CBSE EXAMINATION PAPER-2023

PHYSICS

(Solved)

Time allowed : 3 hours | Maximum Marks : 87

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **42 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 20** are multiple choice questions

v. **Section C** – questions number **21 to 29** are very short answer

vi. **Section D** – questions number **30 to 36** are short answer

vii. **Section E** – questions number **37 to 42** 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 lens maker's formula is useful to design lenses of desired focal lengths using surfaces of suitable radii of curvature. The focal length also depends on the refractive index of the material of the lens and the surrounding medium. The refractive index depends on the wavelength of the light used. The power of a lens is related to its focal length.

Answer the following questions based on the above :

(1) The radius of curvature of two surfaces of a convex lens is R each. For what value of its material will its focal length become equal to R?

[1 Marks]

(2)

The focal length of a concave lens of μ = 1.5 is 20 cm in air. It is completely immersed in water of μ = 4/3. Calculate its focal length in water.

[2 Marks]

(3)

How will the power of a lens be affected with an increase of wavelength of light?

[1 Marks]

(4)

An object is placed in front of a lens which forms its erect image of magnification 3. The power of the lens is 5 D. Calculate the distance of the object and the image from the lens.

[2 Marks]

Question 2. Electrostatics deals with the study of forces, fields, and potentials arising from static charges. Force and electric field, due to a point charge, is basically determined by Coulomb's law. For symmetric charge configurations, Gauss's law, which is also based on Coulomb's law, helps us to find the electric field. A charge/a system of charges like a dipole experiences a force/torque in an electric field. Work is required to be done to provide a specific orientation to a dipole with respect to an electric field.

(1) An electric dipole of dipole moment of 6 10^{-7} C-m is kept in a uniform electric field of 10^{4} N/C such that the dipole moment and the electric field are parallel. Calculate the potential energy of the dipole.

[2 Marks]

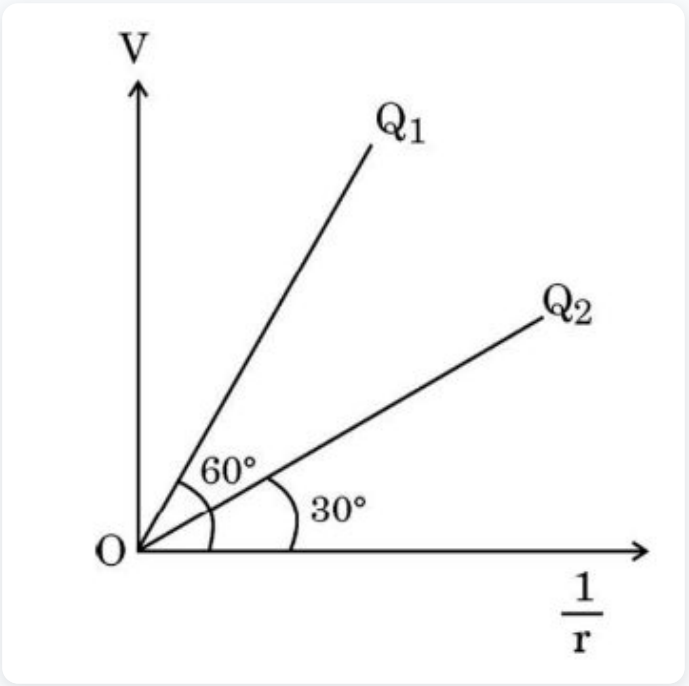
(2) An electric dipole of dipole moment p is initially kept in a uniform electric field E such that p is perpendicular to E . Find the amount of work done in rotating the dipole to a position at which p becomes antiparallel to E

[2 Marks]

(3) Consider a uniformly charged thin conducting shell of radius R. Plot a graph showing the variation of |E| with distance r from the centre, for points 0 < r < 3R.

[1 Marks]

(4) The figure shows the variation of potential V with 1/r for two point charges Q1 and Q2, where V is the potential at a distance r due to a point charge. Find Q1/Q2.



[1 Marks]

Section B

Question 3.

