D-65

Minor-2 (EPL 206: Solid State Physics)

March 23, 2014 | **Time: 60 min** | **Maximum Marks: 20**

1. KCl has NaCl crystal structure with lattice parameter of **0.63** nm. The electronic polarizability of K^+ is 1.3×10^{-40} Fm^2 and of Cl^- is 4.5×10^{-40} Fm^2. The mean ionic polarizability per ion pair is 7.8×10^{-40} Fm^2. Calculate

   a) the optical frequency dielectric constant,

   b) the low frequency dielectric constant and

   c) the refractive index of the KCl crystal. 6

2. Using the concept of electron being scattered by phonons (having momentum $\hbar K$) in a solid (having Debye temperature T_D), qualitatively obtain the temperature dependence of electronic conductivity of the solids in the following regimes (i) $T < T_D$ and (ii) $T > T_D$. 5

3. State the experimental observation about the solids that Einstein's quantum theory of solid failed to explain. Why the Einstein's model failed to account for these observations? 3

4. The Debye temperature (T_D) for silicon is **625 K**. Make a plot of molar specific heat for silicon crystal as a function of temperature in the temperature range of 0 – 1000 K. Mark the scale appropriately on both the axes. Also determine the highest frequency for oscillators in the Debye model. 3

5. Answer the following (in not more than 3 sentences):

   (a) The $BaTiO_3$ crystal exhibits ferroelectricity at room temperature. But above 130°C, it does not exhibit ferroelectric behavior. Why?

   (b) The NaCl is an ionic crystal. But it does not exhibit piezoelectricity. Why?

   (c) Briefly explain the working mechanism of the 'Intruder alarms'. 1x3=3

Physical constants: $h = 6.63\times10^{-34}$ J.s ; $e = 1.6\times10^{-19}$ C ; $k_B = 1.38\times10^{-23}$ JK^{-1} ; $m_e = 9.11\times10^{-31}$ kg ; **1 amu** $= 1.66\times10^{-27}$ kg; $N_A = 6.023\times10^{23}$ mol^{-1}; $\varepsilon_o = 8.854\times10^{-12}$ Fm^{-1} ; $R = 8.31$ $JK^{-1}mol^{-1}$.