NS – 287

V Semester B.Sc. Examination, November/December 2016
(2013-14 and Onwards) (CBCS-Fresh/NS- Repeaters)
PHYSICS – V
Quantum Statistical Physics, Quantum Mechanics – I and II

Time : 3 Hours Max. Marks : 70

***Instruction** : Answer **five** questions from **each** Part.*

PART – A

Answer **any five** of the following questions. **Each** question carries **eight** marks : (5×8=40)

1. Derive Bose-Einstein distribution law for bosons. 8

2. What are fermions ? Derive an expression for the probability distribution of particles governed by Fermi-Dirac statistics. 8

3. Explain briefly the failure of classical theory in the explanation of :
   i) Stability of an atom.
   ii) Blackbody radiation. (4+4)

4. a) Explain phase velocity and group velocity for a matter wave.
   b) Establish a relation between the particle velocity and group velocity of a non relativistic particle. (3+5)

5. a) With a neat diagram, describe gamma-ray microscope experiment to illustrate the Heisenberg's uncertainty principle.
   b) Show that electrons cannot remain inside a nucleus using uncertainty principle. (6+2)

6. a) Mention any two conditions that a wave function must satisfy.
   b) Arrive at Schrödinger's time independent equation for a free particle in one dimension. Write the equation for three dimensions. (2+6)

7. Set up Schrödinger equation for a particle in a one dimensional box and solve it to obtain eigen values of energy. Also represent the first three wave functions graphically.

8. Develop the Schrödinger's equation for a linear harmonic oscillator. Mention the energy eigen value expression.

PART – B

Solve **any five** of the following problems. **Each** problem carries **four** marks : (5×4=

Use $h = 6.63 \times 10^{-34}$ JS, $m_e = 9.1 \times 10^{-31}$ kg and $e = 1.6 \times 10^{-19}$ C wherever necessary.

9. A system of 5 particles are arranged in two compartments. The first compartment is divided into 6 cells and the second into 5 cells. The cells are of equal size. Calculate the number of microstates in the macrostate (2, 3), if the particles obey Fermi-Dirac statistics.

10. A gas has two particles A and B. Show with the help of diagrams how these two particles can be arranged in three different quantum states 1, 2, 3 using Bose-Einstein statistics.

11. The Fermi energy for lithium is 4.72 eV at T = 0K. Calculate the number of conduction electrons per unit volume in lithium.

12. Calculate the frequency and energy in eV of a photon of wavelength 400 nm.

13. Calculate the deBroglie wavelength of neutron of energy 28.8 eV. Given $m_n = 1.67 \times 10^{-27}$ kg, $h = 6.63 \times 10^{-34}$ Js.

14. A microscope using photons is employed to locate an electron in an atom within a distance of 0.1 Å. Calculate the uncertainty in the momentum of the electron located.

15. An electron is trapped inside a box of 1 nm. Calculate the first three eigen values in eV.

16. The energy of a linear harmonic oscillator in its third excited state is 0.1 eV. Calculate the frequency and zero point energy.

PART – C

Answer **any five** of the following questions. **Each** question carries **two** marks : **(5×2=10)**

17. a) Can an electron have zero energy at T = 0K ? Explain.

    b) Does Fermi energy depends on temperature ? Explain.

    c) An electron and proton are possessing same amount of kinetic energy. Which of the two have greater deBroglie wavelength ? Justify.

    d) We do not experience the existence of matter waves in our day-to-day life. Why ?

    e) Can matter waves move faster than light ? Explain.

    f) Why do we normalise a wave function ? Explain.

    g) Distinguish between a particle in a box and a free particle.

    h) Can the quantum number n be zero for a particle in a one dimensional box ? Justify.