

Dr P.B. Bera

Enrollment No.

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

B.Tech. (CSE, ECE, IT) VI Semester

COURSE CODE: 10B11PH611

MAX. MARKS: 35

COURSE NAME: MATERIALS SCIENCE

COURSE CREDITS: 04

MAX. TIME: 2 HR

Note: All questions are compulsory. Carrying of mobile phone during examinations will be treated as case of unfair means. Answer all parts of a question in sequence. Scientific calculator is allowed.

- (a) Derive an expression for the penetration depth of superconductor. Analyze the temperature dependence of penetration depth of a superconductor. **3 marks [CO-1]**

(b) Derive an equation in superconductivity which justifies the Ohm's law. **3 marks [CO-1]**

(c) A superconducting Nb solenoid carries a current of 20 A to produce a magnetic field of 6.104 A/m. If the solenoid is immersed in liquid helium (4.2 K) and $H(0)$ for Nb is 1.56×10^5 A/m, estimate the minimum diameter of the wire that may be used. Given T_c for Nb is 9.5 K. **4 marks [CO-5]**
- (a) For a light signal launched from a medium of refractive index μ_0 , derive the expression for acceptance angle and hence obtain the numerical aperture of the fibre. **3 marks [CO-2]**

(b) An optical fibre (profile parameter 2) has core diameter 40 μm , numerical aperture 0.21 and operating at a wavelength 1.3 μm . Calculate the number of modes in this fibre. **3 marks [CO-5]**

(c) Explain briefly the working of LCD. **2 marks [CO-4]**

(d) What are shape memory alloys? **1 marks [CO-4]**
- (a) What is quantum confinement? Give its physical significance. **2 marks [CO-4]**

(b) The density and atomic mass of Nb are 8.57×10^3 kg/m³ and 93 respectively. It has one conduction electron per atom. Calculate the London penetration depth of Nb. Also calculate the penetration depth at 2K if T_c for Nb is 9.5 K **4 marks [CO-3]**

(c) The number average molecular weight of polypropylene (C_3H_6) is 10^6 gm/mole. Compute the degree of polymerization **2 marks [CO-3]**
- (a) For an antiferromagnetic material show that the Neel temperature is approximately same as the paramagnetic Curie temperature. **3 marks [CO-2]**

(b) There are 1.6×10^{20} molecules/m³ in NaCl vapour. Determine the orientational polarization at 300 K if the vapour is subjected to a field of 5×10^6 V/m. Assume that NaCl molecule consists of Na⁺ and Cl⁻ separated by 2.5 Å. **3 marks [CO-3]**

(c) Consider He atom in its ground state. The Bohr radius for Helium is 0.529 Å. The density and atomic mass of Helium are 0.178 kg/m³ and 4.003 respectively. Calculate the diamagnetic susceptibility of a Helium atom. **2 marks [CO-2]**

$$\mu_0 = 4\pi \times 10^{-7} \text{ Hm}^{-1}; m_e = 9.1 \times 10^{-31} \text{ kg}; e = 1.6 \times 10^{-19} \text{ C}; \epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2\text{N}^{-1}\text{m}^{-2}; k_B = 1.38 \times 10^{-23} \text{ J/K},$$
$$h = 6.6 \times 10^{-34} \text{ Js}; N_A = 6.02 \times 10^{23}$$