

2015

M.Sc. Part-II Examination

PHYSICS

PAPER—X

Full Marks : 75

Time : 3 Hours

The figures in the right-hand margin indicate full marks.

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

Illustrate the answers wherever necessary.

Use separate answer-scripts for Group-A and Group-B

Group-A

[Marks : 40]

1. Answer any five questions : 5×2

- (a) How can you develop an opto electronic XOR logic gate with SLM ?
- (b) What is the advantage of trinary logic system over binary logic system ?

(Turn Over)

- (c) Write down the name of four non-linear materials.
- (d) Why a material shows non-linear behavior, when it is exposed under laser radiation ?
- (e) What do you mean by graded index optical fibre ?
- (f) What is the difference between spontaneous emission and stimulated emission of a laser radiation ?
- (g) What do you mean by Q-switching ?

2. Answer any *two* questions : 2×3

- (a) Describe the method of Q-switching by mechanical shuttering.
- (b) Find the ratio of the stimulated to the spontaneous emission rate at a temperature of 250°C for the sodium D1 lines ($\lambda = 590 \text{ nm}$) $h = 6.6 \times 10^{-34} \text{ Js}$; $k = 1.38 \times 10^{-23} \text{ Jk}^{-1}$.
- (c) A step index fibre has a core of index 1.500 and a cladding of index 1.489. Find the temporal broadening of a pulse in nano second per km. Also find the spread in space for 1 km of the fibre.

3. Answer any *one* question : 1×4

- (a) What do you mean by Q-factor of a laser resonator ? And derive its relation with the exponential time constant of a resonator.
- (b) Using 'Burger's law' show that the amplification of light is not possible in a two level laser system.

4. Answer any *two* questions : 2×10

- (a) What is a four level laser system ? Why this type of system is advantageous over other laser systems ? Obtain the equation of population inversion in a four level laser system.

In a He - Ne laser transition from 3S \rightarrow 2P level gives a laser emission of $\lambda = 632.8 \text{ nm}$. If the 2P level has energy $15.2 \times 10^{-19} \text{ J}$, calculate the pumping energy required, assuming no loss whatsoever.

$$(h = 6.6 \times 10^{-34} \text{ Js} ; 1\text{eV} = 1.6 \times 10^{-19} \text{ J}) \quad 1+1+5+3$$

- (b) Deduce the relation $n = n_0 + n_1 I$ for a non-linear material. Symbols have their usual meaning. Discuss the process of self focussing by exploitation of non-linear phenomenon of a dielectric medium. What is

intermodal dispersion in a step index optical fibre. Derive its expression for a step-index optical fibre.

3+2+1+4

- (c) Show how can you obtain all optical XOR, AND, OR, NOR gates in practice. What is 'Basic Module'? How tristate input signal can be generated by using Basic Module ?

Write down the truth table of tristate (I, O, T) AND, OR & XOR gates.

3+1+3+3

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Group-B

[Marks : 35]

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

1. Answer any two bits : 2×2½

- (a) Calculate the energy difference between conduction band and Fermi energy in an intrinsic Si sample at 300K.

$$(m_e^* = 1.1m, m_h^* = 0.59m)$$

- (b) Find the electrical neutrality condition when a semiconductor is doped with donor impurity.

- (c) The minority carrier lifetime in p type material is 10^{-7} second. The mobility of electron in Si is $0.15 \text{ m}^2\text{V}^{-1}\text{s}^{-1}$ at 300K. If 10^{20} electrons/ m^3 are injected at $x = 0$, what is the diffusion current density just at the junction ?
2. (a) Find the density of electron in the conduction band for a non-degenerate semiconductor at Temperature T.
(b) What is law of mass action ? 8+2
3. (a) Clearly draw the band diagram of a p-n junction under equilibrium condition.
(b) Derive Diode equation assuming band picture of a p-n junction. 3+7
4. (a) What is meant by Linearly Graded Junction ?
(b) Find the expression of Junction Capacitance for linearly graded junction. 2+8
5. (a) What is meant by equilibrium and non-equilibrium carriers ?

- (b) Find an expression of Growth of carriers when light falls on a semiconductor ?
- (c) What is meant by relaxation time. 2+7+1
6. (a) Assuming Boltzman Transport equation find the expression of electrical conductivity of a nondegenerate semiconductor.
- (b) Prove that mobility of a nondegenerate semiconductor is proportional to $T^{3/2}$ at low temperature region. 7+3
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