RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Forth year – Semester II Examination – March / April 2014

PHY 4212 – STATISTICAL THERMODYNAMICS

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

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

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 steps 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) What is the mean value of n_1?

(20 marks)

c) What is the mean value of n_2?

(20 marks)

d) A drunk starts out from a lamppost in the middle of a street, taking steps of equal length either to the right or to the left with equal probability. What is the probability that the man again be at the lamp post after taking N steps if N is an even number?

(20 marks)

2)

a) A particle of mass m is confined in a cube of volume V. The density of states of the system is given by; $\omega(E) = \frac{V}{4\pi^2}\left(\frac{2m}{\hbar^2}\right)^{3/2} E^{1/2}$. Symbols have their usual meanings.

(40 marks)

b) A N_2 molecule is confined to a cubic box. Each side of the box is 1 cm and mass of a N_2 molecule is 5×10^{-23} g. If the energy of the system is 10^{-21} J. Calculate the number of states accessible to the system.

(40 marks)

c) Determine the density of states of the system.

(20 marks)

3)

a) Define,

i) purely thermal interaction and

ii) purely mechanical interaction

(30 marks)

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

(20 marks)

c) The mean pressure p of a thermally insulated gas varies with its volume V according to the relation $p = CV^m$ where m ($m \neq -1$) 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.

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

(iii) Is your answer valid for $m = -1$? Explain.

(50 marks)

4) Briefly explain,

i) Quantum statistics.

(40 marks)

ii) Bose-Einstien statistics.

(30 marks)

iii) Fermi-Dirac statistics.

(30 marks)

5)

a) What do you mean by quasi-static process?

(20 marks)

b) 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 $\Omega(E)$.

(40 marks)

c) 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.

(40 marks)