Department of Physics, IIT Delhi

Minor – I, II Semester 2014-2015

Date: February 14, 2015; 2:30-3:30PM

Total = 15 marks

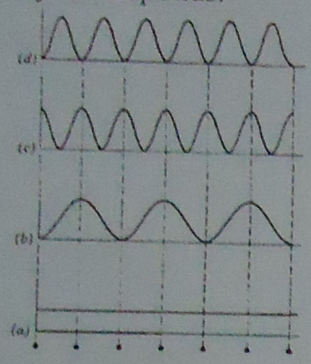
PYL-102 (Principles of Electronic Materials)

ALL problems are compulsory. Answer all sub-parts of the same question in one sequence.

The exam will be graded on a step-by-step basis, with partial credit being awarded for correct steps and techniques even if the answer is wrong. **FULL** credit will be awarded only if the right answer is obtained for the right reason, **NO** credit will be given if the calculations are not completed and proper units not mentioned even if correct formulae have been used.

1. **Bonding in Solids**

In the figure below, four charge density distributions for valence electrons as functions of location of atoms, ions, or molecules (shown as dots at the bottom) are illustrated schematically. For each distribution (a), (b), (c), (d); state (with clear explanations) to which type of bonding in solids it most closely corresponds.



[4]

2. **Electrical & Thermal Conductivity**

Electron drift mobility in Indium (In) is measured to be 6 $cm^2V^{-1}s^{-1}$. The room temperature (27°C) resistivity of In is 8.37 $\times 10^{-8}$ Ωm, and its atomic mass and density are 114.82 $gmol^{-1}$ and 7.31 gcm^{-3}, respectively.

(a) Based on the resistivity value, determine how many free electrons are donated by each In atom in the crystal. How does this compare with the position of In in the Periodic Table (Group IIIB)? [3]

(b) If the mean speed of conduction electrons in In is 1.74 $\times 10^8$ cms^{-1}, what is the mean free path? [2]

(c) Calculate the thermal conductivity of In. How does this compare with the experimental value of 81.6 $Wm^{-1}K^{-1}$? [2]

3. **Hall Effect**

A Hall probe, consisting of a thin rectangular slab of current-carrying material, is calibrated by placing it in a known magnetic field of magnitude 0.10 T. When the field is oriented normal to the slab's rectangular face, a Hall emf of 12 mV is measured across the slab's width. The probe is then placed in a magnetic field of unknown magnitude B incident at angle of 60°, and a Hall emf of 63 mV is measured. Determine the magnitude of the incident magnetic field B. [4]

Useful constants: $h = 6.626\times10^{-34}$ Js, $N_A = 6.023\times10^{23}$ mol^{-1}, $k_B = 1.381\times10^{-23}$ JK^{-1}, $C_{WFL} = 2.44 \times 10^{-8}$ W Ω K^{-2}

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