ALL BRANCH / SEM-I / C-2019 / SUMMER-2024

(2 Hours) [Total Marks: 60]

N.B.: (1) Question No. **1** is **compulsory.**
(2) Attempt **any three** questions from Q.2 to Q.6.
(3) Assume **suitable** data wherever **required.**
(4) Figures to the right indicate marks.

Q.1 Attempt any **FIVE** (All questions carry equal marks) **(15)**

(a) What is the probability of an electron being thermally excited to conduction band in Silicon at 20°C if the band gap is 1.12 eV. (Given: $k=8.6 \times 10^{-5}$ eV/K)

(b) Draw the following with reference to cubic unit cell:
(121), (100) and (011)

(c) Explain why an extensively thin film appears black in reflected light.

(d) What are the properties of matter waves?

(e) Explain at least three applications of super capacitors.

(f) Explain different phases of liquid crystal.

(g) State de Broglie's hypothesis. Deduce an expression for the wavelength of de Broglie's matter waves.

Q.2 (a) State the conditions of Maxima and Minima in Newton's rings and derive expression for the diameter of dark ring in reflected light system. **(08)**

(b) Explain with neat diagram construction of Bragg's X-ray spectrometer and explain the procedure to determine crystal structure using it. Calculate the maximum order of diffraction if x-ray of wavelength $0.819A^0$ is incident on a crystal with lattice spacing of 0.282nm. **(07)**

Q.3 (a) Discuss Heisenberg's Uncertainty principle and prove that electrons cannot reside inside the nucleus of an atom using the same principle. **(08)**

(b) Explain the construction and working of Light Emitting Diode with the help of diagrams. State the merits, demerits and applications. **(07)**

Q.4 (a) Calculate electron and hole concentration in intrinsic silicon at room temperature if its electrical conductivity is 4×10^{-4} mho/m. (mobility of electron=0.14 m^2/V-s & mobility of hole=0.04 m^2/V-s) **(05)**

(b) Write the expression for Schrodinger's time dependent equation of matter waves and derive Schrodinger's time independent equation. **(05)**

(c) A wedge-shaped film of solution which had refractive index 1.28 was observed normally. The distance between successive bands was 0.15cm. The angle of wedge was 0.01°. Determine the wavelength of light used. **(05)**

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Q.5 (a) Discuss the importance of critical temperature in superconductors. Differentiate between Type I and Type II superconductors. **(05)**

(b) Show that Fermi energy level is placed in the center of the energy band gap in intrinsic semiconductor. **(05)**

(c) Show that group velocity of matter waves is equal to particle velocity. **(05)**

Q.6 (a) What is Meissner Effect? With the help of this effect show that superconductors are diamagnetic in nature. **(05)**

(b) Find the minimum thickness of the soap film which appear yellow (wavelength 5896 A°) in reflection when it is illuminated by white light at an angle of 45°.Given refractive index of the film is 1.33. **(05)**

(c) An electron is bound in one dimensional potential well of width $2A^0$ that of infinite height. Find its energy value in the ground state and in first two exited states. **(05)**

N.B. : (1) Question No 1 is Compulsory.
(2) Attempt any three questions from Q2.to Q6.
(3) Assume suitable data, if required and state it clearly.
(4) Figures to the right indicate marks.

Q1. Attempt any **FIVE** [15]

(a) Find the miller indices of the plane in a cubic crystal having intercepts a, b/2, infinity and draw the plane for the same.

(b) Explain with reason if it is a bright or dark fringe at the edge in wedge shaped thin film set up in reflected light system.

(c) What is the probability of an electron being thermally excited to conduction band in Silicon at 20°C if the bandgap is 1.12 eV. (Given: $k=8.6 \times 10^{-5}$eV/K)

(d) Define the following terms: Wave packet, Phase velocity and Group velocity.

(e) What is energy density and power density?

(f) What are Multiferroic materials? Differentiate between Type I and Type II Multiferroics.

