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PG CBCS
M.SC. Semester-III Examination, 2021
PHYSICS
PAPER: PHS 301
(QUANTUM MECHANICS & STATISTICAL MECHANICS)

Full Marks: 40 **Time: 2 Hours**

Write the answer for each unit in separate sheet

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

PHS 301.1: Quantum Mechanics-III

Marks: 20

Answer any TWO questions of the following: 2X10=20

1. Using the Born approximation, the amplitude of scattering by a spherically symmetric potential V(r) with a momentum transfer q is given by

$$A=\int_0^{\infty}\left[\frac{\sin\left(\frac{qr}{\hbar}\right)}{\frac{qr}{\hbar}}\right]V(r)4\pi r^2dr$$

Show that in case of a Yukawa -type potential, this leads to an amplitude proportional to $(q^2+m^2c^2)^{-1}$

2. Deduce the Lippmann-Schwinger equation with suitable assumptions.

3. If $H=\left(\frac{-\hbar^2}{2m}\right)\left(\Delta_1^2+\Delta_2^2\right)-2e^2\left(\frac{1}{r_1}+\frac{1}{r_2}\right)+\frac{e^2}{r_{12}}$

where r_1 and r_2 are the position vectors of the two electrons with nucleus as the origin.

Prove that ionization of the He atom is 75 eV.

4. Discuss the splitting of atomic of atomic energy levels in a strong magnetic field. (Paschen-Back effect).

5. A harmonic oscillator in the ground state is subjected to a perturbation $H'=-x\exp\left(\frac{-t^2}{t_0^2}\right)$ from t=0 to t=∞, Calculate the probability for transition from the ground state, given that

$$\int_0^{\infty}\exp(-\alpha t^2+i\omega t)dt=-i\sqrt{\frac{\pi}{\alpha}}\exp\left(\frac{-\omega^2}{4\alpha}\right)$$

(P.T.O.)

PHS 301.2: Statistical Mechanics-I

Marks: 20

Answer any TWO questions of the following: 2X10=20

1. a) Ideal Bose gas has negative value of Chemical potential. What is its significance?
   b) Discuss the dependence of i) density of states on energy ii) Fermi energy on electron concentration iii) Internal energy on electron concentration for 2-D electron gas.
2. a) What is the relation between Grand Canonical partition function and Canonical partition function?
   b) Discuss the physical significance of chemical potential.
   c) A system of spin-1/2 particle is placed in external magnetic field H and total energy of system is E. Calculate the entropy of the system (in terms of E and H)
3. a) Discuss the importance of Density Matrix.
   b) How do you distinguish between pure and mixed state in terms of density matrix
   c) In how many ways 5 electrons can be put into 3 energy levels where ground state is non degenerate, first excited state and second excited states are 2 fold degenerate.
4. a) Define phase space density for discrete and continuous systems.
   b) What is the limit for applying classical and quantum statistics?
   c) Find out the probability of finding a molecule of ideal gas i) in a particular position and momentum interval ii) in a momentum interval irrespective of the position.
5. a) How do you distinguish between the approach of finding the expectation value of any observable quantity in classical and quantum statistics.
   b) When does Statistical Mechanics predict very close to the actual value of a system?
   c) What is thermodynamic limit?
   d) Is it mandatory for a particle to visit every phase space point of the phase space trajectory? Elaborate.

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