Register Number:

DATE:

ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27
M.Sc. PHYSICS – II SEMESTER
SEMESTER EXAMINATION : APRIL 2018
PH 8315 : STATISTICAL PHYSICS

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

This question paper contains 2 printed pages and 2 parts
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. a) Consider a thermally isolated system in equilibrium. Find the change in entropy of the system when an external parameter of the system changes quasi-statically.

   b) The expression for entropy of a system is $S=k\ln\Omega$ where the system's energy is between E and $E+\delta E$. If the interval length is changed to $\delta E'$ what will be the effect on entropy? Substantiate your answer.

   (5+5)

2. Consider a system of ideal gas in the classical limit. Enumerate the possible quantum states s and corresponding energies ϵ_s of a single non-interacting particle in this system. (Calculate the number of states per unit volume whose wave vector lies between $\vec{k}$ and $\vec{k}+d\vec{k}$.)

   (10)

3. Calculate the specific heat and entropy of a system of ideal mono atomic gas. (Use classical partition function) $\int_0^{\infty} e^{-\alpha x^2} dx = \frac{\sqrt{\pi}}{2}\alpha^{-1/2} = \frac{1}{2}\sqrt{\frac{\pi}{\alpha}}$

   (10)

4. a) Explain the term grand canonical ensemble and derive the expression for grand canonical distribution with explanation of variables.

   b) What is meant by dispersion? Derive an expression for the mean square dispersion in energy of a system in terms of the partition function for a canonical distribution of systems.

   (5+5)

5. For a system of electromagnetic radiation in thermal equilibrium inside an enclosure, obtain Wien's displacement law from Planck distribution.

   (10)

6. a) Using he partition function for Maxwell-Boltzmann statistics arrive at the expression

$$\bar{n}_s = N \frac{e^{-\beta \epsilon_s}}{\sum_r e^{-\beta \epsilon_r}}$$

b)Show that in the classical limit of sufficiently low density or sufficiently high temperature both Fermi-Dirac and Bose-Einstein distribution laws reduce to Maxwell-Boltzmann distribution.

(5+5)

7. a) Describe briefly about white dwarf stars and obtain a general expression for pressure P_0 exerted by a uniform Fermi gas.

b) Discuss the case where electron gas is at high density that relativistic effects are important.

$$\frac{\hbar c}{\gamma m_p^2} = 10^{39} \qquad \bar{M} = \frac{9\pi}{8} \frac{M}{m_p} \qquad \bar{R} = \frac{R}{\hbar / m_e c} \qquad m_p = 1.6 \times 10^{-27}\, kg$$

(5+5)

PART – B

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

8. There are four energy levels E, 2E, 3E and 4E (E>0). Write the canonical partition function of the system when (i) there are two fermions (ii) there are two distinguishable particles. (3+2)

9. a) From a deck of regular playing cards, two cards are drawn at random. What is the probability that both the cards are kings? (Two cards are drawn in sequence at random)

b) Six sides of a die are numbered in such a way that there are 2 ones, 1 four, 3 sixes, no twos, threes and fives. Write respectively the probabilities of getting one, four, and six in a single throw of one die? (2+3)

10. a)Draw the trajectory on the $z\, p_z$ plane (phase-space trajectory) of a ball bouncing perfectly elastically off a hard surface at $z=0$. (neglect friction)

b)A system consists of 4 spin-1 particles. Obtain the number of possible microstates for this system. (2+3)

11. A Bose-Einstein gas has two particles in the i^{th} state whose degeneracy is three. Determine the number of ways of selecting the particles in the state.

12. Given that $P(v_x) = \left(\frac{m}{2\pi kT}\right)^{1/2} e^{\frac{-m v_x^2}{2kT}}$. What is the value of P_{max} ? Find the values of v_x for which the probability falls to 1/10 times the value of P_{max} .

13. The partition function for a photon gas is given by $\ln Z = \frac{\pi^2}{45} \frac{V(kT)^3}{\hbar^3 c^3}$. Determine the pressure of the photon gas.