CBSE EXAMINATION PAPER-2024

PHYSICS

(Solved)

Time allowed : 3 hours | Maximum Marks : 82

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **38 questions.** All questions are **compulsory.**

ii. This question paper is divided into **5 sections.**

iii. **Section A** – questions number **1 to 2** are case based questions

iv. **Section B** – questions number **3 to 18** are multiple choice questions

v. **Section C** – questions number **19 to 24** are very short answer

vi. **Section D** – questions number **25 to 32** are short answer

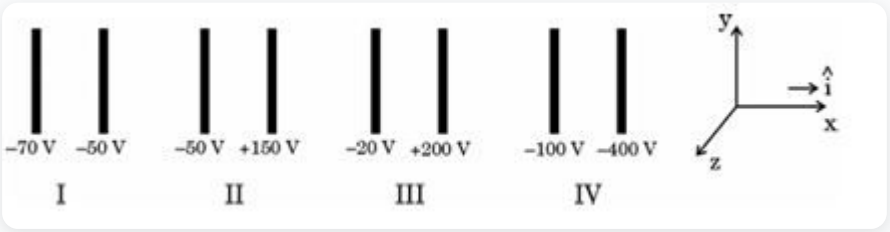
vii. **Section E** – questions number **33 to 38** are long answer

viii. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.

ix. Use of calculator is NOT allowed.

Section A

Question 1. The figure shows four pairs of parallel identical conducting plates, separated by the same distance 2.0 cm and arranged perpendicular to the x-axis. The electric potential of each plate is mentioned. The electric field between a pair of plates is uniform and normal to the plates.



(1)

For which pair of the plates is the electric field □□ along □̂?

a) I

b) II

c) III

d) IV

[1 Marks]

(2)

Let V_o be the potential at the left plate of any set, taken to be at x = 0 m. Then potential V at any point (0 ≤ x ≤ 2 cm) between the plates of that set can be expressed as:

(A) $V = V_o + \alpha x$

(B) $V = V_o + \alpha x^2$

(C) $V = V_o + \alpha x^{1/2}$

(D) $V = V_o + \alpha x^{3/2}$

where α is a constant, positive or negative.

[1 Marks]

(3)

a) Let E_1, E_2, E_3 and E_4 be the magnitudes of the electric field between the pairs of plates, I, II, III and IV respectively. Then:

(A) $E_1 > E_2 > E_3 > E_4$

(B) $E_3 > E_4 > E_1 > E_2$

(C) $E_4 > E_3 > E_2 > E_1$

(D) $E_2 > E_3 > E_4 > E_1$

[1 Marks]

(4)

An electron is released midway between the plates of pair IV. It will:

(A) move along $\hat{i}$ at constant speed

(B) move along -$\hat{i}$ at constant speed

(C) accelerate along $\hat{i}$

(D) accelerate along-$\hat{i}$

[1 Marks]

(5)

An electron is projected from the right plate of set I directly towards its left plate. It just comes to rest at the plate. The speed with which it was projected is about :

(Take (e/m) =1.76 10^{11} C/kg)

(A) 1.3 *10^{5} m/s

(B) 2.6 *10^{6} m/s

(C) 6.5* 10^{5} m/s

(D) 5.2 *10^{7} m/s

[1 Marks]

Question 2.

Diffraction and interference are closely related phenomena that occur together. Diffraction is the phenomenon of bending of light around the edges of the obstacle, while interference is the combination of waves that results in a new wave pattern. In order to get interference, there must be at least two waves that are diffracting. So while diffraction can occur without interference, interference cannot occur without diffraction.

Two slits of width 2 μm each in an opaque material are separated by a distance of 6 μm. Monochromatic light of wavelength 450 nm is incident normally on the slits. One finds a combined interference and diffraction pattern on the screen.

