EPL 335 LOW DIMENSIONAL PHYSICS

MAJOR 22 November 2008 2008-09 SEM-I

Time: 2 hrs M. Marks: 50

All questions are of 10 marks each. Give short and to the point answers only.

1. Consider the case of a deep quantum well confined by opaque barriers.
   (a) Using an E-k diagram sketch the band structure of this well when the lowest two levels are partially occupied. Show two allowed and one forbidden optical transitions in it.
   (b) Write the expression for the optical conductivity and show that absorption is possible only at certain specific frequencies. And total absorbing power depends only on total density of electrons in the well.

   (4+ 6)

2. (a) Starting with the equation for the current through a tunnel barrier, show that only under low bias and low temperature conditions, the conductance maps the energy dependence of transmission of the barrier.
   (b) Define T matrixes $T^{(21)}$ and $T^{(12)}$ for waves going over the top of a tunnel barrier. Show that for waves incident from left and right the transmission coefficients 't' are same but reflection coefficients 'r' differ only in phase.

   (5+5)

3. Consider a double quantum well structure of identical wells centered at z=0.
   (a) Write the Schrodinger equation and wave functions $\chi_v(z)$ for this case.
   (b) Name the terms and their origin that signify the coupling between the wells. Sketch the systematic shift, due to the coupling terms, in the energy state from that for the single well to that for the double well.
   (c) When more wells are added to realize a superlattice structure, (i) sketch the modified DOS function and (ii) the modified conduction band structure.

   (3+4+3)

4. (a) Sketch the energy band structure of a quantum well formed by GaAs and GaAlAs and give brief reason for obtaining very high electron mobility in this nano-structure.
   (b) Write the T matrix for a potential step.
   (c) Melting point of bulk gold is 1300 K. Sketch to scale the variation of MP of gold nano-particles in the size range of 10 – 300 nm and give brief reason to justify the variation.
   (d) Sketch to scale the variation of the Fermi level as a function of applied magnetic field of 0 – 10 T for a 2-D electron gas.in GaAs with $E_F^0 = 10$ meV in the absence of field.

   (2.5x4)

5. (a) Briefly explain the lifting of degeneracy of the HH and LH states under lattice strain..
   (b) Write the condition of resonance for resonant tunneling and give the origin of terms in it.
   (c) An InSb spherical nanoparticle is embedded in a AlSb matrix. If E_G(InSb)= 0.24 eV and E_G(AlSb)= 2.32 eV, and ratio of VB and CB off-set is 3:5, sketch to scale the potential-wells as seen by free electrons and free holes in the quantum dot.
   (d) Estimate the minimum radius of the quantum dot in order to ensure that there is one bound hole state in the above quantum dot. Also estimate the radius at which a second hole state will also become bound. Take $m^*_{hh} = 0.4\ m_0$.

   (2+2+3+3)