CBSE EXAMINATION PAPER-2022

PHYSICS

(Solved)

Time allowed : 3 hours | Maximum Marks : 38

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **15 questions.** All questions are **compulsory.**
ii. This question paper is divided into **3 sections.**
iii. **Section A** – questions number **1 to 4** are very short answer Each question carries **2 marks.**
iv. **Section B** – questions number **5 to 14** are short answer Each question carries **3 marks.**
v. **Section C** – questions number **15 to 15** are case based questions
vi. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.
vii. Use of calculator is NOT allowed.

Section A

Question 1.

What is meant by doping of an intrinsic semiconductor ? Name the two types of atoms used for doping of Ge/Si.

[2 Marks]

Answer: Doping of an intrinsic semiconductor refers to the process of introducing impurities into the semiconductor material to modify its electrical properties. By adding specific atoms, the conductivity of the material can be increased. The two types of atoms used for doping Germanium (Ge) or Silicon (Si) are 'donor' atoms, typically from group V of the periodic table, like phosphorus (P) or arsenic (As), which donate extra electrons, and 'acceptor' atoms, like boron (B), which create holes by accepting electrons.

Question 2.

(a) (i) Distinguish between isotopes and isobars.

(ii) Two nuclei have different mass numbers A1, and A2. Are these nuclei

necessarily the isotopes of the same element ? Explain.

[2 Marks]

Answer: Isotopes are nuclides with the same atomic number (Z) but different neutron numbers (N), which results in different mass numbers (A). For example, 12C and 14C are isotopes of carbon. Isobars, on the other hand, have the same mass number (A) but different atomic numbers (Z), such as 40Ar and 40Ca. Two nuclei with different mass numbers A1 and A2 are not isotopes of the same element, as isotopes must have the same Z.

Question 3.

Explain the formation of the barrier potential in a p-n junction.

[2 Marks]

Answer: The barrier potential in a p-n junction forms due to the diffusion of charge carriers. When p-type and n-type materials are joined, electrons from the n-region diffuse into the p-region and recombine with holes, leading to a depletion region. This region becomes positively charged on the p-side and negatively charged on the n-side, creating an electric field. The electric field then establishes the barrier potential, preventing further charge carrier movement.

Question 4.

(b) (i) Name the factors on which photoelectric emission from a surface

depends.

(ii) Define the term 'threshold frequency' for a photosensitive material.

[2 Marks]

Answer: Photoelectric emission from a surface depends on several factors: the intensity of the incident light, the frequency of the light, and the work function of the material. The threshold frequency is the minimum frequency of incident radiation required to emit photoelectrons from a material's surface. Below this frequency, no emission occurs, regardless of light intensity. Different materials have different threshold frequencies based on their work functions.

Section B

Question 5.

State Bohr's postulate to explain stable orbits in a hydrogen atom. Prove that the speed with which the electron revolves in nth orbit is proportional to (1/n).

[3 Marks]

Answer: Bohr's postulates regarding the hydrogen atom state that electrons move in circular orbits around the nucleus due to electrostatic attraction. These orbits are stable because the angular momentum of the electron is quantized, given by $L = n(h/2\pi)$, where n is a positive integer, and h is Planck's constant. To prove that the speed (v) of the electron in the nth orbit is proportional to (1/n), we start with the centripetal force required for circular motion equated to the electrostatic force. The centripetal force (F) is given by $m(v^2/r)$, where m is the mass of the electron and r is the radius of the orbit. The electrostatic force (F') is given by $k(e^2/r^2)$, where k is Coulomb's constant and e is the charge of the electron. Equating the forces, we get $m(v^2/r) = k(e^2/r^2)$. Rearranging this gives $v^2 = k(e^2/m) * (1/r)$. Since r can be expressed as $n^2h^2/(4\pi^2ke^2m)$ from Bohr's model, substituting this back, we find v = (constant)/(n), hence proving $v \propto (1/n)$.

Question 6.

Briefly explain how emf is generated in a solar cell. Draw its I-V characteristics.

[3 Marks]

Answer: Electromotive force (emf) in a solar cell is generated through the photovoltaic effect. When sunlight hits the solar cell, photons are absorbed by the semiconductor material, typically silicon. This absorption provides enough energy to excite electrons, allowing them to break free from their atomic bonds, creating electron-hole pairs. The built-in electric field within the solar cell's p-n junction drives these free electrons towards the n-type layer and holes toward the p-type layer, generating an electric current. The current produced is direct current (DC), and the amount of current output is directly related to the intensity of the incident light. The I-V characteristics of a solar cell are represented graphically by plotting current (I) on the y-axis and voltage (V) on the x-axis, showcasing the relationship between the two. The curve typically shows an initial rising current until it reaches a maximum, beyond which the voltage increases while the current decreases until reaching the open-circuit voltage.

Question 7.

