BPHCT-135

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME
(BSCG/BSCM)

THERMAL PHYSICS AND STATISTICAL MECHANICS

Valid from 1st January, 2025 to 31st December, 2025

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2025)

Dear Student,

Please read the section on assignments in the Programme Guide for B.Sc. that we sent you after your enrolment. A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, **which would consist of one tutor-marked assignment** for this course. The assignment is in this booklet, and it consists of two parts, Part A and B. The total marks of all the parts are 100, of which 35% are needed to pass it.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully:

1) On top of the first page of your answer sheet, please write the details exactly in the following format:

ROLL NO.: ……………………………………………

NAME: ……………………………………………

ADDRESS: ……………………………………………

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COURSE CODE:…………………………..

COURSE TITLE: …………………………

ASSIGNMENT CODE: …………………..

STUDY CENTRE: ……………………….. **DATE:** ………………………………………...

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

2) Use only foolscap size writing paper (but not of very thin variety) for writing your answers.
3) Leave 4 cm margin on the left, top and bottom of your answer sheet.
4) Your answers should be precise.
5) Solve Part A and Part B of this assignment, and **submit the complete assignment answer sheets containing Parts A and B within the due date.**
6) The assignment answer sheets are to be submitted to your Study Centre as per the schedule. **Answer sheets received after the due date shall not be accepted.**

   We strongly suggest that you retain a copy of your answer sheets.
7) This assignment is **valid from 1st January, 2025 to 31st December, 2025**. If you have failed in this assignment or fail to submit it by 31st December, 2025, then you need to get the assignment for the year 2026, and submit it as per the instructions given in the Programme Guide.
8) **You cannot fill the examination form for this course** until you have submitted this assignment. For any queries, please contact: drsgupta@ignou.ac.in, slamba@ignou.ac.in. We wish you good luck.

Tutor Marked Assignment
THERMAL PHYSICS AND STATISTICAL MECHANICS

Course Code: BPHCT-135
Assignment Code: BPHCT-135/TMA/2025
Max. Marks: 100

Note: Attempt all questions. The marks for each question are indicated against it.

PART A

1. a) Discuss Regnault's experiments on Hydrogen, nitrogen and carbon dioxide for 273 K. Also discuss the Andrews experiments for CO_2 on the *p-V* diagram at various temperatures. (5)

   b) Write the assumptions made by Maxwell to derive the expression for distribution function of velocities. Hence derive the expression of Maxwellian distribution function for molecular speeds. Plot Maxwellian distribution function as a function of molecular speed. (10)

   c) The average speed of hydrogen molecules is $1850\ \text{ms}^{-1}$. The radius of a hydrogen molecule is $1.40 \times 10^{-10}\ \text{m}$. Calculate (i) Collision cross-section, (ii) collision frequency, and (iii) mean free path. Take $n = 3 \times 10^{25}\ \text{m}^{-3}$. (5)

   d) What is Brownian motion? Discuss Perrin's method for determination of Avogadro number in Brownian motion. How can this method be used to estimate the mass of molecule (5)

2. a) Explain the classification of boundaries in a thermodynamic system. (5)

   b) State Zeroth law of thermodynamics. How does this law introduces the concept of temperature. Write parametric as well as exact equation of state for one mole of a ideal gas and stretched wire. (5)

   c) Show that for an ideal gas

   $$\alpha = \frac{1}{T} \quad \text{and} \quad \beta_T = \frac{1}{p}$$

   where β_T is the isothermal compressibility and α is isobaric coefficient of volume expansion. (5)

   d) Derive Mayer's formula: $C_p - C_V = R$ where C_p and C_V are the molar heat capacity at constant pressure and constant volume respectively. (5)

   e) Obtain an expression for work done in expanding a gas from volume V_i to V_f in an isobaric process. (5)

PART B

3. a) With the help of entropy – temperature diagram of Carnot cycle, obtain an expression of efficiency of a Carnot engine. A Carnot engine has an efficiency of 50%. It operates between reservoirs of constant temperature with temperature difference of 80 K. Calculate the temperature of the low-temperature reservoir in Celsius. (10)

   b) Define thermodynamic potentials. Derive Maxwell's relations from thermodynamic potentials. (5)

   c) When two phases of a substance coexist in equilibrium at constant temperature and pressure, their specific Gibb's free energies are equal. Using this fact, obtain Clausius-Clapeyron equation. (5)

   d) Derive Planck's law of radiation and hence obtain Rayleigh-Jeans law and Wien's law. (5)

4. a) Consider a classical ideal gas consisting of N particles. The energy ε of a particle is given by $\varepsilon = cp$ where c is a constant and p is the magnitude of the momentum. Calculate (i) the partition function of the system, (ii) internal energy, and (iii) C_V. (8)

   b) 5.4×10^{21} electrons are confined in a box of volume 1cm^3. Calculate their Fermi wavelength and Fermi energy. (5)

   c) Define thermodynamic probability of a macrostate. Establish the Boltzmann relation between entropy and thermodynamic probability:

   $$S = k_B \ln W. \quad (5)$$

   d) Obtain an expression of Fermi-Dirac distribution function. Plot Fermi function versus energy at different temperatures. (7)

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