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. A pure semiconductor like Ge or Si, when doped with a small amount of suitable impurity, becomes an extrinsic semiconductor. In thermal equilibrium, the electron and hole concentration in it are related to the concentration of intrinsic charge carriers. A p-type or n-type semiconductor can be converted into a pn junction by doping it with suitable impurity. Two processes, diffusion and drift take place during the formation of a pn junction. A semiconductor diode is basically a pn junction with metallic contacts provided at the ends for the application of an external voltage. A pn junction diode allows currents to pass only in one direction when it is forward biased. Due to this property, a diode is widely used to rectify alternating voltages, in half-wave or full wave configuration.

(1)

When Ge is doped with pentavalent impurity, the energy required to free the weakly bound electron from the dopant is about

(A) 0.001 eV (B) 0.01 eV

(C) 0.72eV (D) 1.1eV

[1 Marks]

(2)

At a given temperature, the number of intrinsic charge carriers in a semiconductor is 2.0 x 10^{10}cm^{-3}. It is doped with pentavalent impurity atoms. As a result, the number of holes in it becomes 8 x 10^{3} cm^{-3}. The number of electrons in the semiconductor is

1. **2×10^{24} m^{-3}**
2. **4×10^{23} m^{-3}**
3. **1×10^{22} m^{-3}**
4. **5×10^{22} m^{-3}**

[1 Marks]

(3)

(a) During the formation of a p-n junction —

(A) electrons diffuse from p-region into n-region and holes

diffuse from n-region into p-region.

(B) both electrons and holes diffuse from n-region into p-region.

(C) electrons diffuse from n-region into p-region and holes

diffuse from p-region into n-region.

(D) both electrons and holes diffuse from p-region into n-region.

[1 Marks]

(4)

An ac voltage V = 0.5 sin (100 π t) volt is applied, in turn, across a half-wave rectifier and a full-wave rectifier. The frequency of the output voltage across them respectively will be

(A) 25 Hz, 50 Hz (B) 25 Hz, 100 Hz

(C) 50 Hz, 50 Hz (D) 50 Hz, 100 Hz

[1 Marks]

(5)

(b) Initially during the formation of a p-n junction —

(A) diffusion current is large and drift current is small.

(B) diffusion current is small and drift current is large.

(C) both the diffusion and the drift currents are large.

(D) both the diffusion and the drift currents are small.

[1 Marks]

Question 2. A lens is a transparent optical medium bounded by two surfaces; at least one of which should be spherical. Applying the formula of image formation by a single spherical surface successively at the two surfaces of a thin lens, a formula known as lens maker's formula and hence the basic lens formula can be obtained. The focal length (or power) of a lens depends on the radii of its surfaces and the refractive index of its material with respect to the surrounding medium. The refractive index of a material depends on the wavelength of light used. Combination of lenses helps us to obtain diverging or converging lenses of desired power and magnification.

(1)

The radii of curvature of two surfaces of a convex lens are R and 2R. If the focal length of this lens is 4/3R, the refractive index of the material of the lens is:

1. **5/3**
2. **4/3**
3. **3/2**
4. **7/5**

[1 Marks]

(2)

A thin converging lens of focal length 20 cm and a thin diverging lens of focal length 15 cm are placed coaxially in contact. The power of the combination is

1. **-5/6D**
2. **-5/3D**
3. **4/3D**
4. **3/2D**

[1 Marks]

(3)

The focal length of an equiconvex lens

(A) increases when the lens is dipped in water.

(B) increases when the wavelength of incident light decreases.

(C) increases with decrease in radius of curvature of its surface.

(D) decreases when the lens is cut into two identical parts along its principal axis.

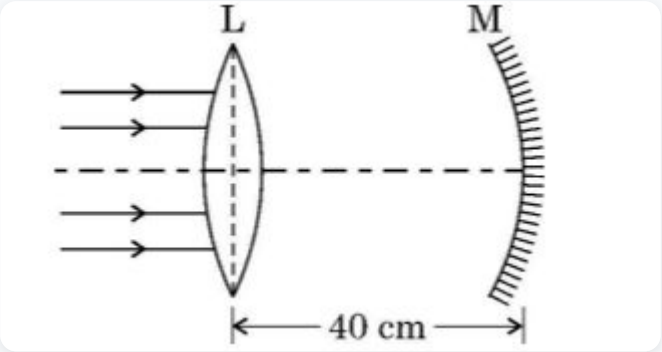
[1 Marks]

(4)

