RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2016

THIRD YEAR [BATCH 2013-16]

Date : 04/05/2016 **PHYSICS (Honours)**

Time : 11 am – 1 pm **Paper :** VII-B Full Marks : 30

Group - B

Answer <u>any three</u> of the following : [3×10]

1. a) What is phase space? A classical particle is free to move in a cube of side L. If its energy $\leq E$, find the volume of phase space available to it. [1+3]

   b) Consider a free Fermi gas in two dimension, confined to a square area $A = L^2$

   i) Derive a formula for the density of states.

   ii) Find the Fermi energy ($\in_F$) and show that the average energy of the particles is $\frac{\in_F}{2}$ at absolute zero. [2+2+2]

2. a) State the classical equipartition theorem or energy. Comment on its limit of validity. [1+1]

   b) Because of the Doppler effect, the frequency of the light observed from an atom having an x-component of velocity v_x is $v \simeq v_0\left(1+\frac{v_x}{c}\right)$. v_0 is constant.

   i) Calculate <v>

   ii) Calculate the dispersion $<(\Delta v)^2> = <(v - <v>)^2>$.

   iii) Calculate the line width = $\sqrt{<(\Delta v)^2>}$ [3]

   c) For a canonical system, utilize the Shanon's definition of entropy, to show that $S = \frac{<E>}{T} + k_B T \ln Z$ and $F = k_B T \ln Z$.

   Hence show that $G = F + PV = k_B T\left[-\ln Z + V\left(\frac{\partial \ln Z}{\partial V}\right)T\right]$ [symbols are of usual significance] [2+1+2]

3. a) Obtain an expression for the BE statistics using microcanonical ensemble. What is the range of the chemical potential in the BE statistics? [3+1]

   b) Starting from the expression for B-E statistics, obtain Planck's law of energy distribution for photons. Show how Raybeigh-Jean's law and Wein's distribution law follow from Planck's law as limiting cases. [3+3]

4. a) Write down he expression of grand canonical partition function Z. Find the expression of mean energy <F>. [1+2]

   b) Show that relative mean square fluctuation in the particle density (n), i.e., $\frac{<(\Delta n)^2>}{<n^2>} = \frac{k_B T}{V} K_T$, where K_T is the isothermal compressibility of the system and V is the volume of the system. [4]

   c) 4 bosons are distributed among two energy levels ($\in$ and $2\in$). Higher energy level is 2-fold degenerate. Find the number of microstates for which the total energy of the system is $7\in$. [3]

5. a) A drunk person starts from the origin and moves randomly along x or –x direction. Each step is of equal length ℓ. The probability that any one steps along x or along –x are same and equal to $\frac{1}{2}$. Suppose that the person has taken N steps and mean time taken for each step is τ.

i) Estimate the probability $P'_N(r)$ that the displacement (x) of the person from the origin is equal to $r\ell$ (r is any positive integer). [2]

ii) Find out the value $< r^2 >$. Show that $< r^2 >$ is proportional to t, where $t = N\tau$ is the time taken by the person for N steps. [2+1]

b) Write down the distribution law obeyed by electron gas in metal and apply it to derive Richardson equation for thermionic emission. [5]

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