MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2022/2023

FIRST YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS

SPH 7151: STATISTICAL MECHANICS

DATE: AUGUST 2023 **TIME: 3 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

A Van der Waal's gas has the equation of state

$$\left(P + \frac{a}{v^2}\right)(V - b) = RT$$

a) Discuss the physical origin of the parameters a and b. Why is the correction to p inversely proportional to V2? (6 Marks)

b) The gas undergoes an isothermal expansion from volume V1 to volume V2. Calculate the change in the Helmholtz free energy. (4 Marks)

c) From the information given, can you calculate the change in internal energy. Discuss your answer (7 Marks)

d) Show that the entropy of a thermodynamic system can be written as $s = k\beta\ell n\Omega$ explaining all terms used. (8 Marks)

e) Using the result in (d) above, give the statistical interpretation of your result for entropy.

(5 Marks)

QUESTION TWO (20 MARKS)

Suppose the energy level of a system contains two particles to be distributed in three states. Calculate and illustrate possible distributions if the system obeys:

a) Bose-Einstein statics (7 Marks)

b) Fermi-Dirac Statistics (6 Marks)

c) Maxwell-Boltzman Statistics (7 Marks)

QUESTION THREE (20 MARKS)

Suppose that the Earth's atmosphere is an ideal gas with molecular weight μ and suppose that the gravitation field near the surface is uniform and produces an acceleration g.

a) Show that the pressure P varies as $\frac{1}{p}dp = -\frac{\mu g}{RT}dz$ where z is the height above the surface, T is the temperature, and R is the gas constant. (4 Marks)

b) Suppose that the pressure decrease with height is due to adiabatic expansion. Show that $\frac{dp}{p} = \frac{\gamma}{\gamma-1}\frac{dT}{T}, \gamma = \frac{C^p}{C_v}$ (4 Marks)

c) Evaluate $\frac{dT}{dz}$ for a pure N_2 atmosphere with $\gamma = 1.4\ d)$. Suppose the atmosphere is isothermal with temperature T, find $p(z)$ in terms of T and p_0, the sea level pressure.

(4 Marks)

d) Suppose at sea level, $T = T_0$ and $p = p_0$, find $p(z)$ for an adiabatic atmosphere.

(8 Marks)

QUESTION FOUR (20 MARKS)

Calculate the average energy for an ideal 2D electron gas with areal density n = N/A (where A is the system area) at temperature, $T = 0$ (20 Marks)