M.Sc. (Applied Physics) 4th Semester Examination, 2010

Material Physics-II
(PGP-401)

Time : 4 hours **Full Marks : 100**

Answer anu FIVE questions,
taking at least ONE from Group A & B and at least TWO from Group C,

GROUP-A

I. a) Show that the free energy difference between the normal and the superconducting state varies quadratically with critical magnetic field. For A/, H_c = 105 G at absolute zero, calculate the free energy difference. Give the analytical expression and its graphical representation for variation of H_c with temperature. For A/, T_c = 1.14 K, what is the value of H_c at 0.57 K? When does H_c become zero?

b) Using thermodynamic arguments, show that the superconducting phase is more ordered than the normal phase. Show that the discontinuity in electronic specific heat at T_c is always positive and depict it graphically. [12+81

2. a) Consider a closed circuit consisting of two identical superconductors separated by a thin penetrable material and a DC source. Show that the temporal rate of change of cooper pair density in each superconductor varies sinusoidally with time. What is the frequency of this variation when the DC voltage is 2uV? Suggest a possible use of this frequency. What happens when the DC source is removed?

b) Write briefly on 'magnetic flux exclusion in superconductors'. |14+6J

GROUP-B

3. a) For a linear diatomic ionic crystal, derive and explain the folio wings :

where the notations carry their usual meanings.

b) Assume that there exists two stable orientations of the polar molecules in a solid. Explain how the bulk polarization of this polar solid material is estimated in low frequency region. Can we use the Clausius-Mossotti relation here? Explain why. l(6+6)+(6+2)]

4. a) Using thermodynamical treatment, obtain the expressions for (i) order parameter (p_s) and (ii) heat capacity (C_v) as functions of temperature. Hence explain the characteristics of the second-order ferroelectric phase transition.

   b) Write short notes on :
   (i) PLASMON, (ii) Phosphorescence and (iii) Electrostriction.

|(7+7)+(2x3)|

GROUP-C

5. a) Explain why lightwave communication system is important in today's context. Obtain the scalar wave equation in cylindrical system of coordinates for an optical fiber and solve it to obtain the LP modes of a step index fiber. Draw the LP ii and LP_{52} modal field distribution pattern in transverse plane.

   b) What are the differences between macro bending loss and microbending loss?

   c) Discuss how modal field distribution controls the maximum tolerable limit of transverse offset and angular misalignment, for calculating the splice loss.

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6. a) How can you differentiate between intermodal and intramodal dispersion? Show that the broadening of light pulse due to waveguide dispersion is given by

   where all symbols have their usual meanings.

   b) On the light of waveguide dispersion phenomena, discuss about the dispersion shifted fibers (DSFs)

   c) What do you mean by pulse chirping due to group velocity dispersion? By showing suitable diagram show how chirping is produced in case of a conventional single mode fiber (CSF) and dispersion compensating fiber (DCF).

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7. a) Write down the names of different techniques adopted to fabricate optical fibers. Discuss how fiber preforms can be manufactured by soot process and draw suitable diagrams.

   b) Distinguish between direct and indirect recombination in a semiconductor.

   c) Write short notes on <u>any two</u> of the following :
   (i) Exciton recombination process,
   (ii) Auger recombination process,
   (iii) Electroluminescence in semiconductors.

   d) Show how internal quantum efficiency (**T**)) of a LED is dependent on life time of carriers.

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8. a) Discuss in detail how a net optical gain, i.e. more stimulated emission than absorption can be achieved in case of a p-n junction laser diode. Draw the energy level diagram of the laser diode to cause population inversion.
What is meant by threshold current for Iasing to occur? Draw the typical optical output vs. diode current characteristics and corresponding output spectrum above threshold.

b) Show how output voltage for a p-n photodiode in photovoltaic mode depends on the incident optical power. What are the benefits of using photodiode in photoconductive mode? Draw schematic representation of a p^{+}-n photodiode (photoconductive mode) as a photodetector, net space change across the diode in depletion region and the electric field in depletion region.

[(6+2+2+2)+(3+2+3)J