(a) A thin convex lens L of focal length 10 cm and a concave mirror M of focal length 15 cm are placed coaxially 40 cm apart as shown in figure. A beam of light coming parallel to the principal axis is incident on the lens. The final image will be formed at a distance of

(A) 10cm, left of lens (B) 10cm, right of lens

(C) 20cm, left of lens (D) 20cm, right of lens



[1 Marks]

(5)

A beam of light coming parallel to the principal axis of a convex lens L_1, of focal length 16 cm is incident on it. Another convex lens L_2, of focal length 12 cm is placed coaxially at a distance 40 cm from L_1,. The nature and distance of the final image from L_2, will be

(A) real, 24cm (B) virtual, 12 cm

(C) real, 32 cm (D) virtual, 18 cm

[1 Marks]

Section B

Question 3.

Two charges + q each are kept ‘2a’ distance apart. A third charge -2q is placed midway between them. The potential energy of the system is-

[1 Marks]

(A) $q^2/8\pi\varepsilon_0 a$

(B) $-6q^2/8\pi\varepsilon_0 a$

(C) $-7q^2/8\pi\varepsilon_0 a$

(D) $9q^2 8\pi\varepsilon_0 a$

Question 4.

Two identical small conducting balls B_1, and B_2, are given -7 pC and + 4 pC charges respectively. They are brought in contact with a third identical ball B_3, and then separated. If the final charge on each ball is -2 pC, the initial charge on B_3, was

[1 Marks]

(A) -15 pC

(B) -2pC

(C) -5 pC

(D) -3pC

Question 5.

The quantum nature of light explains the observations on photoelectric effect as-

[1 Marks]

(A) the photoelectric current is independent of the intensity of incident radiation.

(B) when the metal surface is illuminated, electrons are ejected from the surface after sometime.

(C) the maximum kinetic energy of photoelectrons depends only on the frequency of incident radiation.

(D) there is a minimum frequency of incident radiation below which no electrons are emitted.

Question 6.

A straight wire is kept horizontally along east-west direction. If a steady current flows in wire from east to west, the magnetic field at a point above the wire will point towards.

[1 Marks]

(A) South

(B) West

(C) North

(D) East

Question 7.

The magnetic susceptibility for a diamagnetic material is

[1 Marks]

(A) small and positive

(B) large and negative

(C) small and negative

(D) large and positive

Question 8.

A galvanometer of resistance 100 Ω is converted into an ammeter of range (0 — 1 A) using a resistance of 0.1 Ω. The ammeter will show full scale deflection for a current of about

[1 Marks]

(A) 0.1 mA

(B) 1 mA

(C) 0.1A

(D) 10 mA

Question 9.

A circular loop A of radius R carries a current I. Another circular loop B of radius r (=R/20) is placed concentrically in the plane of A. The magnetic flux linked with loop B is proportional to

[1 Marks]

(A) $\sqrt{R}$

(B) $R^{3/2}$

(C) R^2

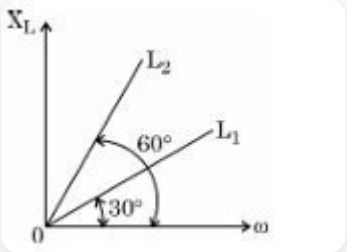
(D) R

Question 10.

Figure shows the variation of inductive reactance X_L of two ideal

inductors of inductance L_1, and L_2, with angular frequency ω. The value of L_1/L_2 is

[1 Marks]



(A) 3

(B) 1/3

(C) 1/√3

(D) √3

Question 11.

The phase difference between electric field □□ and magnetic field □□ in an

electromagnetic wave propagating along z-axis is

[1 Marks]

(A) π/2

(B) π/4

(C) 0

(D) π

Question 12.

A coil of N turns is placed in a magnetic field □□ such that □□ is perpendicular to the plane of the coil. □□ changes with time as

$B = B_0 \cos(2\pi t/T)$ where T is time period. The magnitude of emf induced in the coil will be maximum at....

Here, n = 1, 2, 3, 4, ...

[1 Marks]

(A) t=nT/8

(B) t=nT/4

(C) t=nT/2

(D) t=nT

Question 13.

In Balmer series of hydrogen atom, as the wavelength of spectral lines decreases, they appear

[1 Marks]

(A) closer together and weaker in intensity.

(B) equally spaced and equally intense.

(C) further apart and stronger in intensity.

(D) closer together and stronger in intensity.

Question 14.

Assertion (A) : The temperature coefficient of resistance is positive for metals and negative for p-type semiconductors.

