

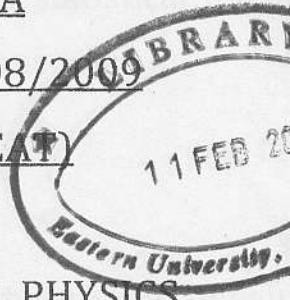
EASTERN UNIVERSITY, SRI LANKA

THIRD EXAMINATION IN SCIENCE - 2008/2009

SECOND SEMESTER (PROPER/REPEAT)

(October/November 2010)

PH 305 FUNDAMENTALS OF STATISTICAL PHYSICS



Time: 01 hour.

Answer ALL Questions

1. Derive Maxwell-Boltzmann distribution function in statistical physics, using the thermodynamic probability distribution function;

$$\Omega = N! \prod_j \frac{g_j^{n_j}}{n_j!} \quad \text{and} \quad \beta = \frac{1}{KT}$$

Consider a gas of N magnetic atoms with spin $\frac{1}{2}$ due to one unpaired electrons. Each atom has intrinsic magnetic moment μ and the interaction between atoms is negligible. The magnetic moment of an atom is: $\mu = \mp \frac{1}{2} g_s \mu_B$

Where: μ – Magnetic moment

g_s – Degeneracy of a state

μ_B – Magnetic moment due to magnetic field

- Write down expressions for energies correspond to Spin Down (μ anti-parallel to B) and Spin Up (μ parallel to B).
- Express Maxwell-Boltzmann distribution function for this system.
- Obtain an expression for partition function for this system.
- Determine the total energy of the system by using above expressions.
- Hence, show that the magnetization of the electron is:

$$M = -\frac{E}{BV} \quad \text{where} \quad M = \frac{1}{V} \sum n_j \mu_j$$

2. State the conditions under which a system of particles obeys the Bose-Einstein distribution law and derive an expression for the corresponding distribution.

You may use the thermodynamic probability distribution function;

$$\Omega = \prod_j \frac{(m_j + g_j - 1)!}{m_j! (g_j - 1)!} \text{ and } \beta = \frac{1}{KT}$$

Consider a quantum mechanical gas of non interacting spin zero bosons each of mass m which is free to move within the volume V at a temperature T . The Density of State of the boson is:

$$D(\omega) = \frac{V\omega^2}{\pi^2 C^3} d\omega$$

- Obtain an expression for energy of bosons $U(T)$ in the region.
- Show how the expression obtained in part (a) is modified for photon (mass = 0) gas in the distribution function at very low temperature as $\mu \rightarrow 0$.
- Hence prove that the energy $U(T)$ satisfied the black body radiation using the function:

$$\int_0^{\infty} \frac{x^3}{e^x - 1} dx = \frac{\pi^4}{15}$$