(1)

The number of peaks of the interference fringes formed within the central peak of the envelope of the diffraction pattern will be :

(A) 2

(B) 3

(C) 4

(D) 6

[1 Marks]

(2)

If instead of 450 nm light, another light of wavelength 680 nm is used, the number of peaks of the interference formed in the central peak of the envelope of the diffraction pattern will be:

(A) 2

(B) 4

(C) 6

(D) 9

[1 Marks]

(3)

The number of bright fringes formed due to interference on 1 m of screen placed at 4/3m away from the slits is :

(A) 2

(B) 3

(C) 6

(D) 10

[1 Marks]

(4)

The number of peaks of the interference formed if the slit width is doubled while keeping the distance between the slits same will be :

(A) 1

(B) 2

(C) 3

(D) 4

[1 Marks]

(5)

Consider the diffraction of light by a single slit described in this case study. The first minimum falls at an angle θ equal to :

(A) $\sin^{-1}$ (0.12)

(B) $\sin^{-1}$ (0.225)

(C) $\sin^{-1}$ (0.32)

(D) $\sin^{-1}$ (0.45)

[1 Marks]

Section B

Question 3.

Consider a group of charges q_1, q_2, q_3,.. such that $\Sigma q \neq 0$. Then equipotentials at a large distance, due to this group are approximately :

[1 Marks]

(A) Spherical surface

(B) Paraboloidal surface

(C) Plane

(D) Ellipsoidal surface

Question 4.

A proton is taken from point P_1 to point P_2, both located in an electric field. The potentials at points P_1 and P_2 are -5 V and +5 V respectively. Assuming that kinetic energies of the proton at points P_1 and P_2 are zero, the work done on the proton is:

[1 Marks]

(A) Zero

(B) $0{\cdot}8 \times 10^{-18}$ J

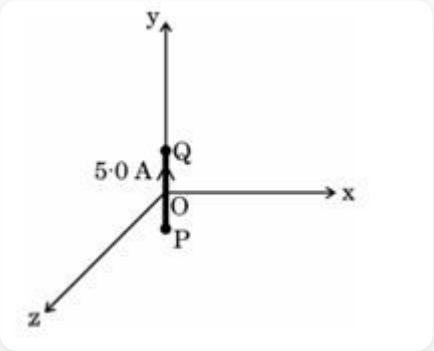
(C) $1{\cdot}6 \times 10^{-18}$ J

(D) $-1{\cdot}6 \times 10^{-18}$ J

Question 5.

A 2.0 cm segment of wire, carrying 5.0. A current in positive y-direction lies along y-axis, as shown in the figure. The magnetic field at a point (3 m, 4 m, 0) due to this segment (part of a circuit) is :

[1 Marks]



(A) $-(0.10\ \text{nT})\ \hat{j}$

(B) $-(0.24\ \text{nT})\ \hat{k}$

(C) $(0.24\ \text{nT})\ \hat{k}$

(D) $(0.12\ \text{nT})\ \hat{j}$

Question 6.

A circular loop of wire, carrying a current 'I' is lying in xy plane with its centre coinciding with the origin. It is subjected to a uniform magnetic field pointing along +z-axis. The loop will:

[1 Marks]

(A) remain stationary

(B) move along z-axis

(C) move along y-axis

(D) move along x-axis

Question 7.

A current carrying circular loop of magnetic moment □□ is suspended in a vertical plane in an external magnetic field □□such that its plane is normal to □□. The work done in rotating this loop by 45 degrees about an axis perpendicular to □□ is closest to :

[1 Marks]

(A) 1.7 MB

(B) -0.3 MB

(C) -1.7 MB

(D) 0.3 MB

Question 8.

The current in a coil of 15 mH increases uniformly from zero to 4 A in 0.004 s. The emf induced in the coil will be:

[1 Marks]

(A) 15.0 V

(B) 12.5 V

(C) 17.5 V

(D) 22.5 V

Question 9.

Consider a solenoid of length l and area of cross-section A with fixed number of turns. The self-inductance of the solenoid will increase if:

[1 Marks]

(A) both l and A are decreased

(B) l is decreased and A is increased

(C) both l and A are increased

(D) l is increased and A is decreased

Question 10. Which one of the following has the highest frequency?