Q2. (a) Explain the construction and working of Light Emitting Diode with the help of neat diagrams. State the merits, demerits and applications. [8]

(b) Derive the equations for optical path difference in a parallel thin film in reflected light system. Also find the conditions for maxima and minima. [7]

Q3. (a) Derive the expression for interplanar spacing in cubic crystals. The unit cell dimension of NaCl is 5.63 A°. If x-ray beam of wavelength 1.1 A° falls on a family of planes with a separation of $\frac{a}{\sqrt{5}}$, how many orders of diffraction are visible? [8]

(b) Write the expression for Schrodinger's time dependent equation of matter waves and derive Schrodinger's time independent equation. [7]

Q4. (a) Distinguish between Type I and Type II superconductors. [5]

(b) Define liquid crystals. Explain different phases with the help of neat diagrams. [5]

(c) A copper strip 0.02m wide and 2mm thick is placed in a magnetic field B= 2.5 Wb/m^2. If current of 300Amp is set up in the strip, calculate Hall voltage and charge density that appears across the strip. Given, $R_H= 6 \times 10^{-7}$ m^3/C [5]

Q5. (a) Explain the construction and working of electrolytic double layer capacitor (EDLC) with diagram. [5]

(b) Show that fermi energy level is placed in the center of the energy bandgap in intrinsic semiconductor. [5]

(c) An electron is bound in a one-dimensional potential well of width 5 A° but of infinite height. Find its energy values in the ground state and in first two excited states. [5]

Q6. (a) Explain the effect of doping concentration on fermi level in n-type semiconductor. [5]

(b) State de' Broglie hypothesis and derive an expression for de' Broglie wavelength. Mention three properties of matter waves. [5]

(c) In Newton's rings experiment the diameter of n^{th} and $(n+10)^{th}$ bright rings are 5.2mm and 8.5mm respectively. Radius of curvature of the lower surface of lens is 200cm. Determine the wavelength of light? [5]

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(2) Attempt any three questions from Q.2 to Q.6.

(3) Assume suitable data wherever required.

(4) Figures to the right indicate marks.

Q1. Attempt any five [15mks]

a. Draw the following planes in a cubic unit cell (121), (100), (011).

b. The diameter of 5^{th} dark ring in Newton's ring experiment was found to be 0.42 cm. Determine the diameter of 10^{th} dark ring in the same set up.

c. An electron is bound in a one-dimensional potential well of width 2 A° but of infinite height. Find its energy values in the ground state and in first excited state.

d. Define superconductivity and explain the terms critical temperature and critical magnetic field.

e. Find the resistivity of intrinsic germanium at 300 K. Given density of carriers is 2.5×10^{19} /m^3, mobility of electrons is 0.39 m^2/volt-sec and mobility of holes is 0.19 m^2/volt-sec.

f. What are matter Waves? State three properties of matter waves.

g. Explain the formation of colours in thin film.

Q2 a) State Hall Effect. Obtain an expression for Hall voltage. Calculate the mobility of charge carriers in a doped Si, whose conductivity is 100 per ohm meter and Hall coefficient is 3.6×10^{-4} m^3/C. [8mks]

b) Obtain an expression for Optical Path Difference in a thin film of uniform thickness observed in reflected light. Hence obtain conditions for maxima and minima. [7mks]

Q3a) Explain with neat diagram the effect of doping and temperature on the fermi level in N type extrinsic semiconductor. What is the probability of an electron being thermally excited to the conduction band in Si at 20° C. The band gap energy is 1.12 eV [8mks]

b) Show that the energy of an electron in a one-dimensional deep potential well of infinite height varies as the square of the natural numbers. [7mks]

Q4.a) Explain Bragg's spectrometer for the investigation of crystal structure with the help of a neat diagram. [5mks]

b) Derive one dimensional Schrödinger's time dependent equation for matter waves. [5mks]

c). White light is incident on a soap film at an angle $\sin^{-1}(4/5)$ and the reflected light is observed with a spectroscope. It is found that two consecutive dark bands correspond to wavelength 6100 A° and 6000 A°. If the refractive index of the film is 4/3, calculate its thickness. [5mks]

