MAJOR EXAM

EPL 335/PYL321 – Low Dimensional Physics

21/11/2015, Marks: 40

1. Consider an abrupt heterostructure between Si and Ge in which the conduction and valence band discontinuities are ΔE_C and ΔE_V. Draw a band diagram and label all relevant features.
(Given Si, E_g=1.12 eV, χ=4.05 eV, for Ge, E_g=0.66 eV, χ=4 eV) [4]

2. Draw the energy band diagram for a AlGaAs/GaAs based HEMT. What is the working principle of HEMT? [2+2]

3. (a) Draw the energy band diagrams for a *pn* homojunction heterostructure laser. (b) If the photon output of a laser diode is equal to the bandgap energy, find the wavelength separation between adjacent resonant modes in a GaAs laser with L = 75 μm, where L is the length of the cavity. [2+2]

4. Consider a massless fermion of Fermi velocity V_F in graphene incident on a one-dimensional rectangular potential barrier of height V_0 and width L. (a) Write the Hamiltonian for this case, (b) draw the schematic of Energy (E) *vs* wavevector (k) curves for three different regions. (c) How it will be different from the conventional tunnelling in semiconductor junctions. (d)Why does Klein tunnelling observable for graphene? (e) What is the effective mass of tunnelling massless Fermions in graphene? [2+2+1+2+1]

5. (a) On the given graphene paper mark the positions to show the formation of a (5,5) armchair nanotube. (b) Group (3,0), (3,3), (3,6) and (2, 9) carbon nanotubes based on their chirality to metallic, semiconductor and semiconductor with a very small band gap. (c) Determine the diameter of (3,0) nanotube (lattice constant $\boldsymbol{a}$ = 0.25 nm). [2+2+2]

6. Determine the reflection and transmission coefficients for a particle with energy $E = V_0$ incident from the left on a one-dimensional rectangular barrier:

$$V(x) = V_0 \quad \text{for } -a < x < a$$
$$= 0 \text{ for } |x| > a$$
[4]

7. Write the form of Schrodinger equation of a moving electron under uniform magnetic field. (b) What is quantum Hall effect? (c) Describe Landau levels for two-dimensional electron gas (2DEG). [2+2+2]

8. Show that for a static potential V the transition rate in a scattering event (Fermi Golden rule) is given by $W_{fi} = \frac{2\pi}{\hbar}|\langle f|V|i\rangle|^2 \rho_f$: ρ is the density of state of final state in continuum. [4]