KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2019/2020 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS)

COURSE CODE: SPH 416

COURSE TITLE: STATISTICAL MECHANICS

DURATION: 2 HOURS

DATE: ~~APRIL 2020~~ 12/02/21 **TIME:** 8-10Am

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 **3**printed pages. Please Turn Over

Latent heat of fusion of ice $= 334 \times 10^3 \, Jk^{-1}$

QUESTION ONE [30 Marks]

a) Explain the concept of statistical mechanics [2mks]

b) State the second law of thermodynamics and the mathematical expression representing the law [2mks]

c) Describe what you understand by Microscopic and macroscopic system. [2mks]

d) Explain the concept of Entropy in thermodynamics [2mks]

e) 1 kg of ice at 0°C is melted and converted to water at 0^{o} C. Compute its change in entropy. Comment with reasons weather there is an increase in entropy or not. [4mks]

f) Define the term statistical Ensemble in statistical mechanics [2mks]

g) Describe Grand Canonical ensemble and give the probability density function that describe the system in a phase space. Explain what the constants stand for [4mks]

h) What is a cyclic process? [2mks]

i) A gas expands adiabatically and reversibly. What is its change in Entropy? [3mks]

j) Discuss Heisenberg's uncertainty principle and show that it is impossible to have sharp phase paths in quantum theory. [2 Marks]

k) Write the expression for density in space phase for Uniform ensemble. [2mks]

l) An engine operating between 150°C and 25°C takes 500 J heat from a high temperature reservoir. Assuming that there are no frictional losses, calculate the work that can be done by this engine. [3mks]

QUESTION TWO [20 Marks]

a) Define and derive an expression describing the distributions:

i) Fermi –Dirac Count [7mks]

ii) Bose – Einstein Count [7 mks]

b) Show that ; $C_p - C_v = Nk = R$ [6 mks]

QUESTION THREE [20 Marks]

a) If entropy, S is defined as $S = KlogC_{Class}$ where C_{Class} stands for classical count; the most probable distribution is given by $n_i = \omega_i e^{-(\alpha+\beta\epsilon_i)}$, where $\beta = \frac{1}{KT}$ and $e^{\alpha} = \frac{V}{Nh^3}(2m\pi KT)^{\frac{3}{2}}$, derive an expression for the ideal gas equation, i.e show that $PV = NKT$ [12 Marks]

b) Derive expressions for the internal energy, E and enthalpy, H in terms of the partition function, Q [8 Marks]

QUESTION FOUR [20 Marks]

a) Write down the equations of motion of a phase point considering the motion of an oscillator in phase space. [3 Marks]

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. [10 Marks]

c) Using Hamilton's equations show that the path of the body falling under gravity is a parabola. [7 Marks]

QUESTION FIVE [20 Marks]

a) If the entropy of a classical assembly is given by $S = K \log C$, where C is the classic count , then show that ; $S = Nk(1+\alpha) + k\beta E$. where N=total number of particles ,E is the total energy, α and β are constants and k is the Boltzman constant. (10 Marks]

b) A 100kg of water at 0°C is heated to 100°C . compute its change in entropy. [Take the specific heat capacity of water to be $4200 J / kgK$] [6 Marks]

c) A gas Expands adiabatically and reversibly. what is its change in entropy? [4 Marks]

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