Reason (R) : The charge carriers in metals are negatively charged,whereas the majority charge carriers in p-type semiconductors are positively charged.

[1 Marks]

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

(B) If Assertion (A) is true but Reason (R) is false.

(C) If both Assertion (A) and Reason (R) are false.

(D) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

Question 15.

Assertion (A) : When electrons drift in a conductor, it does not mean that all free electrons in the conductor are moving in the same direction.

Reason (R) : The drift velocity is superposed over large random velocities of electrons.

[1 Marks]

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

(B) If both Assertion (A) and Reason (R) are false.

(C) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

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

Question 16.

Assertion (A) : Electrons are ejected from the surface of zinc when it is irradiated by yellow light.

Reason (R) : Energy associated with a photon of yellow light is more than the work function of zinc.

[1 Marks]

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

(B) If both Assertion (A) and Reason (R) are false.

(C) If Assertion (A) is true but Reason (R) is false

(D) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

Question 17.

Assertion (A) : In interference and diffraction of light, light energy reduces in one region producing a dark fringe. It increases in another region and produces a bright fringe.

Reason (R) : This happens because energy is not conserved in the phenomena of interference and diffraction.

[1 Marks]

(A) If both Assertion (A) and Reason (R) are false.

(B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

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

(D) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

Question 18.

The radius (r_n) of n^{th} orbit in Bohr model of hydrogen atom varies with n as

[1 Marks]

(A) $r_n \propto n$

(B) $r_n \propto 1/n$

(C) $r_n \propto n^2$

(D) $r_n \propto 1/n^2$

Section C

Question 19.

Draw the circuit diagram of a p-n junction diode in

(i) forward biasing and (ii) reverse biasing. Also draw its I-V characteristics in the two cases.

[2 Marks]

Question 20.

A proton and α-particle are accelerated through different potentials V_1 and V_2 respectively so that they have the same de Broglie wavelengths. Find V_1 / V_2.

[2 Marks]

Question 21.

A ray of light is incident normally on one face of an equilateral glass prism of refractive index μ. When the prism is completely immersed in a transparent medium, it is observed that the emergent ray just grazes the adjacent face. Find the refractive index of the medium.

[2 Marks]

Question 22.

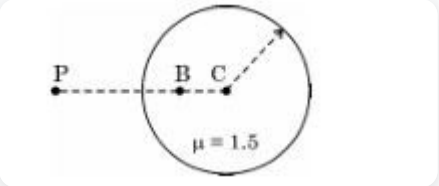
Two electric heaters have power ratings P_1 and P_2 at voltage V. They are connected in series to a dc source of voltage V. Find the power consumed by the combination. Will they consume the same power if connected in parallel across the same source?

[2 Marks]

Question 23.

An air bubble is trapped at point B (CB = 20 cm) in a glass sphere of radius 40 cm and refractive index 1.5 as shown in figure. Find the nature and position of the image of the bubble as seen by an observer at point P.

[2 Marks]



Question 24.

In normal adjustment, for a refracting telescope, the distance between objective and eye piece lens is 1.00 m. If the magnifying power of the telescope is 19, find the focal length of the objective and the eyepiece lens.

[2 Marks]

Section D

Question 25.

(a) Differentiate between nuclear fission and fusion.

(b) The fission properties of $_{94}Pu^{239}$ are very similar to those of $_{92}U^{235}$. How much energy (in MeV), is released if all the atoms in 1 g of pure $_{94}Pu^{239}$ undergo fission? The average energy released per fission is 180 MeV.

[3 Marks]

Question 26.

Draw the graph showing variation of scattered particles detected (N) with the scattering angle (θ) in Geiger-Marsden experiment. Write two conclusions that you can draw from this graph. Obtain the expression for the distance of closest approach in this experiment.

[3 Marks]

Question 27.

The electric field in a region is given by □□ =(10x+4)□̂

where x is in m and E is in N/C. Calculate the amount of work done in taking a unit charge from

i) (5m, 0) to (10 m, 0)

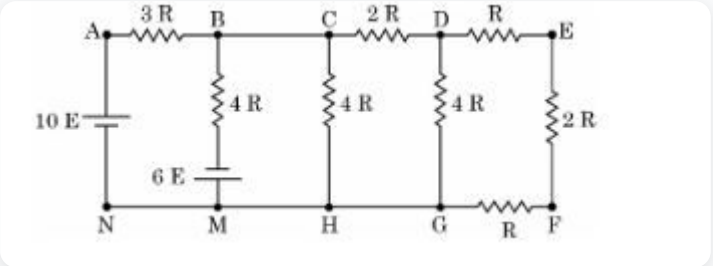
ii) (5m, 0) tom, 10 m)

[3 Marks]

Question 28.

