## PHY-502

## Statistical Mechanics and Quantum Mechanics M. Sc. PHYSICS (MSCPHY-12/13/16)

First Year, Examination, 2017

## Time : 3 Hours

Max. Marks : 80
Note: This paper is of eighty (80) marks containing three (03) Sections A, B and C. Learners are required to 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 nineteen (19) marks each. Learners are required to answer two (02) questions only.

1. State and prove Liouville's theorem.
2. Discuss the evidences which show the inadequacy of classical mechanics and led to the origin of quantum theory.
3. Discuss time dependent perturbation theory and establish the expression for transition probability per unit time.
4. Discuss and establish Klein-Gordon equation.
P. T. O.

## Section-B

## (Short Answer Type Questions)

Note : Section 'B' contains eight (08) short answer type questions of eight (08) marks each. Learners are required to answer four (04) questions only.

1. Explain principle of indistinguishability.
2. Explain the charge conjugation of Dirac equation.
3. State and explain Fermi Golden Rule. Give its significance.
4. 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 $\rightarrow$ $\sigma_{1}, \sigma_{2}$.
5. Assuming the proton-neutron interaction in deuteron as the central force potential $\mathrm{V}(r)=-\mathrm{A} e^{-r / a}$, solve the Schrödinger equation of the equivalent one body problem to get the bound state with $l=0$.
6. If $z$ is the partition function for the molecules of an ideal gas at absolute temperature T K , prove that the average energy of gas molecules is given by :

$$
\varepsilon=-\frac{\partial}{\partial \beta}\left(\log _{e} z\right)
$$

where $\beta=\frac{1}{k \mathrm{~T}}$.
7. Write the conditions for Fermi-Dirac statistics.
8. Find the norm and hence the normalization constant of the particle described by the Gaussian wave packet wave function namely.

$$
\Psi(x)=a \exp \left(-\frac{\alpha^{2} x^{2}}{2}\right) \exp (i k x)
$$

## 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. Which of the following phenomena supports the quantum nature of light?
(a) Interference
(b) Diffraction
(c) Polarization
(d) Compton effect
2. Which is not uncertainty principle ?
(a) $\Delta x \cdot \Delta p \geq \hbar$
(b) $\Delta t \cdot \Delta \mathrm{E} \geq \hbar$
(c) $\Delta \theta \cdot \Delta \mathrm{J} \geq \hbar$
(d) $\Delta p \geq \Delta x \hbar$
3. If $\frac{d^{2}}{d x^{2}}\left(e^{x}\right)=\lambda e^{x}$, then $\lambda$ is called :
(a) Eigen value equal to 1
(b) Eigen value equal to 0
(c) Eigen function
(d) Eigen value equal to $e^{x}$
4. In barrier penetration problem, the intensity of the transmitted particle $\qquad$ with the thickness of the barrier.
(a) decreases exponentially
P. T. O.
(b) increases exponentially
(c) increases linearly
(d) decreases linearly
5. For a free particle the potential energy is :
(a) Infinite
(b) Zero
(c) Unity
(d) None of these
6. The partition function for Boltzmann-canonical distribution is given by :
(a) $z=\sum e \beta \varepsilon$
(b) $z=\Sigma e^{-\beta \varepsilon}$
(c) $z=\log _{e} \varepsilon$
(d) None of these
7. The total number of microstates for the distribution of 5 particles in two similar boxes is :
(a) $2^{5}$
(b) $5^{2}$
(c) $2^{-5}$
(d) 6
8. In terms of partition function $z$, Helmholtz free energy F is expressed as :
(a) $\mathrm{F}=-\mathrm{NK} \log _{e} z$
(b) $\mathrm{F}=-\mathrm{NK} \log \frac{z}{\beta}$
(c) $\mathrm{F}=-\frac{\mathrm{N}}{\mathrm{KT}} \log _{e} z$
(d) $\mathrm{F}=\mathrm{NK} \log _{e} \frac{z}{\mathrm{~T}}$
9. The eigen values of Hermitian operator are always :
(a) Real
(b) Imaginary
(c) Complex
(d) Orthogonal
10. The probability density of a wave function $\psi$ is :
(a) $|\psi|$
(b) $|\psi|^{2}$
(c) $\int \psi \psi^{*} d \tau$
(d) $|\psi|^{3}$

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