CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR EDUCATION SCIENCE AND BACHELOR OF SCIENCE

PHYS 315: THERMAL AND STATISTICAL PHYSICS

STREAMS: BED (SCI) and B.Sc **TIME: 2 HOURS**

DAY/DATE: THURSDAY 7/12/2017 **11.30 A.M - 1.30 P.M.**

INSTRUCTIONS:

- Answer Question One in Section A and any other Two Questions in Section B
- Do not write anything on the question paper
- This is a closed book exam, No reference materials are allowed in the examination room
- There will be No use of mobile phones or any other unauthorized materials
- Write your answers legibly and use your time wisely

SECTION A

QUESTION ONE

a. Distinguish the following terms as used in thermodynamics [3 Marks]

i. Microcanonical ensemble
ii. Canonical ensemble
iii. Grand canonical ensemble

b. Give 2 statement of 3rd law of thermodynamics. [4 Marks]

c. The macrostate that is most stable contains the majority microsites. Explain this statement.

d. Find the number of ways in which two particles can be distributed in six states is,

i. The particles are distinguishable [2 Marks]
ii. The particles are indistinguishable and obey Bose-Einstein statistics [2 Marks]
iii. The particles are indistinguishable and only one particle can occupy one state [2 Marks]

e. Show that for every large number, the sterling's approximation is $n! = n\ln n - n$ given $n! = n(n-1)(n-2)\dots\dots$ [3 Marks]

f. Differentiate between Bosons and Fermions [4 Marks]

g. State the principle of equipartition of energy theorem [1 Mark]

h. State 3 postulates of Maxwell-Boltzmann distribution [3 Marks]

i. The equilibrium state is the highest entropy of a system, explain this statement [2 Marks]

j. Given that ψ is antisymmetric such that $\psi_a = \sum_p (-1)^p P\ [\psi\ (1,2,3 \ldots\ldots N)]$where p is the permutatic operator, write the linear combination for 3 particles.

QUESTION TWO

a. Taking S and V to be Independent variables with x=s and y=V , derive the Maxwell's thermodynamic relation $\left(\frac{\partial T}{\partial V}\right)_p = -\left(\frac{\partial P}{\partial S}\right)_T$ stating from the relation $dU = Tds - pdV$ for an infentisimal reversible process. [13 Marks]

b. Using the thermodynamic relation $\left(\frac{\partial S}{\partial V}\right)_T = -\left(\frac{\partial P}{\partial T}\right)_V$derive the Stefan Boltzmann law of radiation. [7 Marks]

QUESTION THREE

a. Given that quantized energy is $E_j = \frac{\hbar^2\pi^2}{2mL^2}\left(n_x^2 + n_y^2 + n_z^2\right)$and that the partition function z is given by $Z = \sum_i e^{-\frac{E_i}{kT}}$sho that the partition function for Maxwell-Boltzmann distribution can be expressed as $Z = V\ (\frac{2m\pi kT}{\hbar^2})^{\frac{3}{2}}$where $V = L^3$. [10 Marks]

b. Consider an ideal gas that contains N molecules with continuous distribution of molecular energies in which the Maxwell's distribution law is given by, $n\ (E)dE = g(E)e^{-\alpha}e^{-\beta}dE$ where, $\beta = \frac{E}{kT}$show that the energy level of an ideal gas molecule is $E = \frac{3}{2}kT$ [10 Marks]

QUESTION FOUR

a. If n is the number of conduction electron per unit volume and m is the electron mass, show that the Fermi energy is given by$E_f = \frac{h^2}{8m}(\frac{3n}{\pi})^{\frac{2}{3}}$ [9 Marks]

b. Suppose n_1 particles occupy the first energy level with energy E_1, n_2 occupy the second energy level with energy E_2. Show that the number of ways n_i particles can be distributed into $g_i$cells in Fermi-Dirac distribution is given by, $n_j = \frac{1}{e^{-\alpha}e^{\beta\varepsilon_j}+1}$ [11 Marks]

QUESTION FIVE

a. What are the differences between variable as used in microscopic and macroscopic descriptions. [4 Marks]

b. Given that $dU = Tds - pdV$ derive the Maxwell's equation $\left(\frac{\partial S}{\partial p}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_p$ (9 Marks)

c. For n_i particles and g_i states show that the Bose Einstein distribution law is given by, $n_j = \frac{1}{e^{-\alpha}e^{\beta\varepsilon_j}-1}$ [7 Marks]

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