RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (Joint Major) Degree in Chemistry & Physics
Fourth year - Semester I Examination – March/ April 2013

PHY 4212 – Statistical Thermodynamics

Answer Four questions only **TIME: 2 Hours**

Use of a non-programmable calculator is permitted.

1)

a) Obtain the binomial probability distribution function, $W(n_1) = \frac{N!}{n_1! n_2!} P^{n_1} q^{n_2}$ using one dimensional random walk (symbols have their usual meanings).

b) If $m = n_1 - n_2$ find the mean values of m and m^2.

2)

a) When n is very small compared to N and p is very small ($p << 1$) use the binomial probability distribution function to obtain Poisson probability distribution, $W_N(n) = \frac{\lambda^n}{n!} e^{-\lambda}$ where $\lambda = Np$ (symbols have their usual meanings).

b) A company fills 10 kg of N_2 gas to containers from their huge storage tank. However, N_2 in the storage tank contains 0.1% (weight percentage) of O_2 as an impurity. Use the Poisson distribution to calculate probability of having 50 g of O_2 in a container.

3) Consider the case N identical molecules of monoatomic ideal gas is confined to a volume V. Show that the number of states accessible to the system is given by $\Omega(E) = V^N E^{3N/2}$.

4)

a) Obtain equation for work done on a system in terms of pressure and volume.

b) Define purely thermal interaction and quasi-static process.

c) The mean pressure p of a thermally isolated gas varies with its volume V according to the relation $pV^\gamma = K$, where γ and K are constants.

Find the work done by this gas when it goes from a state with pressure p_1 and volume V_2 to state with pressure p_2 and volume V_2 in quasi-static process.

Express your answer in terms of p_1, V_1, p_1, V_1 and γ.

5)

a) What do you mean by reversible and irreversible processes?

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

c) If the system is at the most probable state, show that

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

ii) The temperature difference between two systems is zero.

6) A one-dimensional simple harmonic oscillator has energy levels $E_n = (n + \frac{1}{2})\hbar\omega$ where ω is the characteristic angular frequency of the oscillator and n = 0, 1, 2, 3, ... Suppose the oscillator is in thermal contact with the heat reservoir at temperature T and $\frac{KT}{\hbar\omega} << 1$.

a) Find the probability of the system being in the 1st exited state to the probability of its being in the ground state.

b) Assuming that only the ground state and first excited states can occupy, find the mean energy of the oscillator as a function of temperature T.