EASTERN UNIVERSITY, SRI LANKA

THIRD EXAMINATION IN SCIENCE - 2008/2009

SECOND SEMESTER (PROPER/REPEAT)

(October/November 2010)

PH 305 FUNDAMENTALS OF STATISTICAL PHYSICS

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Time: 01 hour.

Answer ALL Questions

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

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

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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

a) Write down expressions for energies correspond to Spin Down (μ anti-parallel to B) and Spin Up (μ parallel to B).

b) Express Maxwell-Boltzmann distribution function for this system.

c) Obtain an expression for partition function for this system.

d) Determine the total energy of the system by using above expressions.

e) Hence, show that the magnetization of the electron is:

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

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;

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

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:

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

a) Obtain an expression for energy of bosons U(T) in the region.

b) Show how the expression obtained in part (a) is modified for a photon (mass = 0) gas in the distribution function at very low temperature as $\mu \to 0$.

c) Hence prove that the energy U(T) satisfied the black body radiation using the function:

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