BPHE-106/PHE-06

ASSIGNMENT BOOKLET
Bachelor's Degree Programme (B.Sc.)

THERMODYNAMICS AND STATISTICAL MECHANICS

Valid from January 1, 2025 to December 31, 2025

It is compulsory to submit the Assignment before filling in the Term-End Examination Form.

Please Note

- **You can take electives (56 or 64 credits) from a minimum of TWO and a maximum of FOUR science disciplines, viz. Physics, Chemistry, Life Sciences and Mathematics.**
- **You can opt for elective courses worth a MINIMUM OF 8 CREDITS and a MAXIMUM OF 48 CREDITS from any of these four disciplines.**
- **At least 25% of the total credits that you register for in the elective courses from Life Sciences, Chemistry and Physics disciplines must be from the laboratory courses. For example, if you opt for a total of 64 credits of electives in these 3 disciplines, at least 16 credits out of those 64 credits should be from lab courses.**
- **You cannot appear in the Term-End Examination of any course without registering for the course. Otherwise, your result will not be declared and the responsibility will be yours.**

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

2025

Dear Student

We hope you are familiar with the system of evaluation to be followed for the Bachelor's Degree Programme. At this stage you may probably like to re-read the section on assignments for Elective Courses in the Programme Guide that we sent you after your enrolment. A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, which consists of **one tutor-marked assignment (TMA)** for this 4-credit course. **Submit your assignment response at your Study Centre.**

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully:

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

ENROLMENT NO. : ……

NAME : ……

ADDRESS : ……

……

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COURSE CODE : ……..

COURSE TITLE : ……

ASSIGNMENT NO. : ……

STUDY CENTRE : ……..…….. DATE : ….……

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

2) Use only foolscap size good quality 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 and in your own words.

5) While solving problems, clearly indicate the question number along with the part being answered. Write units at each step of your calculations as done in your study material. Marks will be deducted for not adhering to this practice. Take care of significant digits in your work. Recheck your work before submitting it.

6) **This assignment will remain valid from January 1, 2025 to December 31, 2025**. However, you are advised to submit it within **12 weeks** of receiving this booklet to accomplish its purpose as a teaching-tool.

We strongly feel that you should retain a copy of your assignment response to avoid any unforeseen situation and append, if possible, a photocopy of this booklet with your response.

We wish you good luck.

Tutor Marked Assignment
THERMODYNAMICS AND STATISTICAL MECHANICS

Course Code: BPHE-106/PHE-06
Assignment Code: BPHE-106 /PHE-06/TMA/2025
Max. Marks: 100

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

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1. a) A sonometer wire having cross-sectional area 0.85×10^{-6} m^2 is stretched between two rigid supports 1.2 m apart. A tension of 20 N is applied at its free end. If the temperature is reduced by 12°C, calculate the final tension in the wire. Take coefficient of linear expansion (α) and isothermal Young's modulus (γ) to be 1.5×10^{-5} K^{-1} and 2.0×10^{11} Nm^{-2}, respectively. (5)

   b) One mole of an ideal gas expands isothermally to five times its initial volume. Calculate the entropy change in terms of R, the gas constant. (5)

   c) Calculate the most probable speed, average speed and the root mean square speed for gas molecules at 300 K. The mass of gas molecule is 5×10^{-26} kg and $k_B = 1.38 \times 10^{-23}$ JK^{-1}. (5)

   e) Using the partition function for an ideal gas made up of N indistinguishable particles, obtain Sackur-Tetrode equation. (5)

2. a) Explain the working of a platinum resistance thermometer with the help of a neat and labelled diagram. (5)

   b) