KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF MASTERS (PHYSICS)

COURSE CODE: SPH 814

COURSE TITLE: STATISTICAL MECHANICS

DURATION: 2 HOURS

DATE: 16TH JUNE 2021 TIME: 8.00A.M – 10.00A.M

INSTRUCTIONS TO CANDIDATES

- Answer any **Three (3)** 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 **2** printed pages. Please Turn Over

QUESTION ONE [20 Marks]

a) Differentiate between statistical mechanics and quantum mechanics. [2mks]
b) What do you understand by the term statistical ensemble? [2mks]
c) State the second law of thermodynamics and show how entropy is related to it [2mks]
d) Define density matrix and write down the density matrix for canonical ensemble [3mks]
e) Consider a free gas with N-particles and internal energy U inside a container of volume V. Starting with the Sucker-Tetrode formula for entropy given below;

$$S(U,V,N) = NK\{\frac{5}{2} - \ln[(\frac{3\pi h^2}{m})^{\frac{3}{2}} \frac{N^{\frac{5}{2}}}{VE^{\frac{3}{2}}}]\}$$

Find the Helmoholtz Free energy A, internal energy U, temperature T and pressure P of the gas and hence equation of state. [9mks]

f) State and explain the two postulates of quantum statistical mechanics. [2mks]

QUESTION TWO [20 Marks]

In classical micro-canonical ensemble the entropy of an ideal gas of volume V and number of particles N is given as;

$$S(E,V) = NK\ln[v(\frac{-4\pi mE}{3h^2N})^{\frac{3}{2}}] + \frac{3}{2}NK$$

Where the terms have their usual meanings.

a) Use the above expression to determine;
   i) Temperature, T [4mks]
   ii) Internal energy, U [4mks]
   iii) Heat capacity, Cv [4mks]
   iv) Equation of state [4mks]
b) Show that entropy, S is an extensive property. [4mks]

QUESTION THREE [20 Marks]

a) Define classical partition function. [2mks]
b) Show that the partition function for a classical ideal gas is given by;

$$Q_N(V,T) = \frac{1}{N!}[\frac{V}{h^3}(2\pi mkT)^{\frac{3}{2}}]^N$$ [12mks]

c) Use the above expression to find Helmohltz free energy, A(V,T) [6mks]

QUESTION FOUR [20 Marks]

a) Define phase space and write down the equations of motion of a phase point considering the motion of an oscillator in phase space. [6mks]

b) Show that the orbit in phase space of a simple linear harmonic oscillator is an ellipse and that its period, T in phase space is equal to the area of the phase ellipse divided by the energy, E of the oscillator. [14mks]

QUESTION FVE [20 Marks]

Briefly explain the following giving examples; [@2mks]

i) Macroscopic system

ii) Microstate

iii) Phase path

iv) Gamma space

v) Mu-space.

b) Differentiate between a Fermi system and a Bose system. [4mks]

c) Show that the number of particles per unit volume for an ideal Bose gas is given by;

$$\frac{<N>}{V} = \frac{1}{\lambda^3} g_{\frac{3}{2}}(Z)$$ [6mks]

THIS IS THE LAST PRINTED PAGE