# EASTERN UNIVERSITY, SRI LANKA

## THIRD EXAMINATION IN SCIENCE - 2010/11

## SECOND SEMESTER (Special Repeat)

## (June 2014)

## PH 305 FUNDAMENTALS OF STATISTICAL PHYSICS

Time: 01 hour.

Answer ALL Questions

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1. Specifying macrostates and microstates, describe the concept of a statistical ensemble. Express *entropy* of a statistical ensemble in terms of number of microstates $\Omega$.

   Distinguish a classical statistical system from a quantum statistical system.

   Consider a system of $N$ non-interacting classical particles, each fixed in position carrying a magnetic moment $\mu$, which is immersed in a magnetic field $H$. Each particle may then exist in one of the two non-degenerate energy states $E=0$ and $E=2\mu H$.

   (a) Using Stirling approximation $\ln(x!)=x\ln(x)-x$, obtain an expression for the entropy $S(n)$, where $n$ is the number of particles in the upper state.

   (b) Show that at thermodynamic equilibrium, the entropy $S(n)=k_B N\ln 2$, where $k_B$ is the Boltsman constant.

   (c) Give a schematic plot of $S(n)$ against $n$.

2. Outline the conditions for the three types of statistics used for classical and quantum systems. Give an example for each case.

   Consider a perfect gas of $N$ free electrons in a solid of volume $V$, which obey the Fermi-Dirac distribution $f(E)=\dfrac{n(E)}{g(E)}=\dfrac{1}{\exp[(E-\mu)/k_BT]+1}$, where the density of electron states is given by $g(E)=4\pi V\left(\dfrac{2m_e}{h^2}\right)^{3/2}E^{1/2}$ and the symbols have their usual meaning. Show that the Fermi energy at absolute zero ($T$=0) is given by $E_f = \frac{h^2}{8m_e}\left(\frac{3N}{\pi V}\right)^{2/3}$.

Find the Fermi energy in copper on the assumption that each copper atom contributes one free electron to the electron gas. The density of copper is $8.94 \times 10^3$ kg $m^{-3}$ and its atomic mass is 63.5 a.m.u.

The following values may be useful: Avergadro number $6.023 \times 10^{23}$ $mol^{-1}$, Plank's constant ($h$) = $6.64 \times 10^{-34}$ J s and mass of electron ($m_e$)= $9.1 \times 10^{-31}$ kg.