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# MSCPHY-12 (M.Sc. PHYSICS)
# First Year Examination-2015

# PHY-502

## Statistical Mechanics and Quantum Mechanics

**Time :** 3 Hours **Maximum Marks :** 60

**Note : This paper is of sixty (60) marks divided into 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 any two (02) questions only. (2×15=30)**

1. State postulates of classical statistical mechanics. What is meant by ensembles? Discuss microcanonical, canonical and grand canonical ensembles. Compare these there types of ensembles.
2. Give a clear outline of the concepts of quantum statistical mechanics which lead to an evaluation of energy distribution in an assembly of particles. Explain the distribution between Bose-Einstein and Fermi-Dirac statistics. Discuss the energy distribution near the absolute zero of temperature for an assembly of particles obeying Fermi-Dirac statistics.
3. (a) Explain how the solutions of the schrodinger equation for the hydrogen atom are related to a z-axis despite the fact that the potential is spherically symmetric.

   (b) Show that the components of angular momentum are constants of motion in quantum mechanics.

4. Explain variation method and use it to evaluate the ground state energy of hydrogen atom.

## Section - B

## (Short Answer Type Questions)

**Note : Section 'B' contains eight (08) short-answer-type questions of five (05) marks each. Learners are required to answer any four (04) questions only. (4×5=20)**

1. State and prove Liouville's theorm.
2. What is a degenerate gas? When do the Bose and Fermi-distribution tend to the classical distribution?
3. Use the uncertainly principle to obtain the ground state energy of a linear oscillator.
4. Describe Dirac's bra and Ket vectors.
5. The wave function of a particle in one dimensional potential at time +=0 is $\psi(x,t=0)=\frac{1}{\sqrt{15}}[24_0(x)-\psi_1(x)]$, Where $\psi_0(x)$ and $\psi_1(x)$ are the ground and first excited states of the particle with corresponding energies $E_0$ and $E_1$. Find the wave function of the particle at a time 't'.
6. Give some applications of time-dependent perturbation theory.
7. Derive the free particle Klein-Gordan equation and discuss the defficulties associated with it. How these difficulties are removed in Dirac equation?
8. Discuss Dirac's relativistic equation and give one application.

## 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. (10×1=10)**

1. An ensemble is a collection of large number of systems which are :
   (a) different (b) dependent
   (c) independent (d) None of these
2. For most probable distribution :
   (a) $\frac{\partial P_{\max}}{\partial n_i} = 0$ (b) $P = \frac{N!}{n_1!} g_i!$
   (c) $\sum P = \frac{g^{n_i}}{n_1!}$ (d) $\sum P = g^N = 1$
3. The covariant form of the Klein-Gordon equation is :
   (a) $(\partial_\mu \partial_\mu + K^2)\psi = 0$ (b) $(\partial_\mu \partial_\mu - K)\psi = 0$
   (c) $(\partial_\mu \partial_\mu - K^2)\psi = 0$ (d) $(\partial_\mu \partial_\mu + K)\psi = 0$
4. In time-dependent perturbation theory, the condition $w_{ne}\frac{b}{V} <<< 1$ presents :
   (a) adiabatic approximation to be valid
   (b) Sudden approximation to be valid
   (c) Both (a) and (b)
   (d) None of the above
5. In a micro canonical ensemble.
   (a) Energy is constant
   (b) Total No. of particles is constant
   (c) Energy as well as total No. of particles is constant
   (d) None of these
6. The relativistic relation between total energy and momentum of a particls is given by :
   (a) $\mathrm{E} = \sqrt{\mathrm{P}^2\mathrm{C}^2 + \mathrm{m}^2\mathrm{c}^2}$ (b) $\mathrm{E} = \sqrt{\mathrm{P}^4\mathrm{C}^4 + \mathrm{m}^2\mathrm{c}^2}$
   (c) $\mathrm{E} = \sqrt{\mathrm{P}^2\mathrm{C}^2 + \mathrm{m}^2\mathrm{c}^4}$ (d) $\mathrm{E} = \sqrt{\mathrm{P}^2\mathrm{C}^2 + \mathrm{m}^4\mathrm{c}^4}$

7. Klein Gordon equation is expressed as :

(a) $\left(\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2}\right)\psi(\vec{r},t) = \frac{m_0^2 c^2}{h^2}\psi(\vec{r},t)$

(b) $\left(\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2}\right)\psi(\vec{r},t) = \frac{m_0 c^2}{h^2}\psi(\vec{r},t)$

(c) $\left(\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2}\right)\psi(\vec{r},t) = \frac{m_0 c}{h^2}\psi(\vec{r},t)$

(d) $\left(\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2}\right)\psi(\vec{r},t) = \frac{m_0^2 c^2}{h^2}\psi(\vec{r},t)$

8. Particle having integral spins (in units of h) obey :
   (a) Maxwell-Boltzmann statistics
   (b) Fermi-Dirac statistics
   (c) Bose-Einstein statistics
   (d) None of these

9. Particles described by symmetric wave function obey while such particles are indistinguishable :
   (a) Fermi-Dirac statistics
   (b) Bose-Einstein statistics
   (c) Maxwell-Boltzmann statistics
   (d) None of these

10. The time-independent schrodinger equation of a system represents the conservation of the :
   (a) total binding energy of the system
   (b) total potential energy of the system
   (c) total kinetic energy of the system
   (d) total energy of the system