KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS

COURSE CODE: SPH 416

COURSE TITLE: STATISTICAL MECHANICS

DURATION: 2 HOURS

DATE: 1/8/ 2018 TIME: 9 – 11AM

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **4** printed pages. Please Turn Over

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QUESTION ONE (30 MARKS)

(a) Define the following terms

(i) Microstates (2 marks)

(ii) Macrostates (2 marks)

(b) Compute Ω(E) for:

(i) a single free particle in three dimensions (4 marks)

(ii) a collection of N free particles in three dimensions (4 marks)

(c) Define the term Microcanonical ensemble (2 marks)

(d) State the central limit theorem (3 marks)

(e) What is the average kinetic energy of a gas of N rigid diatomic molecules at temperature T? (4 marks)

(f) Differentiate between intensive and extensive variables giving examples in each case (4 marks)

(g) Using relevant figures, provide a qualitative description of phase transitions for water molecules arranged in solids, liquids and gases (5 marks)

QUESTION TWO (20 MARKS)

a) State the third law of thermodynamics (2 marks)

b) Describe the following concepts as discussed in statistical mechanics

i) Heat and Entropy (8 marks)

ii) Heat capacity (10 marks)

QUESTION THREE 20 MARKS.

A statistical system is composed of N independent distinguishable particles. Each one of these particles has only two energy levels, $E1$ and $E2$, such that $E2 - E1 = \varepsilon > 0$. Choose a suitable ground state for the energy and write down the total energy as a function of the temperature T. Finally, discuss the limits $T \to 0$ and $T \to +\infty$. (20 marks)

QUESTION FOUR (20 MARKS)

a) What do you understand with the term phase diagram? (2 marks)

(b) Using appropriate diagram, explain the four functional elements of a laser (18 marks)

QUESTION FIVE (20 MARKS)

A classical gas in a volume V is composed of N independent and indistinguishable particles. The single particle Hamiltonian is $H = p^2/2m$, with m the mass of the particle and p the absolute value of the momentum. Moreover, for each particle, we find 2 internal energy levels: a ground state with energy 0 and degeneracy $g1$, and an excited state with energy $E > 0$ and degeneracy $g2$. Determine the canonical partition function and the specific heat CV as a function of the temperature T. Analyze the limit of low temperatures and comment on the final result. (20 marks)