Roll No. ……..

PHY–502

Statistical Mechanics and Quantum Mechanics

M. Sc. PHYSICS (MSCPHY–12/13/16)

First Year, Examination, 2017

Time : 3 Hours **Max. Marks : 70**

Note : This paper is of **seventy (70)** marks containing **three (03)** sections A, B and C. Attempt the questions contained in these sections according to the detailed instructions given therein.

Section–A

(Long Answer Type Questions)

Note : Section 'A' contains four (04) long answer type questions of fifteen (15) marks each. Learners are required to answer *two* (02) questions only.

1. Explain postulates of statistical mechanics. Determine the number of accessible states for a macro system. 15
2. Write the basic assumptions of Maxwell-Boltzmann statistics and establish the necessary formula for it. Explain its significance. 15
3. (a) What are eigen values and eigen functions ? 5

   (b) Calculate the expectation value of p for the normalized wave function $\psi(x) = \sqrt{\frac{2}{L}} \sin \frac{\pi x}{L}$ in the region $0 < x < L$ and $\psi(x) = 0$ outside this region. 5

(c) The wave function ψ of a particle is given by $\psi = N \exp\left(\frac{-x^2}{2\beta}\right)$ for $-\infty < x < \infty$. Find the value of N. 5

4. Explain Klein-Gordon relativistic equation. Give its covariant form. Discuss some applications of Klein-Gordon equation. 15

Section–B

(Short Answer Type Questions)

Note : Section 'B' contains eight (08) short answer type questions of five (5) marks each. Learners are required to answer *six* (06) questions only.

1. Explain the difference between Schrödinger picture and Heisenberg picture.
2. Discuss variational method of finding approximate ground energies and wave functions.
3. How was quantum mechanics evolved ? Explain.
4. Describe the basic postulates of quantum mechanics.
5. Obtain Schrödinger wave function for a particle in a square well potential.
6. Explain spin angular momentum. Give its significance.
7. Explain the position function for a canonical ensemble.
8. Show that the operator $\left(\vec{\sigma}_1, \vec{\sigma}_2\right)^n$ for two particles, each of spin $-\frac{1}{2}$, can be linearly expressed in terms of $\vec{\sigma}_1, \vec{\sigma}_2$.

Section–C

(Objective Type Questions)

Note : Section 'C' contains ten (10) objective type questions of one (01) mark each. All the questions of this section are compulsory.

1. The total number of microstates for the distribution of 5 particles in two similar boxes is :

   (a) 5^2

   (b) 2^5

   (c) 2^{-5}

   (d) 5

2. In a canonical ensemble the same quantities are :

   (a) temperatures, volume and number of particles

   (b) energy of particles

   (c) energy, volume and number of particles

   (d) volume and number of particles

3. The entropy S and partition function of an ideal gas are related as :

   (a) $S = Nk \log_e z$

   (b) $S = Nk \log_e \left\{ z + \frac{3}{2} \right\}$

   (c) $S = Nk \log_e z + \frac{3}{2} N k$

   (d) $S = Nk \log_e z + \frac{3}{2}$

4. In the quantum statistics the smallest particle of the system is :
   (a) molecule
   (b) atom
   (c) electron
   (d) None of these

5. Operator form of time dependent Schrödinger equation is :
   (a) $H\psi = 1$
   (b) $H\psi = A$
   (c) $HA = AH$
   (d) $H\psi = E\psi$

6. The eigen values of Hermitian operator are always :
   (a) real
   (b) imaginary
   (c) complex
   (d) orthogonal

7. The potential function of a harmonic oscillator is :
   (a) linear
   (b) elliptical
   (c) hyperbolic
   (d) parabolic

8. The potential energy of a particle in one-dimensional box is :
   (a) zero
   (b) ∞
   (c) 1
   (d) None of these

9. The correct relation between shift operators is :

(a) $\sigma_+ = \sigma_x + i\,\sigma_y$

(b) $\sigma_+ = \sigma_x - i\sigma_y$

(c) $\sigma_- = \sigma_y - i\sigma_x$

(d) $\sigma_- = \sigma_x + i\sigma_y$

10. In the time independent perturbation approach, the Hamiltonian operator H of the system is written as :

(a) $H = H^0 + H^1$

(b) $H = H^0 - H^1$

(c) $H = H^0 + 3H^1$

(d) None of these