BPHCT-135

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME

(BSCG)

THERMAL PHYSICS AND STATISTICAL MECHANICS

Valid from 1st January, 2022 to 31st December, 2022

School of Sciences
Indira Gandhi National Open University,
Maidan Garhi, New Delhi-110068
(2022)

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:

ENROLMENT 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 Jan., 2022 to 31st Dec, 2022**. If you have failed in this assignment or fail to submit it by Dec. 31, 2022, then you need to get the assignment for the year 2023, 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/2022
Max. Marks: 100

Note: Attempt all questions. Symbols have their usual meanings. The marks for each question are indicated against it.

PART A

1. a) Calculate the temperature at which root mean square speed of gas molecules is double of its speed at 27 °C, pressure remaining constant. (5)

   b) Discuss the sedimentation in Brownian motion and show that during sedimentation, particle concentration decreases exponentially as height increases. (5)

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

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

   Using this relation, obtain an expression for most probable speed. (5)

   d) Define mean free path. Obtain its expression under zeroth order approximation. (1+4)

   e) Define viscosity. Discuss the effect of temperature and pressure on viscosity. (1+2+2)

2. a) What do you understand by intensive and extensive variables of a system? State **with reasons**, which of the following variables are intensive and which are extensive?

      i) Number of gas molecules enclosed in a box;

      ii) Density of gas in a box;

      iii) Wavelength of radiation emitted by a black body at temperature T;

      iv) Intensity of radiation emitted by a black body at temperature T. (1+4)

   b) Consider a thermodynamic system consisting of 3 mol of an ideal gas occupying 0.03 m^3 volume at 300 K temperature. Determine its initial pressure. For this gas, γ=1.4. It undergoes the following processes:

      i) It is compressed to 0.01 m^3 volume isothermally. Determine the pressure of the gas.

      ii) then it is allowed to expand adiabatically, till it attains 1 atm pressure. Determine the final volume. (1 atm = 101325 Nm^{-2})

   Draw a labeled indicator diagram of these processes. (2+2+4+2)

c) Explain with examples, what are reversible and irreversible processes? Why can a reversible process be attained only in a hypothetical situation? (2+3)

d) A system is subjected to 5 types of processes depicted in the table below. Using the first law of thermodynamics, fill up the blank spaces. All the entries are made in joules. (5)

Process	Heat added δQ	Work done δW	Internal Energy		Change in internal energy (dU)
			Initial (U_i)	Final (U_f)	
I	45	0	---	45	---
II	---	30	30	---	30
III	65	---	0	---	45
IV	–20	---	15	40	---
V	85	50	40	---	---

PART B

3. a) Derive an expression for efficiency of a Carnot engine using *T*-*S* diagram. A Carnot engine has an efficiency of 50 percent when its sink temperature is at 27 ºC. Calculate the change in source temperature for increasing its efficiency to 60 percent. (10)

b) Using Maxwell's relations, deduce first and second energy equations. (5)

c) What is Joule-Thomson effect? Write an expression for Joule-Thomson coefficient for a van der Waals' gas and discuss the significance of *a* and *b* in this expression. (5)

d) Write an expression of Planck's law of black body radiation and hence obtain Stefan's-Boltzmann law. (5)

4. a) Derive the single-particle partition function for an ideal monatomic gas consisting of *N* identical particles occupying a volume *V*. Obtain expressions for the entropy and pressure of this system. (10)

b) Four particles are to be distributed in 5 states. Calculate the number of ways in which this distribution can be done if the particles obey:
(i) M-B statistics and (ii) B-E statistics. (5)

c) Two systems have thermodynamic probabilities of 3.0×10^{27} and 1.8×10^{28} respectively. Calculate the entropies of the individual systems and as well as their composite system and verify the Boltzmann relation. (5)

d) The number density of copper atoms is 8.49×10^{28} atoms m^{-3}. If each atom contributes one free electron for conduction, examine whether the electron gas is strongly degenerate at room temperature. (5)

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