A narrow beam of protons, each having 4.1 MeV energy is approaching a

sheet of lead (Z = 82). Calculate :

i) the speed of a proton in the beam, and

ii) the distance of its closest approach

[3 Marks]

Answer: To find the speed of a proton in the beam, we can use the kinetic energy formula: KE = (1/2)mv^2. Given that the kinetic energy (KE) is 4.1 MeV, we first convert this energy to joules: 4.1 MeV = 4.1 x 1.6 x 10^-13 J = 6.56 x 10^-13 J. Assuming the mass of a proton, m = 1.67 x 10^-27 kg, we rearrange the formula to solve for speed (v). Thus, v = sqrt((2 * KE) / m) ≈ 1.62 x 10^7 m/s. To calculate the distance of closest approach (r), we apply the formula r = $(1/(4\pi\varepsilon_0))$ * (Z * e^2 / KE), where e = 1.6 x 10^-19 C and ε_0 = 8.85 x 10^-12 $C^2/N{\cdot}m^2$. Plugging in values, we get: r ≈ 2.34 x 10^-14 m.

Question 8.

In a diffraction pattern due to a single slit, how will the angular width of

central maximum change, if

i) Orange light is used in place of green light,

ii) the screen is moved closer to the slit,

iii) the slit width is decreased ?

Justify your answer in each case.

[3 Marks]

Answer: i) When orange light is used instead of green light, the angular width of the central maximum increases because orange light has a longer wavelength than green light. According to the formula for angular width, which is directly proportional to the wavelength, using orange light results in a broader central maximum. ii) Moving the screen closer to the slit does not change the angular width; it merely affects the distance at which the diffraction pattern is observed. The angular width remains unchanged as it depends on the slit width and wavelength. iii) Decreasing the slit width increases the angular width of the central maximum. A narrower slit causes greater spreading of light due to diffraction, leading to a wider central maximum.

Question 9.

(a) Write two necessary conditions for total internal reflection.

(b) Two prisms ABC and DBC are arranged as shown in figure.

The critical angles for the two prisms with respect to air are 41.1° and 45°

respectively. Trace the path of the ray through the combination.

[3 Marks]

Answer: Total internal reflection occurs under two essential conditions: First, the light must travel from a medium of higher refractive index to one of lower refractive index. Second, the angle of incidence must exceed the critical angle for that interface. In the case of prisms ABC and DBC, critical angles are given as 41.1° and 45°, respectively. When light enters prism ABC at an angle greater than 45°, it undergoes total internal reflection and is directed toward prism DBC, following the same principle for angles exceeding 41.1° for the second prism as well.

Question 10.

An electron is accelerated from rest through a potential difference of 100 V.

Find :

i) the wavelength associated with

ii) the momentum of and

iii) the velocity required by, the electron.

[3 Marks]

Answer: When an electron is accelerated through a potential difference of 100 V, it gains kinetic energy equal to the work done by the electric field. The kinetic energy (KE) can be calculated using the formula KE = eV, where e is the charge of the electron (1.6×10^{-19} C). Thus, KE = $1.6 \times 10^{-19} \times 100 = 1.6 \times 10^{-17}$ J. The velocity (v) can be found using the formula KE = $0.5mv^2$, leading to v = sqrt(2KE/m), with m being the mass of the electron (9.11×10^{-31} kg). For momentum (p), we can use p = mv. The wavelength (λ) is derived from the de Broglie equation λ = h/p, where h is Planck's constant (6.63×10^{-34} Js). Performing these calculations will give the required values.

Question 11.

In a Young's double slit experiment using light of wavelength 600 nm, the slit separation is 0.8 mm and the screen is kept 1.6 m from the plane of the slits.

Calculate :

(i) the fringe width

(ii) the distance of (a) third minimum and (b) fifth maximum, from the

central maximum.

[3 Marks]

Answer: To calculate the fringe width (β) in Young's double-slit experiment, we use the formula $\beta = \lambda D / d$, where λ is the wavelength (600 nm or 600×10^{-9} m), D is the distance to the screen (1.6 m), and d is the slit separation (0.8 mm or 0.8×10^{-3} m). Substituting these values, we get $\beta = (600 \times 10^{-9}\ m \times 1.6\ m) / (0.8 \times 10^{-3}\ m) = 0.0012$ m or 1.2 mm. For the third minimum, the distance from the central maximum is given by $y_{min} = (m + 0.5) \times \beta$. For m = 3, $y_{min} = (3 + 0.5) \times 1.2$ mm = 4.2 mm. For the fifth maximum, the distance from the central maximum is given by $y_{max} = m \times \beta$. For m = 5, $y_{max} = 5 \times 1.2$ mm = 6 mm.

Question 12.

(a) Electromagnetic waves of wavelengths λ1, λ2, and λ3 are used in radar

systems, in water purifiers and in remote switches of TV, respectively.

(i) Identify the electromagnetic waves, and

(ii) Write one source of each of them.

[3 Marks]

Answer: The electromagnetic waves used in the mentioned applications are as follows: (i) For radar systems, the wave is classified as microwave, which operates within the wavelength range of about 1 mm to 1 m. A common source of microwave is a magnetron, which generates microwaves for radar. (ii) In water purifiers, ultraviolet (UV) rays are used, which have a wavelength of about 10 nm to 400 nm. A typical source of UV rays is a mercury vapor lamp. (iii) Lastly, for remote switches used in TVs, infrared (IR) waves, with wavelengths ranging from 700 nm to 1 mm, are utilized. The source of IR waves can be an infrared light-emitting diode (LED).

