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Reg. No. : ....

Name : ....

Second Semester M.Sc. Degree Examination, September 2024

Physics / Physics with Specialization in Space Physics / Physics with Specialization in Nano Science

PHSP 522 / PHNS 522 / PH 222 : THERMODYNAMICS, STATISTICAL PHYSICS AND BASIC QUANTUM MECHANICS

(2020 Admission Onwards)

Time : 3 Hours Max. Marks : 75

SECTION – A

Answer any **five** questions. Each question carries **3** marks.

1. The distribution function is constant along a phase trajectory of a sub-system. Identify this theorem and prove it. Mention the conditions for the validity of this theorem.

2. Explain the Gibb's paradox.

3. Discuss the micro canonical ensemble in classical and quantum statistics.

4. Write notes on thermodynamic phase transitions. Draw the P-T phase diagram of one component system.

5. Show that eigen values of Hermitian operators are real and eigen vectors belonging to different eigen values are orthogonal to each other.

6. Write notes on the creation ($\hat{a}^\dagger$) and annihilation ($\hat{a}$) operators. Obtain the commutation relation between $\hat{a}^\dagger$ and $\hat{a}$.

P.T.O.

7. Discuss the **interaction picture** in quantum mechanics.

8. Obtain the operator form of x-component of orbital angular momentum operator ($\hat{L}_x$) from position and momentum operators. Hence, obtain $[\hat{L}_x, \hat{L}_y]$.

(5 × 3 = 15 Marks)

SECTION – B

Answer **all** questions. Each question carries **15** marks.

9. Explain the statistical theory of white dwarfs.

OR

10. Discuss the momentum and position representations in quantum mechanics. Discuss the significance of these representations. Obtain the Schrodinger equation in momentum representation.

11. Derive the general uncertainty relation $\Delta A \, \Delta B \geq \frac{1}{2}\left|\frac{1}{i} < [\hat{A}, \hat{B}] >\right|$. Using the uncertainty relation, show that the ground state energy of a one-dimensional harmonic oscillator is $\frac{1}{2}\hbar\omega$. Obtain the ground state wave function.

OR

12. Discuss the Fermi-Dirac and Bose-Einstein statistics with necessary mathematical support. Give two examples of systems obeying these statistics.

13. Solve the one-dimensional problem of particle in an infinite square well potential. Obtain the energy eigen values. Draw the probability amplitude and probability density for the ground state, first, second and third excited states. Using the results of one-dimensional problem, generate the energy eigen values of a three-dimensional box problem.

OR

14. Explain the concept of partition function. Discuss the partition function of a diatomic gas.

(3 × 15 = 45 Marks)

SECTION – C

Answer any **three** questions. Each question carries **5** marks.

15. Solve the harmonic oscillator problem using the raising and lowering operators.

16. (a) Show that the eigen values of Unitary operator are unimodular.

    (b) Show that product of two Unitary operators is unitary operator.

17. (a) Show that $[\hat{x}, \hat{p}_x] = i\hbar$, where $\hat{x}$ is the position operator and $\hat{p}_x$ is the x-component of the momentum operator.

    (b) Prove that each component of orbital angular momentum commutes with the kinetic energy operator.

18. A particle is in a cubic box of edge L. How many states have energies in the range of 0 to $16h^2/8mL^2$?

19. Show that the entropy of a degenerate Fermi gas vanishes at absolute zero of temperature whereas the pressure remains finite.

20. Obtain an expression for the specific heat of a Bose gas. Discuss its variation with temperature.

(3 × 5 = 15 Marks)
