**JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**SCHOOL OF BIOLOGICAL PHYSICAL, MATHEMATICS AND ACTUARAL SCIENCES**

**UNIVERSITY EXAMINATION FOR DEGREE OF BACHELOR OF EDUCATION (SCIENCE)**

**$4^{TH}$ YEAR $2^{ND}$ SEMESTER 2019/2020 ACADEMIC YEAR**

**SPECIAL EXAMS: NOVEMBER 2020**

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**COURSE CODE: SPH 402**

**COURSE TITLE: STATISTICAL MECHANICS**

**EXAM VENUE:** **STREAM: EDUCATION**

**DATE:** **EXAM SESSION:**

**TIME: 2:00 HRS**

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**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***

a) What are ensembles? List any three types of ensembles in statistical mechanics ( 4 marks)

b) Explain the terms most probable distribution and give its significance ( 2 marks)

c) Differentiate between macro and micro state (2 marks)

d) 1 kg of water is at 0℃ heat, is heated to 100℃ , calculate its change in entropy (3 marks)

e) When is a system referred to an ergodic? ( 2 marks)

f) Derive the formula describing the density distribution $\rho$ in phase space ( 4 marks)

g) If $n$ is the number of conduction electrons per unit volume and $m$ the electron mass then show that the Fermi energy is given by the expression $E_F = \frac{h^2}{8m}\left(3n/_x\right)^{2/3}$ ( 6 marks)

h) The statistical definition of entropy is $S = klogC$. Taking C as the classical count, show that $S = k[N + \alpha N + \beta E]$, where the symbols bear their usual meaning (7 marks)

***QUESTION TWO***

(a) By use of the grand canonical ensemble, evaluate the chemical potential μ(T,P) for an ultra-relativistic gas contained in a box of volume V (10 marks)

(b) Find the entropy S(E,V,N) of an ideal gas of N classical monoatomic particles, with a fixed total energy E, contained in a d-dimensional box of volume V. Deduce the equation of state of this gas , assuming that N is very large (10 marks)

***QUESTION THREE***

(a) Deduce Boltzmann's law for the probability of atoms in thermal equilibrium occupying a state of energy $\epsilon$ having an absolute temperature T ( 10 marks)

(b) Show that the total partition function can be written as a product of the separate functions as $Q_{total} = Q_{tranlational} + Q_{rotational} + Q_{vibrational}$ ( 10 marks)

***QUESTION FOUR***

a) Define the term partition function ( 2 marks)

b) Obtain the expression for the entropy S in terms of the partition function Q. (8 marks)

c) What do you understand by a "virtual change in volume?" using the concept of virtual change in volume, show that the pressure can be written as $P = NKT\left[\frac{\partial}{\partial V} logQ\right]$, where the symbols bear their usual meanings. ( 10 marks)

***QUESTION FOUR***

(a) What is a free electron model? Give its three key importance ( 5 marks)

(b) Describe the Fermi-Dirac statistics (3 marks)

(c) Derive the mathematical formula describing the Fermi-Dirac's statistic (12 marks)

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