2016

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) Find the ratio of the rates of spontaneous and stimulated emissions at $T = 10^3$ K for

visible radiation of frequency 5×10^{14} Hz.

(b) An optical fibre has the core refractive index 1.4 and cladding refractive index 1.3. Find its acceptance angle.

(c) Why coherent light is required in holography recording ?

(d) Write one example of a three level and another example of four level lasers.

(e) What is cladding and what is the necessity of cladding in an optical fibre ?

(f) Explain the superiority of optical logic gates over electronic logic gates and optoelectronic logic gates.

(g) Write the example of one Kerr type and one Pockel's type of non-linear materials.

2. Answer any *two* questions : 2×3

(a) With proper optical circuit diagram, discuss the principle of operation of an optical half adder with optical switching elements.

(b) From the phase matching condition discuss the method of frequency addition with non-linear material.

(c) What is a Dye laser ? Discuss its principle of operation with supporting energy level diagram.

3. Answer any *one* question : 1×4

(a) Construct an opto electronic half-adder circuit.

(b) Derive the expression for raypath in a graded index optical fibre. The refractive index of core and cladding are given below :

$$n^2(r) = n_1^2\left[1-\left(\frac{r}{a}\right)^2\right] \text{ for } |r| < r_0 \quad \text{Core}$$

$$= n_1^2\left[1-\left(\frac{r_0}{a}\right)^2\right] \text{ for } |r| > r_0 \quad \text{Cladding.}$$

4. Answer any *two* questions : 2×10

(a) What is a three level laser system ? Obtaining the rate equations of each of the energy levels, find the expression of population inversion in the system. Obtain also the expression of its threshold power. Find the threshold

power of a ruby laser with number of molecule per unit volume, life time and frequency are 1.6×10^{19} cm^{-3}, 3×10^{-3} S and 6.25×10^{14} Hz respectively.

1+3+2+2+2

(b) What are the advantages of optical fibre communication over traditional wire communication ?

What is V-parameter of an optical fibre and what is its physical significance ? Calculate the minimum and maximum diameter of an optical fibre so that two symmetrical and two anti symmetrical mode can be transmitted through the fibre.

Refractive index of

Core = 1.5

Cladding = 1.48

Wavelength of transmitted wave is 1.5 μm.

What is the advantage of graded index optical fiber over step index optical fibre. 2+2+2+3+1

(c) What is non linear material ? Why a material becomes non linear ? Discuss the method of second harmonic

generation using a non-linear material. Give two applications of non linear materials.

How phase matching condition is achieved for second harmonic generation by using a non linear material ?

What is the basic difference between normal photography and holographic recording ? 1+2+2+1+3+1

Group–B

[Marks : 35]

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

1. Answer any *two* bits : $2\times2\frac{1}{2}$

(a) In an n type semiconductor, the Fermilevel lies 0.3 ev below the conduction band at 300K. If the temperature is increased at 330K, find the new positions of the Fermilevel.

(b) Assuming a p-n junction under equilibrium condition, find an expression of Barrier potential in term of donor concentration, acceptor concentration and intrinsic concentration.

(c) If ϕ is the potential corresponding to fermi level, ψ is the potential corresponding to intrinsic level show that for a n type nondegenerate semiconductor.

$$n = n_i \; e^{q(\psi-\phi)/KT}$$

Assume $m_e^* = m_n^*$.

2. (a) Find an expression of density of states in the conduction band and hence find an expression of density of electron in the conduction band for a degenerate semiconductor.

(b) Find an expression of ionization energy if Si is doped with pentavalent atom ? 6+4

3. (a) Deduce an expression for diffusion length of hole when the holes are injected by forward bias in a p-n junction.

(b) What is ment by ohmic contact ?

(c) What is the physical origin of diode ideality factor ?

6+2+2

4. Clearly explain the mechanism of photovoltage generation in a solar cell. Find an expression of effeciency of solar cell. State the current voltage characteristics of a solar cell under illumination. 2+6+2

5. (a) Find an expression for depletion capacitance for an abrupt junction.

(b) How the barrier potential is determined experimentally ?

8+2

6. (a) Prove that fermi level remain invariant in a p-n junction under equilibrium condition.

(b) Find the variation of Fermi level in a p-type non degenerate semiconductor with respect to temperature.

(c) What is meant by critical concentration ? Find the expression for Fermi level at critical concentration of semiconductor ? 4+1+(1+4)

———