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PG (CBCS)
M.Sc. Semester- III Examination, 2023
PHYSICS
PAPER: PHS 301
(QUANTUM MECHANICS-III & STATISTICAL MECHANICS-I)

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

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.

Write the answer for each unit in separate sheet

UNIT: PHS 301.1
QUANTUM MECHANICS-III

GROUP-A

Answer any **TWO** of the following questions: 2×2=4

1. Prove that$(\chi_0 + m_0)\psi = 0$ where c = ħ = 1 in Dirac equation.
2. State and prove optical theorem in scattering.
3. Distinguish between adiabatic and sudden approximation in perturbation theory.
4. Prove that it is impossible to construct a completely anti-symmetric spin function for three electrons.

GROUP-B

Answer any **TWO** of the following questions: 2×4=8

1. Prove that $(\vec{\alpha}.\vec{A})(\vec{\alpha}.\vec{B}) = \vec{A}.\vec{B} + i\sigma_{a}.(\vec{A}\times\vec{B})$, where $\hat{A}$and $\hat{B}$ commute with $\vec{\alpha}$ but not with each other.
2. Prove that $t_r(\nu_\mu\gamma_\nu) = 4g_{\mu\nu}$
3. Write down the zeroth-order wave function for the 1s2s excited state of the He_2^4 atom.
4. Consider a large number of Fermions of mass m are confined in a cubical box of size L. Find the number of fermions with energy less than E_F

GROUP-C

Answer any **ONE** of the following questions: 1×8=8

1. Deduce Dirac-Pauli equation for spin ½ particle in e.m. field.
2. Deduce Fermi-Golden rule for transition probability.

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UNIT: PHS 301.2
STATISTICAL MECHANICS-I

GROUP-A

Answer any **TWO** of the following questions: 2×2=4

1. Prove that entropy of a canonical system S=$-k_B \sum_i \rho_i \ ln\rho_i$. Where, ρ_i is the probability of the system to be found in i[th] state.
2. State Liouville's theorem in statistical mechanics and hence classify different type of ensembles.
3. The equation of state of a real gas is given by P(v-b) = RT. Find the partition function of the system.
4. Explain why the electron gas at room temperature is highly degenerate.

GROUP-B

Answer any **TWO** of the following questions: 2×4=8

1. Derive the equation of motion for the phase density distribution function (ρ).
2. Explain the pure and mixed state in the light of density matrix.
3. Show that energy fluctuation in a canonical distribution is given by $\overline{(E-\bar{E})^2} = k_B T^2 C_v$.
4. Deduce an expression of Bose-Einstein distribution function from grand partition function.

GROUP-C

Answer any **ONE** of the following questions: 1×8=8

1. What is partition function? Find out its relation with entropy and Helmholtz free energy. Calculate the partition function of a three dimensional quantum mechanical oscillator.
2. Prove that equation of density matrix $\hat{\rho}$
   $i\hbar\frac{d\hat{\rho}}{dt} = [\hat{H}, \hat{\rho}]$ where $\hat{H}$ is the Hamiltonian.

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