QP CODE: 24018801

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Reg No : ....

Name : ....

MSc DEGREE (CSS) EXAMINATION , APRIL 2024

Second Semester

CORE - PH010203 - STATISTICAL MECHANICS

M Sc PHYSICS,M.Sc.SPACE SCIENCE

2019 Admission Onwards

881ACCC2

Time: 3 Hours | Weightage: 30

Part A (Short Answer Questions)

*Answer any **eight** questions.*

*Weight **1** each.*

1. Explain why the Gibbs correction factor works in the classical ideal gas for accounting the indistinguishability.
2. Describe the evolution of a microstate in phase space.
3. Explain the relation between the relative fluctuations in energy and specific heat in canonical ensemble.
4. Using equipartition theorem, obtain the average energy for an ideal gas system on N classical free particles in two dimension.
5. Obtain an expression for chemical potential in terms of Helmholtz free energy.
6. Explain why micro canonical, canonical and grand canonical ensembles for thermodynamic systems with large particle numbers yield the same result.
7. Write down the wave function for a three particle Bosonic system in terms of the single particle wave functions.
8. Show that the specific heat capacity of an ideal Bose system tends to classical limit at high temperatures.
9. Discuss the single particle energy level diagram in the presence and absence of an external magnetic field for a two dimensional motion.
10. Explain the variation of thermionic current and photoelectric current with temperature with appropriate plots in metals.

(8×1=8 weightage)

Part B (Short Essay/Problems)

*Answer any **six** questions.*

*Weight **2** each.*

11. Calculate the ratio C_P/C_V for extreme relativistic gas confined in a cubical box of side L , characterised by the single particle energy states $\epsilon(n_x, n_y, n_z) = \frac{hc}{2L}(n_x^2 + n_y^2 + n_z^2)$
12. A system has four non-degenerate energy levels. The energy levels are $E_1 = 0,\ E_2 = 1.4 \times 10^{-23} J,\ E_3 = 4.2 \times 10^{-23} J$ and $E_4 = 8.4 \times 10^{-23} J$. Given

    that the system is at a temperature of $5K$, what is the probability that the system is in the $E_1 = 0$ level?
13. The canonical partition function for classical ideal gas is given as $Q_N = \frac{1}{N!}\left[V\left(\frac{2\pi mkT}{h^2}\right)^{3/2}\right]^N$. Obtain the average energy U and specific heat capacity C_V.
14. Obtain the the pressure and entropy for system of independent localized particles in grand canonical ensemble, if the single particle canonical partition function is $Q_1(V, T) = kT/\hbar\omega$.
15. For a state of equilibrium, Show that the density matrix in the eigenbasis of the Hamiltonian is diagonal: $\rho_{mn} = \rho_n \delta_{mn}$.
16. Show that the most probable number of particles per energy level in the i^{th} cell is given by $\frac{n_i^*}{g_i} = \frac{1}{e^{(\alpha+\beta\epsilon_i)} + a}$.
17. Show that in Einstein's model for low temperatures the specific heat capacity of solids falls off exponentially.
18. Show that the specific heat capacity of ideal Fermi system is given by $\frac{C_V}{Nk} = \frac{15 f_{5/2}(z)}{4 f_{3/2}(z)} - \frac{9 f_{3/2}(z)}{4 f_{1/2}(z)}$.

(6×2=12 weightage)

Part C (Essay Type Questions)

*Answer any **two** questions.*

*Weight **5** each.*

19. Write a note on the microcanonical ensemble. Discuss the classical ideal gas in microcanonical ensemble.
20. Discuss the density matrix formulation in quantum statistics for various ensembles.
21. Explain the spectral distribution of energy in the blackbody radiation and deduce its thermodynamic properties.
22. Discuss the salient features of first order phase transition. Deduce Clapeyron equation.

(2×5=10 weightage)