Two charges q1 and q2 are placed at the centres of two spherical conducting shells of radius r1 and r2 respectively. The shells are arranged such that their centres are d [> (r1 + r2)] distance apart. The force on q2 due to q1 is:

[1 Marks]

(A) 1/4πε0 q1q2/d2

(B) Zero

(C) 1/4πε0 q1q2/[d−(r1+r2)]^2

(D) 1/4πε0 q1q2/(d−r1)^2

Question 4. An electron enters a uniform magnetic field with speed v. It describes a semicircular path and comes out of the field. The final speed of the electron is:

[1 Marks]

(A) Zero

(B) v

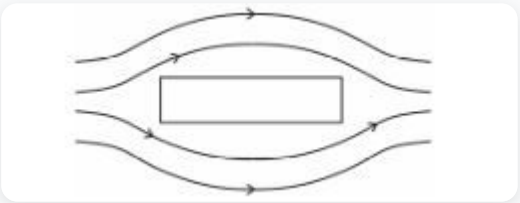
(C) 2v

(D) 2v

Question 5.

The magnetic field lines near a substance are as shown in the figure. The substance is:

[1 Marks]



(A) Iron

(B) Copper

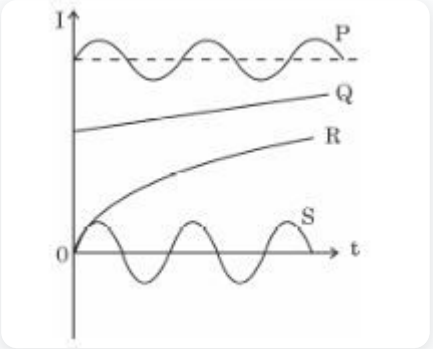
(C) Sodium

(D) Aluminium

Question 6.

The figure shows variation of current (I) with time (t) in four devices P, Q, R and S. The device in which an alternating current flows is:

[1 Marks]



(A) Q

(B) S

(C) P

(D) R

Question 7. The electromagnetic waves used in radar systems are:

[1 Marks]

(A) Infrared waves

(B) Ultraviolet rays

(C) X-rays

(D) Microwaves

Question 8.

In a Young's double slit experiment, the fringe width is found to be β. If the entire apparatus is immersed in a liquid of refractive index μ, the new fringe width will be:

[1 Marks]

(A) β/μ

(B) β

(C) β/μ^2

(D) μβ

Question 9. Photons of energy 3·2 eV are incident on a photosensitive surface. If the stopping potential for the emitted electrons is 1·5 V, the work function for the surface is:

[1 Marks]

(A) 1·5 eV

(B) 4·7 eV

(C) 3·2 eV

(D) 1·7 eV

Question 10.

Which of the following statements is not true for nuclear forces?

[1 Marks]

(A) They are stronger than Coulomb forces.

(B) They saturate as the separation between two nucleons increases.

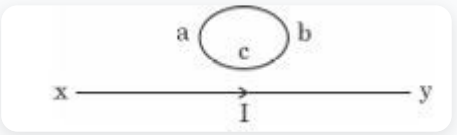
(C) They are always attractive.

(D) They have about the same magnitude for different pairs of nucleons.

Question 11.

The direction of induced current in the loop abc is:

[1 Marks]



(A) along acb if I increases

(B) along abc if I increases

(C) along abc if I is constant

(D) along abc if I decreases

Question 12.

An ac voltage v = v0 sinωt is applied to a series combination of a resistor R and an element X. The instantaneous current in the circuit is I = I0 sin (ωt + π/4). Then which of the following is correct?

[1 Marks]

(A) X is a capacitor and XC = R

(B) X is an inductor and XL = R

(C) X is a capacitor and XC = √2R

(D) X is an inductor and XL = √2R

Question 13.

Assertion (A): When three electric bulbs of power 200 W, 100 W and 50 W are connected in series to a source, the power consumed by the 50 W bulb is maximum.

Reason (R): In a series circuit, current is the same through each bulb, but the potential difference across each bulb is different.

[1 Marks]

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

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

(C) Both Assertion (A) and Reason (R) are false.

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

Question 14.

Assertion (A): A current carrying square loop made of a wire of length L is placed in a magnetic field. It experiences a torque which is greater than the torque on a circular loop made of the same wire carrying the same current in the same magnetic field.

Reason (R): A square loop occupies more area than a circular loop, both made of wire of the same length.

