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**JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES**

**UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN EDUCATION**

**4TH YEAR 2ND SEMESTER 2013/2014 ACADEMIC YEAR**

**CENTRE: MAIN**

**COURSE CODE: SPH 402**

**COURSE TITLE: STATISTICAL MECHANICS**

**EXAM VENUE: AH STREAM: BSc. .Education**

**DATE: 19/12/2013 EXAM SESSION: 9.00 – 11.00 AM**

**TIME: 2 HOURS**

**Instructions:**

1. **Answer question 1(Compulsory) and ANY other 2 questions.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

**QUESTION ONE**

1. a) Define the following terms as associated to statistical mechanics
2. Phase space
3. Microstate
4. Macrostate
5. Ensemble (4 marks)

b. Beginning with the concept microcanonical ensemble, establish the Boltzman entropy expression

c. State which statistics (Maxwell-Boltzmann; Fermi-Dirac; or Bose-Einstein would be appropriate

i) Density of He-4 gas at room temperature and pressure

ii) Density of electrons in copper at room temperature

iii) Density of electrons and holes in semiconducting Ge at room temperature. (6 marks)

d. i. Explain the physical meaning of negative absolute temperature and discuss whether it violates the third law of thermodynamics. (3 marks)

ii. Suggest one example in which negative temperature can actually be achieved. . (1 mark)

e) Briefly describe the systems in microcanonical and grand canonical ensembles in . terms of the systems interactions with their enviroments. (6 marks)

f) Present and briefly explain the four thermodynamic potentials (4 marks)

g) Explain the Bose-Einstein condensation phenomena. (4 marks)

h) Define the term chemical potential of statistical system. (1 mark)

**QUESTION TWO**

1. State the basic differences in the fundamental assumptions and equations underlying Maxwell- Boltzmann (MB)and Fermi-Dirac statistsics (FD). (6 marks)
2. Make a rough plot of the Energy distribution function at two different temperature for a system of free particles governed by MB statistics and one governed by FD statistics. In each case indicate which curve corresponds to the higher temperature. (6 marks)

1. Explain briefly the discrepancy between experimental values of the specific heat of a metal and the prediction of MB statistics. How did FD statistics overcome the difficulty? . (8 marks)

**QUESTION THREE**

1. Obtain the number of microstates of the combined system, corresponding to the system having energy E and N particles and the total number of microstates of the combined system in a canonical ensemble hence obtain the equation of the probability of the system having energy E and N particles.
2. Repeat (a) above for the case of a grand canonical ensemble.

**QUESTION FOUR**

1. A classical harmonic oscillator of mass m and spring constant k is known to have a total energy of E, but its starting time is completely unknown.

Find the probability density function, where is the probability that the mass would be found in the interval at x*.* (6 marks)

1. A two-level system of N = n1 +n2 particles is distributed among two eigenstates 1 and 2 with eigen energies E1 and E2 respectively. The system is in contact with a heat reservoir at room temperature T if a single quantum emission into the reservoir occurs, population changes  and take place in the system. For  and ,
2. Obtain the expression for the entropy change of the level system and the reservoir

. (8 marks)

1. Derive the Boltzmann relation for the ratio  (6 marks) **QUESTION FIVE**
2. Given the canonical partition function for a highly relativistic ideal gas of indistinguishable particles to be 

Find the grand canonical partition function, Q and use it to obtain the equation of state,



1. Consider the classical ideal gas (with indistinguishable particles in a volume V) in the highly relativistic limilt where the energy E of a particle may be approximated as

whereare the components of the momentum of the particle and is the speed of light.

Using the classical micro-canonical ensemble (fixed U, V, N),

1. Find the number of states that have energy  (4 marks)
2. Find U(V,T) (4 marks)
3. Find the equation of state (4 marks)