Register Number:

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ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27
M.Sc. PHYSICS – II SEMESTER
SEMESTER EXAMINATION : APRIL 2017
PH 8315 : STATISTICAL PHYSICS

Time: 2 1/2 hours **Maximum Marks:70**

This question paper contains 2 parts and 2 printed pages.
Use of Clark's tables and scientific calculators permitted.

Instructions : *Draw appropriate figures wherever necessary.*

PART - A

Answer any 5 questions. Each carries 10 marks. (5 x 10 = 50)

1. Obtain the quantum distribution functions (mean number of particles occupying a particular single particle state) for (i) Maxwell-Boltzmann statistics and (ii) Fermi-Dirac statistics. (5+5)

2. a) State and prove equipartition theorem.
b) Write a note on the concept of temperature. (6+4)

3. Write the quantum distribution function for Fermi-Dirac statistics. What is Fermi energy? Obtain the expressions for Fermi energy and Fermi temperature of a gas with negligible mutual interactions. (1+2+7)

4. Derive the equation for the entropy of a system of ideal monoatomic gas, in terms of the classical partition function (use canonical distribution). In this context, discuss Gibb's paradox? (7+3)

5. Consider a 1D harmonic oscillator which is in equilibrium with a heat reservoir at absolute temperature T. Obtain the expressions for the mean energy of this system in low and high temperature limits (using canonical distribution). Compare the results with the results obtained using equipartition theorem.
(7+3)

6. Consider the interaction between two macroscopic systems A and A'. The probability $P(E)$ that A has an energy E, exhibits a sharp maximum at $E=\tilde{E}$ where $\tilde{E}$ is the energy of A when both the systems attain thermal equilibrium with each other. Get the order of magnitude of the width of this probability distribution. (10)

7. Explain the following terms.
a) Microscopic and Macroscopic systems
b) Reversible and irreversible processes
c) Accessible states
d) Equilibrium (2+3+3+2)

PART - B

Answer any 4 questions. Each carries 5 marks. (4 x 5 = 20)

8. What is the most probable kinetic energy $\bar{\epsilon}$ of molecules having a Maxwellian velocity distribution?

9. Two atoms of mass m interact with each other by a force derivable from a mutual potential energy of the form $U=U_0[(\frac{a}{x})^{12}-2(\frac{a}{x})^{6}]$ where x is the separation between the two particles. The particles are in contact with a heat reservoir at a temperature T low enough so that $kT \ll U_0$ but high enough so that classical statistical mechanics is applicable. Calculate the mean separation $\bar{x}(T)$ of the particles.

10. Show that the probability of finding the system, for a canonical ensemble, in a particular microstate r with energy E_r is given by

$$P_r=\frac{e^{-\beta E_r}}{\sum_r e^{-\beta E_r}}$$

11. Consider two different systems each with three identical non-interacting particles. Both have single particle states with energies $\epsilon_0, 3\epsilon_0$ and $5\epsilon_0$. One system is populated by spin 1/2 fermions and the other by bosons. What is the value of E_F-E_B where E_F and E_B are the ground state energies of the fermionic and bosonic systems respectively?

12. A one dimensional random walker takes steps to left and right with equal probability. Find the probability that the random walker starting from the origin is back to the origin after an even number (N) of steps.

13. A system of four identical distinguishable particles has energy 3ϵ. The single particle states are available at energies $0, \epsilon, 2\epsilon, 3\epsilon$. Determine (i) the total number of ways to get energy 3ϵ and (ii) the average number of particles with zero energy.