**RAJARATA UNIVERSITY OF SRI LANKA**
**FACULTY OF APPLIED SCIENCES**

B.Sc. (General) Degree
Forth Year – Semester II Examination – Oct / Nov. 2015

**PHY 4212 – STATISTICAL THERMODYNAMICS**

Answer all **Four** questions Time allowed: 2 Hours

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Planck's constant, $h = 6.626 \times 10^{-34}$ $m^2$ kg $s^{-1}$

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The use of a non-programmable electronic calculator is permitted.

1)

a) Derive the binomial probability distribution function, $W_N(n_1) = \frac{N!}{n_1! n_2!} p^{n_1} q^{n_2}$ using approximations in one dimensional random walk where, $p$ and $q$ are the probability of taking a step to the right and left respectively. $n_1$ is the number of steps to the right and $n_2$ is the number of steps to the left out of total $N$ steps.

(40 marks)

b) Prove that the mean values of $n_1$ and $n_2$ are given by $Np$ and $Nq$.

(20 marks)

c) Consider the case of $N = 100$ steps, where $p = q = 0.5$. Calculate;

i) the mean number of steps to the right,

ii) the mean number of steps to the left,

iii) the mean dispersion and

iv) the mean displacement

(40 marks)

2)

A particle of mass $m$ is confined to a cube of volume $V$. According to quantum theory the energy of the system is given by; $E = \frac{\pi^2\hbar^2}{2m}n^2$ where the symbols have their usual meanings.

a) Obtain an equation for the number states of the system as a function of $E$.

(30 marks)

b) Obtain an equation for the density of states of the system.

(20 marks)

c) One $H_2$ molecule is confined to a cubic box. Assume, each side of the box is 1 mm and mass of a $H_2$ molecule is $3\times10^{-22}$ g. If the energy of this one particle system is $10^{-21}$ J, calculate the number of states accessible to the system.

(30 marks)

d) Determine the density of states of the system.

(20 marks)

3)

Show that quasi-static work done by pressure is given by $pdV$, where $p$ is pressure and $V$ is volume.

(20 marks)

a) The mean pressure $p$ of a thermally insulated gas varies with its volume $V$ according to the relation $p = CV^{m-1}$ where $m$ ($m > 0$) and $C$ are constants.

(i) Find the work done by this gas in quasi-static process from a microstate with pressure $p_1$ and volume $V_1$ to one with pressure $p_2$ and volume $V_2$.

(20 marks)

(ii) Express your answer in terms of $p_1$, $V_1$, $p_2$, $V_2$ and $m$.

(20 marks)

(iii) Answer to above (i) and (ii) if $m = 0$?

(40 marks)

4)

a) Show that $\beta(\tilde{E}) = \text{Constant}$, for a purely thermal quasi static macroscopic interaction of two systems where, $\tilde{E}$ is the most probable energy of the system and $\beta(E) = \frac{\partial}{\partial E} \ln \Omega(E)$. The number of accessible states to the system is denoted by $\Omega(E)$.

(50 marks)

b) Show that when the system is at the most probable state,

i) the entropy change in the combined system is maximum and

ii) the temperature difference between two systems is zero.

(50 marks)