DPA 520

First Year M.Sc., (Physics), Examination

August / September 2009

Directorate of Correspondence Course

(Freshers)

Physics

Paper - II : Quantum and Statistical Mechanics

Time : 3 Hours | Max. Marks : 85

Note : Answer any FIVE questions from Part A , B and C without omitting any part. Part D is compulsory

PART- A

1. a. Explain how a linear operator acting on a vector space is represented by a matrix in certain basis.

   b. Obtain the transformation rule for the matrix of a linear operator under a change of basis. **(8+5)**

2. a. Obtain the uncertainty relation for two observables $\hat{A}$ and $\hat{B}$ satisfying $[\hat{A}, \hat{B}] = i\hat{C}$

   b. Show that the hermitian conjugate of the product of several operators is the product of their hermitian conjugates in the reverse order. **(8+5)**

3. a. List the basic postulates of quantum mechanics.

   b. Obtain the equivalent of Newton's second law in quantum mechanics using Ehrenfest's theorem.

   c. Show that $[\hat{x}, \hat{p}_x] = i\hbar$ **(4+7+2)**

PART- B

4. a. Starting from the time independent Schrodinger equation for a one dimensional harmonic oscillator, arrive at the Hermite differential equation and hence obtain the energy eigenvalues.

   b. Show that the two-body Schrodinger equation of Hydrogen atom can be transformed to single body equations. **(7+6)**

5. a. Discuss the coupling of two independent angular momenta and explain how the coupled basis states are related to the product basic states.

   b. Given the three orthonormal single particle wave functions ϕ_α, ϕ_β and ϕ_γ of a fermion, construct the completely antisymmetric state of three such identical fermions. **(8+5)**

6. a. Estimate the ground state energy of the Helium atom using variational method.
   b. Arrive at the Fermi golden rule for transitions under harmonic perturbation. **(7+6)**

PART- C

7. a. Explain the meaning of i) Microstate ii) Macrostate iii) Ensemble in statistical mechanics.
   b. Mention the postulate of equal apriori probability.
   c. State and prove Liouville's theorem. **(6+3+4)**

8. a. Explain Gibb's paradox.
   b. Obtain the Sackur Tetrode formula.
   c. Show that the two quantum distribution functions reduce to Maxwell's distribution function at high temperature. **(5+4+4)**

9. a. Obtain an expression for the distribution function at equilibrium for bosons.
   b. Arrive at Dulong and Petit's law using statistical mechanics. **(8+5)**

PART- D

10. **Answer the following** **(4x5=20)**
   a. Find the eigenvalues of $A = \begin{pmatrix} 1 & i \\ -i & 1 \end{pmatrix}$
   b. Find the normalization constant N for the wavefunction $\psi(x) = N \exp(-bx^2)$, where b is a real constant.
   c. Find the parity of the spherical harmonics $Y_{lm}(\theta,\phi)$
   d. Show that the energy of the ground state of a system never exceeds the expectation value of energy for any state.
   e. Give the statistical interpretation of entropy

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