[1 Marks]

(A) Infrared rays

(B) Gamma rays

(C) Radio waves

(D) Microwaves

Question 11.

A proton and an alpha particle having equal velocities approach a target nucleus. They come momentarily to rest and then reverse their directions. The ratio of the distance of closest approach of the proton to that of the alpha particle will be:

[1 Marks]

(A) 4

(B) 1/2

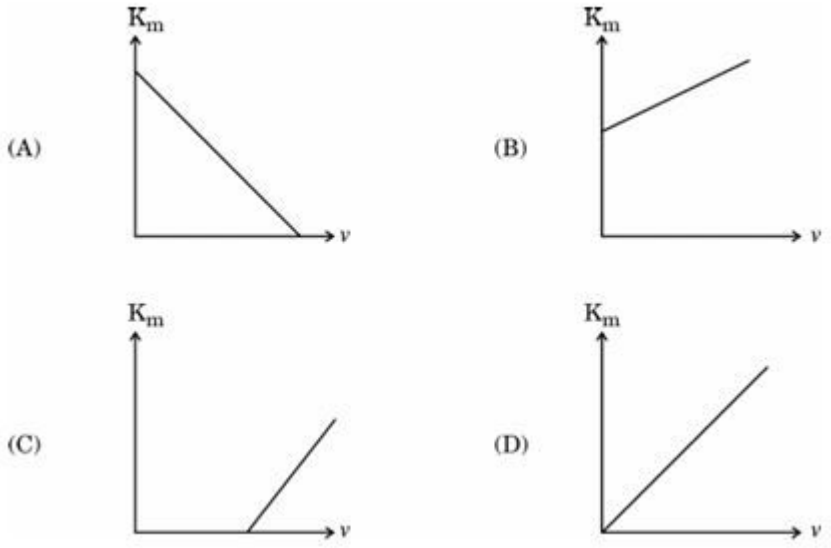
(C) 1/4

(D) 2

Question 12.

Which one of the following is the correct graph between the maximum kinetic energy (K_m) of the emitted photoelectrons and the frequency of incident radiation (ν) for a given photosensitive surface?

[1 Marks]



(A) Graph D

(B) Graph C

(C) Graph B

(D) Graph A

Question 13. An electron makes a transition from n = 2 level to n = 1 level in the Bohr model of a hydrogen atom. Its period of revolution:

[1 Marks]

(A) increases by 87.5%

(B) decreases by 87.5%

(C) increases by 43.75%

(D) decreases by 43.75%

Question 14.

Si is doped with a pentavalent element. The energy required to set the additional electron free is about:

[1 Marks]

(A) 1.1 eV

(B) 0.05 eV

(C) 0.01 eV

(D) 0.72 eV

Question 15.

Assertion (A): In a semiconductor, the electrons in the conduction band have lesser energy than those in the valence band.

Reason (R): Donor energy level is just above the valence band in a semiconductor.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Assertion (A) is false and Reason (R) is also false.

(C) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(D) Assertion (A) is true, but Reason (R) is false.

Question 16.

Assertion (A): Photoelectric effect demonstrates the particle nature of light.

Reason (R): Photoelectric current is proportional to frequency of incident radiation.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(B) Assertion (A) is false and Reason (R) is also false.

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

Question 17.

Assertion (A): A proton and an electron enter a uniform magnetic field □□ with the same momentum □□ such that □□ is perpendicular to □□. They describe circular paths of the same radius.

Reason (R): In a magnetic field, orbital radius r is equal to p/qB.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(B) Assertion (A) is false and Reason (R) is also false.

(C) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(D) Assertion (A) is true, but Reason (R) is false.

Question 18.

Assertion (A): A convex lens, when immersed in a liquid, disappears.

Reason (R): The refractive indices of the material of the lens and the liquid are equal.

[1 Marks]

(A) Assertion (A) is false and Reason (R) is also false.