Find the current in branch BM in the network shown.

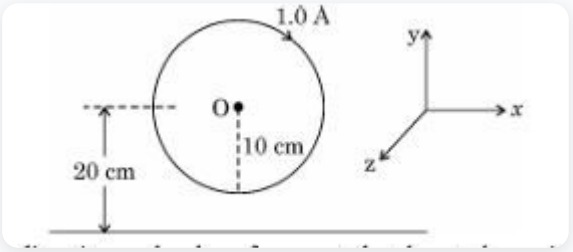
[3 Marks]



Question 29.

A circular loop of radius 10 cm carrying current of 1.0 A lies in x-y plane. A long straight wire lies in the same plane parallel to x-axis at a distance of 20 cm as shown in figure. Find the direction and value of current that has to be maintained in the wire so that the net magnetic field at O is zero. 3

[3 Marks]



Question 30.

Name the electromagnetic waves with their wavelength range which are

used for

i) FM radio broadcast

ii) detection of fracture in bones

iii) treatment of muscular strain

[3 Marks]

Question 31.

(a) (i) Define mutual inductance. Write its SI unit.

(ii) Derive an expression for the mutual inductance of a system of two long coaxial solenoids of same length l, having turns N_1, and N_2, and of radii r_1, and $r_2 > r_1$.

[3 Marks]

Question 32.

(b) What are ferromagnetic materials? Explain ferromagnetism with the help of suitable diagrams, using the concept of magnetic domain.

[3 Marks]

Section E

Question 33.

(a) (i) Draw a ray diagram for the formation of the image of an object by a convex mirror. Hence, obtain the mirror equation.

(ii) Why are multi-component lenses used for both the objective and the eyepiece in optical instruments ?

(iii) The magnification of a small object produced by a compound microscope is 200. The focal length of the eyepiece is 2 cm and the final image is formed at infinity. Find the magnification produced by the objective.

[5 Marks]

Question 34.

(i)Using Gauss's law, show that the electric field □□ at a point due to a uniformly charged infinite plane sheet is given by □□=□/2□0□̂ where symbols have their usual meanings.

(ii)Electric field E in a region is given by

□□ = $(5x^2 + 2)$□̂

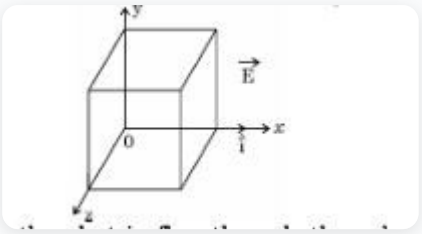
where E is in N/C and x is in meters.

A cube of side 10 cm is placed in the region as shown in figure.

Calculate (1) the electric flux through the cube, and (2) the net charge enclosed by the cube.

meters.

[5 Marks]



Question 35.

(i) Mention the factors on which the resonant frequency of a series LCR circuit depends. Plot a graph showing variation of impedance of a series LCR circuit with the frequency of the

applied a.c. source.

(ii) With the help of a suitable diagram, explain the working of a step-up transformer.

(iii) Write two causes of energy loss in a real transformer.

[5 Marks]

Question 36.

(i) Differentiate between a wavefront and a ray.

(ii) State Huygen's principle and verify laws of reflection using suitable diagram.

(iii) In Young's double slit experiment, the slits S_1 and S_2, are 3 mm apart and the screen is placed 1.0 m away from the slits. It is observed that the fourth bright fringe is at a distance of 5 mm from the second dark fringe. Find the wavelength of light used.

[5 Marks]

Question 37.

(i) A dielectric slab of dielectric constant 'K' and thickness 't' is inserted between plates of a parallel plate capacitor of plate separation d and plate area A. Obtain an expression for its

capacitance.

(ii) Two capacitors of different capacitances are connected first (1) in series and then (2) in parallel across a de source of 100 V. If the total energy stored in the combination in the two cases are 40 mJ

and 250 mJ respectively, find the capacitance of the capacitors.

[5 Marks]

Question 38.

(i) With the help of a diagram, briefly explain the construction and working of ac generator.

(ii) An electron is revolving around a proton in an orbit of radius r with a speed v. Obtain expression for magnetic moment associated with the electron.

[5 Marks]