



JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES
UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF
EDUCATION (SCIENCES)
4TH YEAR SECOND SEMESTER 2023/2024 ACADEMIC YEAR
MAIN REGULAR

COURSE CODE: SPB 9406

COURSE TITLE: STATISTICAL THERMODYNAMICS

EXAM VENUE:

DATE:

TIME:

EXAM SESSION:

STREAM:

INSTRUCTIONS:

- 1. Answer question 1 (Compulsory) in section A and ANY other 2 questions in Section B.**
 - 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.**
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SECTION A (30 MARKS)

Question 1.

- a. Explain what is meant by;
 - i) Phase space (2 mark)
 - ii) Microstate (2 marks)
 - iii) Ensemble (2 marks)
- b. Derive the equation for the Boltzmann's distribution and explain its significance (6 marks)
- c. Find the value of translational partition for argon atoms confined in a box of volume 25.0 L at 298.15 K. The Boltzmann's constant is equal to $1.3807 \times 10^{-23} \text{ JK}^{-1}$ (6 Marks)
- d. Derive an expression for the vibrational partition function (6 Marks)
- c. Calculate C_v and C_p for 1.00 mol of $^{35}\text{Cl}_2$ at 298.15 K. (5 marks)
 $\bar{\nu}_e = 559.7 \text{ cm}^{-1}$.

SECTION B

Question 2 (20 marks)

- a. The vibrational frequency of CO is equal to $6.5048 \times 10^{13} \text{ cm}^{-1}$.
 - i. Find the value of the vibrational partition function at 298.15 K (4 Marks).
 - ii. Find the vibrational contribution to the molar energy at 298.15 K (4 Marks).
- b. Calculate the chemical potential and the Gibbs energy of 1.000 mol of $^{35}\text{Cl}_2$ at 298.15 K and 1.0 atm. (5 Marks).
- c. Find the vibrational contributions to the thermodynamic energy, Helmholtz energy, and entropy of 1.000 mole of water vapor at 1.00 atm and 100°C. There are three vibrational normal modes, with frequencies $1.0947 \times 10^{14} \text{ s}^{-1}$, $4.7817 \times 10^{13} \text{ s}^{-1}$, and $1.1260 \times 10^{14} \text{ s}^{-1}$. (7 Marks).

Question 3 (20 marks)

- a. Derive an expression for the translational partition function (5 Marks)
- b. Write Boltzmann formula for the entropy and explain what happens to *entropy* as the temperature is lowered (5 marks)
- c. Calculate the molar entropy of helium gas at 1.000 bar pressure and 298.15 K (3 Marks).
- d. Describe the basic postulates of Maxwell-Boltzmann (MB) Statistics (7 Marks).

Question 4 (20 marks)

- a. Derive an expression for the rotational partition function (5 Marks)
- b. Derive the Sackur–Tetrode equation and explain its significance (5 marks)
- c. Calculate the vibrational partition function of $^{35}\text{Cl}_2$ at 298.15K. The vibrational frequency is $1.678 \times 10^{13} \text{ S}^{-1}$ (5 Marks)
- d. Describe the basic postulates of Bose- Einstein statistics (5 Marks).

Question 5 (20 marks)

- a. Derive an expression for the relation between Entropy (S) and the partition function . (5 marks)
- b. Write equations for the Helmholtz free energy and Gibbs free energy for a perfect gas in terms of partition function (4 marks)
- c. Describe the basic postulates of Fermi-Dirac statistics (5 Marks)
- d. Describe the various types of ensembles (6 Marks).