End Semester Examination, 2022

Semester - VI

Physics

PAPER - C14T

Full Marks : 40

Time : 2 Hours

Group - A

1. *Answer any <u>five</u> from the following :*

a) Plot Fermi distribution function for T = 0 K and T > 0 K. 2

b) Write down the type of statistics (B–E or F–D) the following particles follow —
neutino, alpha, muon, photon

c) Explain the terms 'microstate' and 'macrostate' with suitable examples. 2

d) Show mathematically under which condition B-E distribution reduces to M-B distribution function. 2

e) How is canonical partition function used to determine the mean energy of the particles in a system ? 2

f) State the most significant difference between the assumptions of Einstein and Debye theories of specific heat of solid.

g) Calculate the number of microstates for a free particle inside a three dimensional cubical box of volume V having energy between E and E+dE. 2

h) Consider a photon gas in equilibrium. What is the value of its chemical potential and why? 2

Group - B

Answer any <u>four</u> from the following :

2. A system of N localized magnetic dipoles is kept in a magnetic field.
   a) Calculate the canonical partition function for the system.
   b) Find out the average magnetic moment.
   c) Plot this as a function of temperature. 2+2+1
3. a) With the help of the fugacity term state the conditions for a system to obey quantum and classical statistics.
   b) Obtain the Planck's blackbody radiation law from B-E statistics. 2+3
4. Show that the Fermi pressure is proportional to the cube root of the fifth power of the number density at T = O in three dimensions. 5
5. Starting from the expression of canonical partition function for a system having discrete energy levels, show that the relative fluctuation in energy $\left(\frac{\triangleleft E}{E}\right)$ is $\sqrt{\frac{2}{lNK}}$ where l is the number of degrees of freedom, N is the number of particles in the system and K is the Boltzmann constant, for an ideal gas.

6. Consider a system consisting of two energy levels. The system is in thermal equilibrium at temperature 500K. The energy difference of the two levels is 0.2 ev.
   a) What is the probability that the system is in the higher energy level?
   b) What is the temperature at which the above probability equals 0.25? 3+2
7. For a two-dimensional free electron gas, show that the number density is given by

$$n = \frac{4\pi mkT}{h^2} ln\left(e^{\frac{E_F}{kT}} + 1\right)$$ 5

Group - C

Answer any <u>one</u> from the following :

8. a) State how the enumeration of the number of microstates leads to Gibbs paradox. How can it be resolved?
   b) Derive the Richardson-Dushman equation for current density of thermionic emission from metal. 3+2+5
9. a) A classical anharmonic oscillator has potential energy $V(x) = ax^2 - bx^3$, where a and b are positive constants. Determine the average energy of the oscillator at a temperature T. How does it differ from the result obtained from equipartition of energy theorem?

b) Show that the effective number of particles in a single particle state or the single particle occupation number for Fermions at TK with an energy within $\pm KT$ of the Fermi energy has an approximate range of 0.46 where K is the Boltzmann constant. 4+2+4

Physical constants :

$h = 6.626 \times 10^{-34} JS$ (Plancle's constant)

$k = 1.38 \times 10^{-23}\ m^2 kg\, s^{-2} k^{-1}$ (Boltzmann constant)