Q5 a) Find the de Broglie wavelength of (i) an electron accelerated through a potential difference of 182 Volts and (ii) 1 Kg object moving with a speed of 1 m/s. Comparing the results, explain why is the wave nature of matter not apparent in daily observations? [5mks]

b). Derive an expression for interplanar spacing in a cubic unit cell? [5mks]

c) Explain the principle and working of Supercapacitors? [5mks]

Q6a) Explain principle, construction and working of Light Emitting Diode? [5mks]

b). State Meissner's effect. Show that superconductors exhibit perfect diamagnetism [5mks]

c). We wish to coat a flat slab of glass with refractive index 1.5 with a thinnest possible film of transparent material so that light of wavelength 600 nm incident normally is not reflected. We have two materials to choose from M_1 (μ= 1.21) and M_2 (μ =1.6). Which one would be appropriate? What will be the minimum thickness of coating? [5mks]

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TIME: 2 Hours MARKS: 60

N.B 1) Question no 1 is Compulsory.

2) Attempt any three questions from **Q.2 to Q.6**

3) Assume suitable data wherever required.

4) Figures on the Right indicates marks.

Q.1 Attempt any five questions from the following [15]

(a) Draw (0 0 2), ($\bar{1}$ 0 0), (0 1 1)

(b) Explain any three properties of matter waves.

(c) Differentiate between Direct and Indirect band gap semiconductor.

(d) Explain any three conditions for Sustained Interference.

(e) A source is emitting 150W of red light of wavelength of 600nm. How many photons per second are emerging from the source?

(f) Explain the Meissner effect with application.

(g) Explain Magneto Resistance with application.

Q.2 (a) Show that Non- Existence of electron in the Nucleus, Find the uncertainty in the position of electron . The speed of an electron is measured to be 4.0×10^5 m/s to an accuracy of 0.002% . [8]

(b) Define the Fermi energy level , Show that in intrinsic semiconductor Fermi level is at the centre of Forbidden energy gap. Draw the position of Fermi level in intrinsic, P-type and N-type semiconductor. [7]

Q.3 (a) Explain with diagram Bragg's X Ray Spectrometer . Calculate the interplaner spacing between the family of planes (1 1 1) in crystal of lattice constant $3A^0$ [8]

(b) Prove that the Diameter of the n^{th} dark ring in Newton's ring setup is directly proportional to the square root of the ring number . In Newton's Rings reflected light of wavelength 5×10^{-5} cm. The diameter of the 10^{th} dark ring is 0.5 cm. Calculate radius of curvature R. [7]

Q.4 (a) Derive one dimensional time independent Schrodinger Equation. [5]

(b) Differentiate between Type I superconductor and Type II superconductor. [5]

(c) Find Resistance of an intrinsic Ge rod of dimensions (1cm long , 1mm wide and 1mm thick) at 300K . For Ge $n_i = 2.5 \times 10^{19}/m^3$, $\mu_n = 0.39 m^2/v\text{-}s$, $\mu_p = 0.19 m^2/v\text{-}s$ [5]

Q.5 (a) Derive the condition for maxima and minima due to interference of light reflected from thin film of uniform thickness. [5]

(b) Explain Hall Effect . Derive the equation for Hall Voltage. [5]

(c) Calculate the lowest three energy states of an electron confined in potential well of width $10A^0$. [5]

Q.6 (a) Explain multiferroics and its different types. [5]

(b) A soap film 4×10^{-5} cm thick is viewed at angle of 35^0 to normal. Calculate Wavelength of light in the visible spectrum which will be absent from the Reflected light ($\mu = 1.33$) [5]

(c) The Coefficient (Rh) of semiconductor is $3.22 \times 10^{-4} m^3 c^{-1}$. Its resistivity is $9 \times 10^{-3} \Omega m$. Calculate the mobility and concentration of carriers. [5]

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