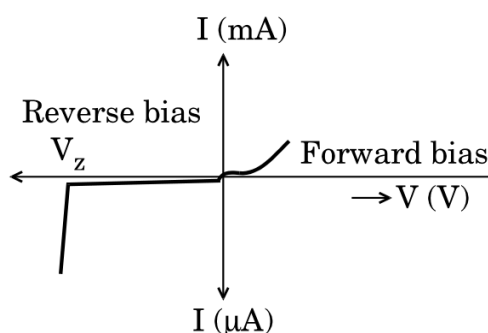
(b) Draw a plot of transfer characteristic and show which portion of the characteristic is used in amplification and why.

22. Define displacement current. What role does it play while charging a capacitor by dc source. Is the value of displacement current same as that of the conduction current? Explain.

23. Hydrogen atom in third excited state de-excites to the first excited state. Obtain the expressions for the frequency of radiation emitted in this process.

Also determine the ratio of the wavelengths of the emitted radiations when the atom de-excites from the third excited state to the second excited state and from the third excited state to the first excited state.

24. The figure shows the V-I characteristic of a semiconductor diode designed to operate under reverse bias.



(a) Identify the semiconductor diode used.

(b) Draw the circuit diagram to obtain the given characteristics of this device.

(c) Briefly explain one use of this device.

Section D

25. (a) A metallic rod of length ' l ' and resistance ' R ' is rotated with a frequency ' ν ' with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius ' l ', about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field ' B ' parallel to the axis is present everywhere.

(i) Derive the expression for the induced emf and the current in the rod.

(ii) Due to the presence of current in the rod and of the magnetic field, find the expression for the magnitude and direction of the force acting on this rod.

(iii) Hence, obtain an expression for the power required to rotate the rod.

(b) A copper coil is taken out of a magnetic field with a fixed velocity. Will it be easy to remove it from the same field if its ohmic resistance is increased?

OR

(a) A rectangular coil rotates in a uniform magnetic field. Obtain an expression for induced emf and current at any instant. Also find their peak values. Show the variation of induced emf versus angle of rotation (ωt) on a graph.

(b) An iron bar falling through the hollow region of a thick cylindrical shell made of copper experiences a retarding force. What can you conclude about the nature of the iron bar? Explain.

26. (a) Draw a labelled ray diagram of compound microscope, when final image forms at the least distance of distinct vision.

(b) Why is its objective of short focal length and of short aperture, compared to its eyepiece? Explain.

(c) The focal length of the objective is 4 cm while that of eyepiece is 10 cm. The object is placed at a distance of 6 cm from the objective lens.

(i) Calculate the magnifying power of the compound microscope, if its final image is formed at the near point.

(ii) Also calculate length of the compound microscope.

OR

(a) With the help of a labelled ray diagram, explain the construction and working of a Cassegrain reflecting telescope.

(b) An amateur astronomer wishes to estimate roughly the size of the Sun using his crude telescope consisting of an objective lens of focal length 200 cm and an eyepiece of focal length 10 cm. By adjusting the distance of the eyepiece from the objective, he obtains an image of the Sun on a screen 40 cm behind the eyepiece. The diameter of the Sun's image is measured to be 6.0 cm. Estimate the Sun's size, given that the average Earth-Sun distance is 1.5×10^{11} m.

27. (a) Derive a relation between the internal resistance, emf and terminal potential difference of a cell from which current I is drawn. Draw V vs I graph for a cell and explain its significance.

(b) A voltmeter of resistance $998\ \Omega$ is connected across a cell of emf 2 V and internal resistance $2\ \Omega$. Find the potential difference across the voltmeter and also across the terminals of the cell. Estimate the percentage error in the reading of the voltmeter.

OR

(a) Two cells of different emfs and internal resistances are connected in parallel with one another. Derive the expression for the equivalent emf and equivalent internal resistance of the combination.

(b) Two identical cells of emf 1.5 V and internal resistance r are each connected in parallel providing a supply to an external circuit consisting of two resistances of $17\ \Omega$ each joined in parallel. A very high resistance voltmeter reads the terminal voltage of the cell to be 1.4 V . Calculate the internal resistance of each cell.

- End of Question Paper -