[1 Marks]

(A) Assertion (A) is true, but Reason (R) is 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) Both Assertion (A) and Reason (R) are false.

Question 15.

A plane wavefront is incident on a concave mirror of radius of curvature R. The radius of the refracted wavefront will be :

[1 Marks]

(A) 2R

(B) R/2

(C) R

(D) R/4

Question 16.

A proton and an alpha particle have the same kinetic energy. The ratio of de Broglie wavelengths associated with the proton to that with the alpha particle is :

[1 Marks]

(A) $2\sqrt{2}$

(B) 1

(C) 2

(D) 1/2

Question 17.

The potential energy of an electron in the second excited state in hydrogen atom is :

[1 Marks]

(A) - 6.8 eV

(B) -1.51 eV

(C) -3.4 eV

(D) -3.02 eV

Question 18.

The difference in mass of 7X nucleus and total mass of its constituent nucleons is 21·00 u. The binding energy per nucleon for this nucleus is equal to the energy equivalent of :

[1 Marks]

(A) 3u

(B) 3.5u

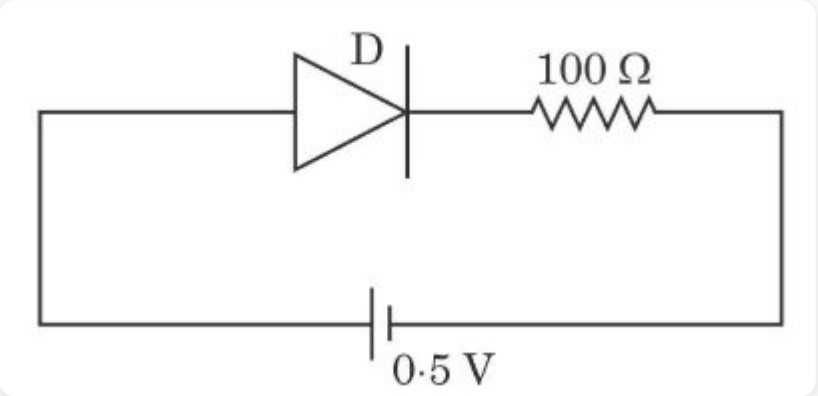
(C) 7u

(D) 21u

Question 19.

The threshold voltage for a p-n junction diode used in the circuit is 0·7 V. The type of biasing and current in the circuit are :

[1 Marks]



(A) Reverse biasing, 0 A

(B) Forward biasing, 0 A

(C) Reverse biasing, 2 mA

(D) Forward biasing, 5 mA

Question 20.

Assertion (A) : In 'n' type semiconductor, number density of electron is greater than the number density of holes but the crystal maintains an overall charge neutrality.

Reason (R) : The charge of electrons donated by donor atoms is just equal and opposite to that of the ionised donor.

[1 Marks]

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

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

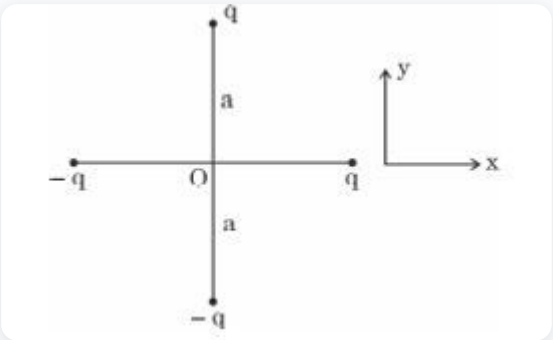
(C) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

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

Section C

Question 21. Two identical dipoles are arranged in the x-y plane as shown in the figure. Find the magnitude and the direction of the net electric field at the origin O.

[2 Marks]



Question 22. Write two differences between the emf and terminal potential difference of a cell. What is the most important precaution that one should take while drawing current from a cell?

[2 Marks]

Question 23.

What is a displacement current? How is it different from a conduction current?

[2 Marks]

Question 24.

a) Obtain an expression for the electrostatic potential energy of a system of three charges q, 2q, and -3q placed at the vertices of an equilateral triangle of side a.

[2 Marks]

Question 25.

A small magnetised needle P is placed at the origin of x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions, one by one.

