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(Name of the Department	Department of Physics & Astrophysics
Name of the Course	B.Sc. (Hons.) Physics_ NEP: UGCF-2022
Name of the Paper	Physics of Materials (DSE Paper)
Semester	V
Unique Paper Code	2223010014

Question No.1 is Compulsory. Attempt four Questions in ALL.

Time: 2 Hours

Q1. Attempt any Five Parts

$3 \times 5 = 15$

- Show the Fermi levels for intrinsic, lightly and very heavily doped n-type semiconductors in the energy level diagram with appropriate labels.
- Define piezoelectric coefficient? How much displacement will be produced by a stacked actuator of 100 layers having $d_{33} = 200 \frac{pm}{V}$ on applying a voltage of 200 V?
- How are the structure and positional anisotropy of nematic liquid crystals different than the cholesteric liquid crystals? Explain with a suitable diagram.
- Discuss three parameters in which C_{60} fullerene is different from any other fullerene structure?
- What is cross-linking? Discuss its effect on any two properties of polymers with example.
- Calculate the mean free path in a vacuum chamber for a gas having molecular diameter of $3.8 \times 10^{-10} m$. ($T = 300 K$; $P = 2 \times 10^{-6} Pa$)

Q2(a) Differentiate between ferroelectric and piezoelectric materials. What are actuators and briefly explain what is the role of piezoelectric material in micro positioners? (5)

(b) Describe the shape of the hysteresis loop for hard and soft magnetic materials. Explain the key characteristics that distinguish hard magnetic materials from soft magnetic materials. (5)

(c) What is Pyroelectric coefficient? Explain mathematically with units. Calculate pyroelectric coefficient for a material showing a change in spontaneous polarization of $2 \times 10^{-6} C/m^2$ on subjecting to a temperature change from 300 K to 360 K. (5)

Q3(a) A semiconductor has a Fermi level which is 0.2 eV above the valence band. Calculate the ratio of electron to hole concentration at $T=300\text{ K}$. ($k_B = 8.617 \times 10^{-5}\text{ eV/K}$) (4)

(b) Mention any three differences between thermosetting and thermoplastic polymers. Mention one example of each type. (4)

(c) What are liquid crystals? Mention any two properties in which these differ from the conventional liquids and solid crystals. (4)

(d) For a multi-walled carbon nanotube (MWCNT) with an inner diameter of 5 nm and an outer diameter of 10 nm, calculate the volume fraction occupied by the carbon atoms. Assume the length of the MWCNT is 1 micrometer. (3)

Q4 (a) Explain the processes of calcination and sintering for ceramics preparation. How do they influence the structural properties of the final synthesized material? Give two specific applications where these ceramics are used? (6)

(b) Explain pulsed laser deposition (PLD) technique. Describe the steps involved in depositing a thin film using PLD. Describe any three factors which influence the film growth. (9)

Q5(a) Explain how molecular beam epitaxy (MBE) technique is different from the thermal evaporation. Mention one advantage and disadvantage of each technique. (6)

(b) Given the chiral indices ($n = 4, m = 2$) for a carbon nanotube, determine the chiral angle and specify whether the nanotube exhibits metallic or semiconducting behaviour. (5)

(c) If the Fermi energy of a metal is 5 eV at absolute zero, what is the average kinetic energy of its electrons? (4)