

MSc Sem.-1 Examination

403

Medical Physics

February-2025

Time : 2-30 Hours]

[Max. Marks : 70

- Q.1 (a) Describe Laue's photographic method for X-ray diffraction [14]
 (b) Discuss Debye's model of the heat capacity of solid.

OR

- Q.1 (a) Discuss Bragg's law $\lambda = 2d \sin \theta$, and scattering from a crystal. [14]
 (b) Give brief introduction about the heat capacity of solid, and describe Einstein's theory of the heat capacity of solid.

- Q.2 (a) Give the assumptions for the classical free electron theory of metals. Derive an expression for an electrical conductivity based on this theory. State Wiedemann Franz law. [14]
 (b) Consider free electron gas in a one dimensional box of length L and obtain its allowed wave functions. Show that energy eigen values E_n for electron is proportional to n^2 .

OR

- Q.2 (a) The solution of Schrodinger equation for an electron in one-dimensional periodic potential leads to the condition

$$P \frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka$$

Draw the plot for $P \frac{\sin \alpha a}{\alpha a} + \cos \alpha a \rightarrow \alpha a$ for $P = \frac{3\pi}{2}$. Write the important [14] conclusions from the graph based on Kronig-Penney model.

- (b) What are N-type semiconductors? Describe the carrier concentration in N-type semiconductors and hence derive an equation for Fermi energy and the density of electrons such semiconductors.

- Q.3 (a) What are paramagnetic materials? Discuss Quantum theory of paramagnetism and hence derive the equation for susceptibility for such magnetic materials at normal value of magnetic field and at an ordinary temperature. [14]
 (b) What is Ferrimagnetism? What are ferrites? Show that ferrimagnetics possess spontaneous magnetization at temperature less than Neel temperature and exhibit hysteresis.

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OR

- Q.3** (a) Derive the London equations for the macroscopic theory of superconductors and discuss how does it help in understanding super conducting state of material. What is penetration depth? [14]
(b) What is a SQUID? Explain how this interferometer leads to oscillations. Describe how superconductors can be useful as switching devices.

- Q.4** (a) List name of four types polarization processes, and discuss any one with relevant equations [14]
(b) Give brief introduction above photo voltaic cells. Discuss construction, working and applications of it.

OR

- Q.4** (a) Define dielectric constant and give brief introduction about dielectric materials. Also derive Classius-Mosotti relation. [14]
(b) What is photo-luminance? List various types of photo-luminance process and explain any one.

- Q.5** Attempt any **seven** out of twelve from the following (Each question is of **two** marks): [14]

- (i) The Fermi energy of sodium is 3.11 eV. What is the average energy of free electron at 0 K?
- (ii) Where does the Fermi level lie in the intrinsic, n-type and p-type semiconductors in the energy band diagram?
- (iii) What is magnetic levitation?
- (iv) A paramagnetic material has susceptibility of 2.8×10^{-4} at 350 K. Calculate its susceptibility at 280 K.
- (v) A current of 10 mA flows through n-type Ge strip of 1 mm thickness and 10 mm width placed in a magnetic field B of 0.1 T. If the voltage produced across the strip is 1 mV, determine Hall coefficient of material.
- (vi) For an electron moving in a periodic potential, select correct statements from the following:
 - (a) The effective mass of an electron is infinite at $k = \pm \frac{\pi}{a}$.
 - (b) The effective mass of an electron is positive in lower half of energy band.
 - (c) The velocity of an electron is zero at the top and bottom of first Brillouin zone.
 - (d) The effective mass of an electron is zero at $k = \pm \frac{\pi}{a}$.

- (vii) Write two drawbacks of photo voltaic cells.
 - (viii) Define photo-conductivity.
 - (ix) List two applications of photo-luminance spectroscopy.
 - (x) What are limitations of Einstein's theory of the heat capacity of solid?
 - (xi) A beam of X-rays of wavelength $\lambda = 0.071$ nm is diffracted by (110) plane of rock salt with lattice constant of 0.28 nm. Calculate value of the glancing angle for the second-order diffraction..
 - (xii) In a NaCl crystal, planes are 0.252 nm apart. If the first-order maximum is observed at an incidence angle of 18.1° , calculate the wavelength of the X-ray scattering from NaCl crystal?
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