Case 1 : at (a, 0) with its magnetic moment pointing along x-axis.

Case 2 : at (0, a) with its magnetic moment pointing along y-axis.

(a) In which case is the potential energy of P and Q minimum ?

(b) In which case is P and Q not in equilibrium ?

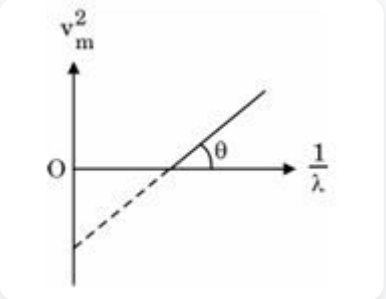
Justify your answers.

[2 Marks]

Question 26.

The figure shows v^2_m versus 1/λ graph for photoelectrons emitted from a surface where Vm is the maximum speed of electrons and λ is the wavelength of incident radiation. Using this graph and Einstein's photoelectric equation, obtain the expression for Planck's constant and work function of the surface.

[2 Marks]



Question 27.

Draw the graph showing the variation of binding energy per nucleon with mass number A of nuclei (2 < A < 170). Use this graph to explain the release of energy in nuclear fission.

[2 Marks]

Question 28.

Write any two characteristics of an electromagnetic wave. Why are microwaves used in radar systems?

[2 Marks]

Question 29.

b) Two small conducting balls A and B of radius r1 and r2 have charges q1 and q2 respectively. They are connected by a wire. Obtain the expression for charges on A and B in equilibrium.

[2 Marks]

Section D

Question 30. Two circular loops A and B, each of radius 3 m, are placed coaxially at a distance of 4 m. They carry currents of 3 A and 2 A in opposite directions respectively. Find the net magnetic field at the centre of loop A.

[3 Marks]

Question 31. Briefly explain the Geiger-Marsden experiment. Show the variation of the number of particles scattered (N) with scattering angle (θ) in this experiment. What is the main conclusion that can be inferred from this plot?

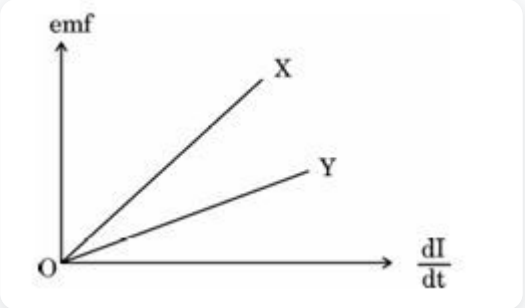
[3 Marks]

Question 32.

(a) The figure shows the variation of induced emf as a function of rate of change of current for two identical solenoids X and Y. One is air cored and the other is iron cored. Which one of them is iron cored ? Why ?

(b) Obtain an expression for self-inductance of a long solenoid of length L and cross-sectional area A having N turns.

[3 Marks]



Question 33.

(a) A resistor of 30 ohm and a capacitor of 250/π μF are connected in series to a 200 V, 50 Hz ac source. Calculate (i) the current in the circuit, and (ii) voltage drops across the resistor and the capacitor. (iii) Is the algebraic sum of these voltages more than the source voltage ? If yes, solve the paradox.

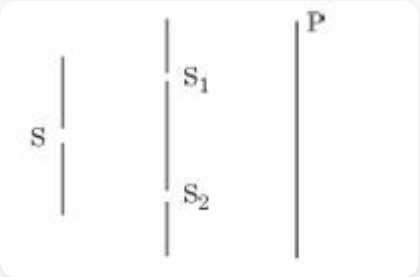
[3 Marks]

Question 34.

(b) (i) In a Young's double-slit experiment SS2-SS1 = λ/4 , where S1 and S2 are the two slits as shown in the figure. Find the path difference (S2P -S1P) for constructive and destructive interference at P.

(ii) What is the effect on the interference fringes in a Young's double-slit experiment, if the monochromatic source S is replaced by a source of white light ?

[3 Marks]



Question 35.

(b) A series LCR circuit with R = 20 ohm , L = 2 H and C = 50 μF is connected to a 200 volts ac source of variable frequency. What is (i) the amplitude of the current, and (ii) the average power transferred to the circuit in one complete cycle, at resonance ? (iii) Calculate the potential drop across the capacitor.