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(D) Assertion (A) is true, but Reason (R) is false.

Section C

Question 19.

What is meant by relaxation time of free electrons in a conductor? Show that the resistance of a conductor can be expressed by $R = ml/ne^2 \tau A$, where symbols have their usual meanings.

[2 Marks]

Question 20.

The magnifying power of an astronomical telescope is 24. In normal adjustment, distance between its two lenses is 150 cm. Find the focal length of the objective lens.

[2 Marks]

Question 21.

Explain the following :

a) For a simple microscope, the angular size of the object equals the angular size of the image. Yet it offers magnification.

b) Both plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances ?

[2 Marks]

Question 22.

The minimum intensity of white light that our eyes can perceive is about 0.1 nW/m^{-2}. Calculate the number of photons of this light entering our pupil (area 0.4 cm^2) per second.

(take average wavelength of white light =500nm and Planck's constant = $6.6 * 10^{-34}$ Js)

[2 Marks]

Question 23.

Suppose a pure Si crystal has 5×10^{28} atoms/m^{-3}. It is doped by 1 ppm concentration of boron. Calculate the concentration of holes and electrons, given that $n_i = 1.5 \times 10^{16}$ m^{-3}. Is the doped crystal n-type or p-type?

[2 Marks]

Question 24.

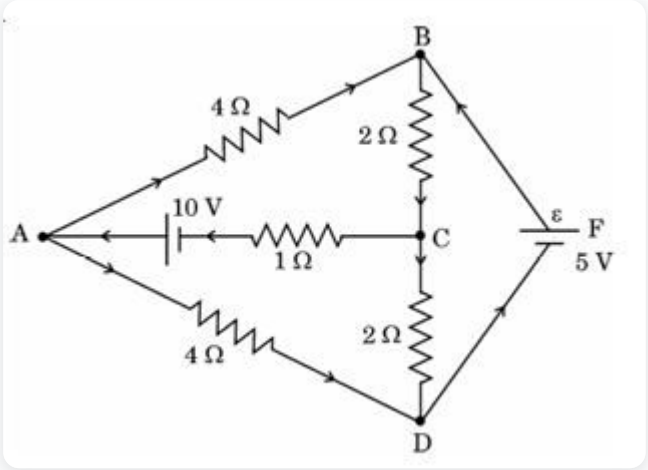
Draw the circuit diagram of a Wheatstone bridge. Obtain the condition when no current flows through the galvanometer in it.

[2 Marks]

Section D

Question 25. Determine the current in branches AB, AC and BC of the network shown in figure.

[3 Marks]



Question 26. Two long straight parallel conductors carrying currents exert a force on each other. Why? Derive an expression for the force per unit length between two long straight parallel conductors carrying currents in opposite directions. Explain the nature of the force between these conductors.

[3 Marks]

Question 27.

A sinusoidal voltage is applied to an electric circuit containing a circuit element 'X' in which the current leads the voltage by π/2

(a) Identify the circuit element 'X' in the circuit.

(b) Write the formula for its reactance.

(c) Show graphically the variation of this reactance with frequency of ac voltage.

(d) Explain the behaviour of this element when it is used in (i) an ac circuit, and (ii) a dc circuit.

[3 Marks]

Question 28.

The electric field in an electromagnetic wave in vacuum is given by:

□□= (6.3 N/C) [cos (1.5 rad/m) y + (4.5 × 10^8 rad/s) t] î.

(a) Find the wavelength and frequency of the wave.

(b) What is the amplitude of the magnetic field of the wave ?

(c) Write an expression for the magnetic field of this wave.

[3 Marks]

Question 29.

State Bohr's first and second postulates. Use them to derive an expression for the radius of the n^{th} orbit in a hydrogen atom.

[3 Marks]

Question 30.

a) Define atomic mass unit (u).

b) Calculate the energy required to separate a deuteron into its constituent parts (a proton and a neutron). Given:

m(D) = 2.014102 u,

m_H = 1.007825 u,

m_n = 1.008665 u.

