BPHCT-135

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME
(BSCG)

THERMAL PHYSICS AND STATISTICAL MECHANICS

Valid from 1st January, 2024 to 31st December, 2024

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2024)

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, 2024 to 31st December, 2024**. If you have failed in this assignment or fail to submit it by 31st December, 2024, then you need to get the assignment for the year 2025, 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/2024
Max. Marks: 100

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

PART A

1. a) Write the assumptions of kinetic theory of gases. Derive the following expression of the pressure exerted by an ideal gas:

$$p = \frac{1}{3} mn\bar{v}^2$$

Also, using this expression deduce Avogadro's law. What is the kinetic interpretation temperature? (10)

b) The expression for the number of molecules in a Maxwellian gas having speeds in the range v to $v + dv$ is given by

$$dN_v = 4\pi N\left(\frac{m}{2\pi k_B T}\right)^{3/2} v^2 \exp\left[-\left(\frac{mv^2}{2k_B T}\right)\right]dv$$

Obtain an expression of average speed and root mean square speed of a molecule. (5)

c) Define mean free path of the molecules of a gas. Show that it is equal to $\frac{1}{n\pi d^2}$ under Zeroth order approximation. (5)

d) What is Brownian motion? Write any four characteristics of Brownian motion. (5)

2. a) What are Intensive and extensive variables. Write two examples of each. List the intensive and extensive variables required to specify the thermodynamic systems (i) paramagnetic solid and (ii) stretched wire. (2+1+2)

b) State Zeroth law of thermodynamics. Discuss how this law introduces the concept of temperature. Write parametric as well as exact equation of state for one mole of a real gas and paramagnetic substance. (5)

c) For a pVT – system, show that:

$$\frac{dV}{V} = \alpha dT - \beta_T dp$$

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

d) What is an adiabatic index? Using the first law of thermodynamics, show that $TV^{-1} = K,$ when one mole of an ideal gas is made to undergo quasi-static adiabatic expansion. (5)

e) Derive an expression for the work done in an isothermal process of an ideal gas. (5)

PART B

3. a) Define efficiency of a Carnot engine. A Carnot engine has an efficiency of 50% when its sink temperature is at 27^0C. Calculate the source temperature for increasing its efficiency to 60%. (5)

   b) State third law of thermodynamics. Write its mathematical expression. Discuss some important consequences of third law. (5)

   c) Write Maxwell's relations and using these relations derive first and second *energy* equations. (5)

   d) Derive Clausius-Clapeyron equation for two phases to coexist in equilibrium. (5)

   e) What is Joule-Thomson effect? Write the mathematical expression of Joule Thomson Coefficient for van der Waals' gas. What will be the effect on gas if the intermolecular forces are strong? (5)

4. a) Obtain an expression of single particle partition function. Hence, using this expression obtain expressions for entropy and pressure. (10)

   b) Define phase space of the system. Draw the phase space for a linear harmonic oscillator. (5)

   c) Establish the Boltzmann relation $S = k_B \ln W$. (5)

   d) Show that Bose derivation of Planck's law for energy density is given by

$$U_v dv = \frac{8\pi h}{c^3} \frac{v^3 dv}{\exp\left[\frac{hv}{k_B T} - 1\right]}$$ (5)

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