PG/IVS/EL-2203/10

M.Sc. 4th Semester Examination, 2010

ELECTRONICS

(*Quantum Electronics*)

PAPER—EL-2203

(Theory)

Full Marks : 40

Time : 2 hours

Answer **Q. No. 1** and any **three** from the rest

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

1. Answer any *five* questions : 2×5

(*a*) In case of one dimensional quantum well laser the energy band gap between two consecutive levels should be greater than K_BT. (Where K_B and T are the Boltzmann's constant and temperature in Kelvin respectively). Justify this comment.

(*b*) Explain clearly the term "carrier confinement" in a double heterojunction laser.

(*c*) Draw the density-of-states function for electrons in bulk, Quantum Well, Quantum Wire and Quantum Dot in the same diagram.

(*d*) Why should the direct bandgap semiconducting materials be used for developing opto-electronic devices generally ?

(*e*) Draw the band diagram of a GRIN-SCH laser. Mention its advantages.

(*f*) Why should the potential barrier widths outside the quantum well be made very thin ?

2. (*a*) Show using time dependent perturbation theory that the transition probability from an initial state $|m>$ to a final state $|k>$ may be expressed as

$$|a(t)|^2 = 4|<k|\,H'\,|m>|^2 \sin^2(1/2\ \omega_{km} t)/\hbar^2\ \omega_{km}{}^2.$$

The symbols have the usual meanings. 5

(*b*) Write the expression for Fermi Golden Rule explaining the meaning of the terms. Briefly indicate how you would derive the expression for Einstein B coefficient using Fermi Golden Rule. Complete derivation is not needed. 5

3. (*a*) Derive the expression for the first order perturbation in energy in a time independent problem. Give one example in which the theory is employed. 5

(*b*) Explain with suitable diagrams the principle of operation of a MASER. 5

4. (*a*) Describe the working principle of a quantum well infra red photo detector. 5

(*b*) Explain how a photomultiplier tube works ? How do you find its solid state version ? 5

5. Obtain the expression of stored photon density in a semiconductor laser cavity. From the expression, show that the laser gives a very good performance if the effective width(d) of electro-hole

recombination zone is decreased as much as possible. Hence discuss the advantage of developing quantum well in the system. 5 + 3 + 2

6. What do you mean by super lattice ? Draw the schematic diagram of a super lattice structure. What do you mean by SQW and MQW ? Discuss why the dimension of a quantum well should be less than the mean free path of the electron/hole in the material. What is a quantum box ?

2 + 1 + 1 + 2 + 2 + 2