BPHCT-135

ASSIGNMENT BOOKLET

BACHELOR'S DEGREE PROGRAMME

(BSCG)

THERMAL PHYSICS AND STATISTICAL MECHANICS

Valid from 1st July, 2020 to 30th June, 2021

School of Sciences
Indira Gandhi National Open University,
Maidan Garhi, New Delhi-110068
(2020-2021)

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 July, 2020 to 30th June, 2021**. If you have failed in this assignment or fail to submit it by June 30, 2021, then you need to get the assignment for the year 2021-22, 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/2020-21
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) The mean speed of the molecules of an ideal gas is $2.0 \times 10^3\,\mathrm{m\,s^{-1}}$. The radius of a gas molecule is $1.5 \times 10^{-10}\,\mathrm{m}$. Calculate the (i) collision frequency, and (ii) mean free path. It is given that $n = 4 \times 10^{24}\,\mathrm{m^{-3}}$. (5)

   b) Write van der Waals' equation of state for one mole of a gas. What do the symbols *a* and *b* signify? Under what conditions does this equation reduce to ideal gas equation? (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 average speed. Also, plot Maxwellian distribution function versus speed at three different temperatures. (10)

   d) What is Brownian motion? State four significant characteristics of Brownian motion. (5)

2. a) Explain the five types of boundaries with one example each (other than the ones discussed in the study material) encountered in the thermodynamic systems. (5)

   b) For a thermodynamic system, isobaric coefficient of volume expansion (α) and isothermal compressibility (β) are defined as

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p$$

$$\beta = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_T$$

   Show that for an isochoric change, $\beta\, dp = \alpha\, dT$. (5)

   c) What is meant by internal energy of a system? State the first law of thermodynamics in its differential form. Write it for isothermal, adiabatic and isochoric changes. (1+1+3)

   d) Air in an enclosure is compressed isothermally until its pressure is doubled. It is then expanded adiabatically until its original volume is restored. Its pressure is

then recorded as 0.75 of its initial value. Determine the value of γ. (5)

e) One mole of oxygen at 273 K and atmospheric pressure is adiabatically compressed to 5 atm. Calculate the final temperature. Also calculate the work done on the gas. Take $\gamma = 1.4$ and $R = 8.31$ J mol^{-1} K^{-1}. (5)

PART B

3. a) Derive Planck's law of black body radiation. (5)

b) Derive the expression for the efficiency of a Carnot cycle for an ideal gas. Hence, obtain its value for a heat engine operating between fixed temperatures 600 K and 300K. (5)

c) Two separate containers are filled with different gases. If these gases are allowed to mix, obtain an expression for entropy of mixing per mole of the mixture. (5)

d) Using Maxwell's relations, deduce first and second TdS equations. (5)

e) Derive Clausius-Clapeyron equation. Explain why the boiling point of water increases with increasing pressure. (5)

4. a) For a Bose-Einstein system, the expression for the thermodynamic probability is

$$W = \prod \frac{(g_i + N_i - 1)!}{N_i!(g_i - 1)!}$$

Derive an expression for the Bose-Einstein distribution function. (10)

b) A box of volume 1 cm^3 contains 5.2×10^{21} electrons. Calculate their Fermi momentum and Fermi energy. Take

$m_e = 9.1 \times 10^{-28}$ g, $m_n = 1.67 \times 10^{-24}$ g and $h = 6.62 \times 10^{-27}$ ergs . (5)

c) Two indistinguishable particles are to be placed in five cells. Enumerate the possible macrostates and the corresponding microstates. (5)

d) Calculate the partition function, free energy, entropy, C_V and C_p of N linear harmonic oscillators. (5)

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