M. ETCE. ENGG. EXAMINATION 2017

2nd Semester

QUANTUM WELL AND NANO STRUCTURED DEVICES

Full Marks : 100 Time : Three hours

The figures in the margin indicate full marks.

Answer ***any five*** questions.

(*All parts of the same question must be answered together*)

1.(a) Mention the periodic boundary condition and obtain a general form of density of states (DOS) function. 2+3

(b) Starting with the above general form, derive expressions for the DOS function for 3D, 2D and 1D systems for a semiconductor with parabolic E-k relation. 2+4+4

(c) Sketch the above variations of DOS function with energy, and show that the effective band gap energy of a semiconductor increases as dimension of the system decreases. 5

2.(a) Two semiconductors A and B are mixed via an appropriate growth technique. Classify the resulting alloy on the basis of atomic arrangement in it. Also describe the role of bond energies in determining the nature of the alloy. 5+5

(b) Describe various possible heterointerfaces and give one specific example of each case. 10

3.(a) Consider a small band gap semiconductor system within which a narrow layer of the same material is sandwiched between two narrow layers of a large band gap semiconductor. In presence of an electric field, electrons in the system may tunnel through the pair of barriers to appear on the opposite side. Employ Transfer Matrix method to determine the transmission co-efficient. 15

(b) Calculate the number of bound electron states supported in the middle layer of thickness 40 *nm* sandwiched between layers of heights 0.4 *eV*. Assume $m_n^* = 0.067\ m_0$. 5

4.(a) Prove that in a parabolic QW, energy states of the confined carriers are identical to those of a harmonic oscillator. 15

(b) Describe a practical scheme that utilizes a parabolic QW to determine the bandedge discontinuities appearing at a heterojunction. 5

5.(a) With the help of appropriate energy band diagram, describe the quantum mechanical phenomenon of resonant tunneling in a double–barrier structure. Explain how the conservation of lateral momentum is achieved during the process. 10

(b) Give a schematic description of the structure of a resonant tunneling diode. What will be the effect on the diode performance if the two barrier layers of the diode lack symmetry? Discuss the factors on which its peak to valley current density ratio depends. 5+2+3

6.(a) Describe Landau quantization. Mention the conditions to be satisfied to achieve such quantization. 6+2

(b) Assuming the *E-k* dispersion relation to be parabolic, derive an expression for the *DOS* function under magnetic quantization. 6

(c) What is magneto-size quantization? Calculate the capacity of each Landau level in terms of number of electrons. 3+3

7. Explain what is the Quantum Hall Effect (QHE) and how does it originate. Why the Hall plateaus are broadened in a non-ideal situation? Mention some important features and application of the QHE. 8+3+4+5

It is necessary to maintain very low temperature for observation of the QHE, and still lower temperature to observe the fractional QHE – explain why.

8. Write down some important properties of carbon nanotube (CNT). What are the differences between single walled and multiple walled CNT? What are the disadvantages of CNT? "Electrical conductivity and thermal conductivity of CNT is very high." Explain. 3+2+3+12

9. Write notes on (**any two**): 10+10

(a) Comparison of compositionally graded superlattice and *n-i-p-i* superlattice

(b) Modulation doped field effect transistor

(c) Tunnel FET

(d) Single electron transistor.