Question 13.

(a) An object is placed in front of a converging lens. Obtain the conditions

under which the magnification produced by the lens is (i) negative and

Gi) positive.

(b) A point object is placed at O in front of a glass sphere as shown in figure.

Show the formation of image by the sphere.

[3 Marks]

Answer: In a converging lens, magnification is defined as the ratio of the image height to the object height. It is positive when the object is placed between the focal point and the lens, resulting in an upright, virtual image. Conversely, the magnification becomes negative when the object is beyond the lens's focal point, producing an inverted real image. For part (b), if we consider the point object placed at O in front of a glass sphere, the image formation occurs due to refraction at the surfaces of the sphere, resulting in a real image on the opposite side of the object.

Question 14.

(b) (i) State two conditions for two light sources to be coherent.

(ii) Give two points of difference between an interference pattern due to

a double — slit and a diffraction pattern due to a single slit.

[3 Marks]

Answer: For two light sources to be coherent, they must fulfill two primary conditions: first, they should have the same frequency, which ensures that they oscillate at identical rates, thereby producing a consistent wave pattern over time. Second, there must be a stable phase difference between them, meaning the relative position of their peaks and troughs remains constant. This coherence allows for the formation of a clear interference pattern. In contrast, an interference pattern from a double-slit setup exhibits equally spaced bright and dark fringes due to coherent sources, while a diffraction pattern from a single slit contains a central maximum with gradually diminishing side maxima, demonstrating the effects of wave spreading.

Section C

Question 15.

A compound microscope consists of two converging lenses. One of them, of smaller aperture and smaller focal length is called objective and the other of slightly larger aperture and slightly larger focal length is called eye-piece. Both the lenses are fitted in a tube with an arrangement to vary the distance between them. A tiny object is placed in front of the objective at a distance slightly greater than its focal length. The objective produces the image of the object which acts as an object for the eye-piece. The eye piece, in turn produces the final magnified image.

> **(1)**
>
> **In a compound microscope the images formed by the objective and the eye-piece are respectively**
>
> **(A) virtual, real (B) real, virtual**
>
> **(C) virtual, virtual (D) real, real**

[1 Marks]

Answer: The images formed by the objective and the eye-piece in a compound microscope are respectively real and virtual. Therefore, the correct option is (B) real, virtual.

Key Points: objective forms real image-eye piece forms virtual image

(2)

The magnification due to a compound microscope does not depend upon

(A) the aperture of the objective and the eye-piece

(B) the focal length of the objective and the eye-piece

(C) the length of the tube

(D) the colour of the light used

[1 Marks]

Answer: The correct answer is (D) the colour of the light used, as magnification primarily depends on the focal lengths and apertures of the lenses.

Key Points: Magnification depends on focal lengths of lenses-Depends on apertures of lenses-Does not depend on light's colour

(3)

Which of the following is not correct in the context of a compound microscope ?

(A) Both the lenses are of short focal lengths.

(B) The magnifying power increases by decreasing the focal lengths of

the two lenses.

(C) The distance between the two lenses is more than (fo + fe).

(D) The microscope can be used as a telescope by interchanging the two

lenses.

[1 Marks]

Answer: (C) The distance between the two lenses is more than (fo + fe) is not correct in the context of a compound microscope.

Key Points: Objective lens has a shorter focal length than the eyepiece; The distance between lenses is typically equal to the sum of their focal lengths; Interchanging lenses does not convert a microscope into a telescope.

(4)

A compound microscope consists of an objective of 10X and an eye-piece of 20X. The magnification due to the microscope would be

(A) 2 (B) 10

(C) 30 (D) 200

[1 Marks]

Answer: The total magnification of a compound microscope is calculated by multiplying the magnification of the objective lens with that of the eye-piece. Given that the objective magnification is 10X and the eye-piece magnification is 20X, the total magnification is $10 \times 20 = 200$. Therefore, the correct answer is (D) 200.

Key Points: Total magnification formula (Objective × Eye-piece) - Objective magnification of 10X - Eye-piece magnification of 20X - Final magnification of 200

(5)

The focal lengths of objective and eye-piece of a compound microscope

are 1.2 cm and 3.0 cm respectively. The object is placed at a distance of

1.25 cm from the objective. If the final image is formed at infinity, the

magnifying power of the microscope would be

(A) 100 (B) 150

(C) 200 (D) 250

[1 Marks]

Answer: The magnifying power of the microscope can be calculated using the formula M = (v_o / f_o) * (D / f_e), where v_o is the image distance from the objective, f_o is the focal length of the objective, D is the least distance of distinct vision (assumed to be 25 cm), and f_e is the focal length of the eye-piece. With the given values, the calculation gives a magnifying power of 200.

> Key Points: Use the formula for magnifying power-M = (v_o / f_o) * (D / f_e) -Identify values: f_o = 1.2 cm, f_e = 3.0 cm, object distance = 1.25 cm -Final answer choice is (C) 200.