[3 Marks]

Question 31.

Draw the circuit diagrams for obtaining the V-I characteristics of a p-n junction diode. Explain briefly the salient features of the V-I characteristics in (i) forward biasing, and (ii) reverse biasing.

[3 Marks]

Question 32.

On the basis of energy band diagrams, distinguish between (i) an insulator, (ii) a semiconductor, and (iii) a conductor.

[3 Marks]

Section E

Question 33.

(i) Obtain the expression for the capacitance of a parallel plate capacitor with a dielectric medium between its plates.

(ii) A charge of 6 μC is given to a hollow metallic sphere of radius 0.2 m. Find the potential at (i) the surface and (ii) the centre of the sphere.

[5 Marks]

Question 34.

(i) (1) What is meant by current sensitivity of a galvanometer ? Mention the factors on which it depends.

(2) A galvanometer of resistance G is converted into a voltmeter of range (0-V) by using a resistance R. Find the resistance, in terms of R and G, required to convert it into a voltmeter of range (0-V/2)

(ii) The magnetic flux through a coil of resistance 5 Ω increases with time as : $\varphi = (2.0\ t^3 + 5.0\ t^2 + 6.0\ t)$ mWb

Find the magnitude of induced current through the coil at t = 2 s.

[5 Marks]

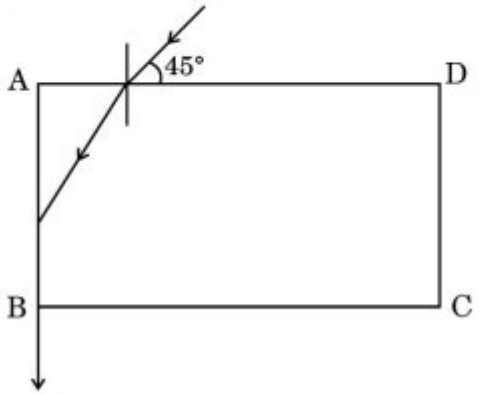
Question 35.

(i) Trace the path of a ray of light showing refraction through a triangular prism and hence obtain an expression for angle of deviation (δ) in terms of A, i and e, where symbols have their usual meanings. Draw a graph showing the variation of angle of deviation with the angle of incidence.

(ii) In the figure, a ray of light is incident on a transparent liquid contained in a thin glass box at an angle of 45° with its one face. The emergent ray passes along the face AB. Find the refractive index of the liquid.

[5 Marks]

(ii) In the figure, a ray of light is incident on a transparent liquid contained in a thin glass box at an angle of 45° with its one face. The emergent ray passes along the face AB. Find the refractive index of the liquid.



Question 36.

(i) A charge + Q is placed on a thin conducting spherical shell of radius R. Use Gauss's theorem to derive an expression for the electric field at a point lying (i) inside and (ii) outside the shell.

(ii) Show that the electric field for same charge density (**σ**) is twice in case of a conducting plate or surface than in a nonconducting sheet.

[5 Marks]

Question 37.

(i) A rectangular coil of N turns and area of cross-section A is rotated at a steady angular speed ω in a uniform magnetic field. Obtain an expression for the emf induced in the coil at any instant of time.

(ii) Two coplanar and concentric circular loops L_1 and L_2 are placed coaxially with their centres coinciding. The radii of L_1 and L_2 are 1 cm and 100 cm respectively. Calculate the mutual inductance of the loops. (Take $\pi^2 = 10$)

[5 Marks]

Question 38.

(i) The displacement of two light waves, each of amplitude 'a' and frequency ω, emanating from two coherent sources of light, are given by $y_1 = a \cos \omega t$ and $y_2 = a \cos (\omega t + \varphi)$. φ is the phase difference between the two waves. These light waves superpose at a point. Obtain the expression for the resultant intensity at that point.

(ii) In Young's double slit experiment, find the ratio of intensities at two points on a screen when waves emanating from two slits reaching these points have path differences (i) λ/6 (ii) λ/12 .

[5 Marks]