[3 Marks]

Question 36.

(a) (i) In diffraction due to a single slit, the phase difference between light waves reaching a point on the screen is 5π . Explain whether a bright or a dark fringe will be formed at the point.

(ii) What should the width (a) of each slit be to obtain eight maxima of two double-slit patterns (slit separation d) within the central maximum of the single slit pattern ?

(iii) Draw the plot of intensity distribution in a diffraction pattern due to a single slit.

[3 Marks]

Section E

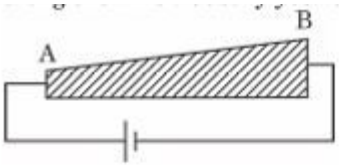
Question 37.

a) (i) Define mobility of electrons. Give its SI units.

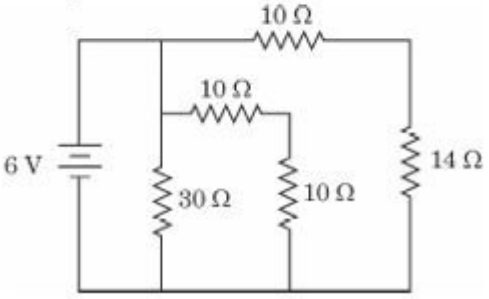
(ii) A steady current flows through a wire AB, as shown in the figure. What happens to the electric field and the drift velocity along the wire? Justify your answer.

(iii) Consider the circuit shown in the figure. Find the effective resistance of the circuit and the current drawn from the battery.

[5 Marks]



) Consider the circuit shown in the figure. F
resistance of the circuit and the current
battery.



Question 38.

(a) (i) Draw a ray diagram to show how the final image is formed at infinity in an astronomical refracting telescope. Obtain an expression for its magnifying power.

(ii) Two thin lenses L_1 and L_2, L_1 being a convex lens of focal length 24 cm and L_2 a concave lens of focal length 18 cm are placed coaxially at a separation of 45 cm. A 1 cm tall object is placed in front of the lens L_1 at a distance of 36 cm. Find the location and height of the image formed by the combination.

[5 Marks]

Question 39.

a) (i) A germanium crystal is doped with antimony. With the help of an energy-band diagram, explain how the conductivity of the doped crystal is affected.

(ii) Briefly explain the two processes involved in the formation of a p-n junction.

(iii) What will the effect of (1) forward biasing, and (2) reverse biasing be on the width of depletion layer in a p-n junction diode?

[5 Marks]

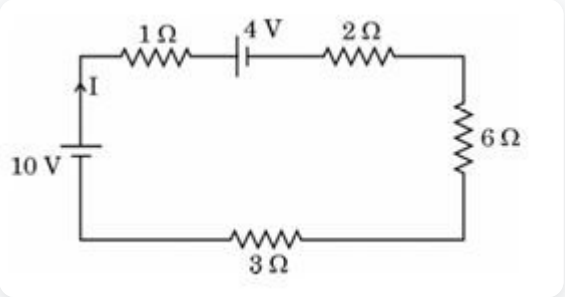
Question 40.

(b) (i) Define electrical conductivity of a wire. Give its SI unit.

(ii) High current is to be drawn safely from (1) a low-voltage battery, and (2) a high-voltage battery. What can you say about the internal resistance of the two batteries ?

(iii) Calculate the total energy supplied by the batteries to the circuit shown in the figure, in one minute.

[5 Marks]



Question 41.

(b) (i) Explain the working principle of an optical fibre with the help of a diagram. Mention one use of a light pipe.

(ii) A ray of light is incident at an angle of 60 degree on one face of a prism with the prism angle A = 60 degree. The ray passes symmetrically through the prism. Find the angle of minimum deviation (δm) and refractive index of the material of the prism. If the prism is immersed in water, how will δm be affected ? Justify your answer.

[5 Marks]

Question 42.

(b) (i) With the help of a circuit diagram, briefly explain the working of a full-wave rectifier using p-n junction diodes.

(ii) Draw V- I characteristics of a p-n junction diode. Explain how these characteristics make a diode suitable for rectification.

(iii) Carbon and silicon have the same lattice structure. Then why is carbon an insulator but silicon a semiconductor ?

[5 Marks]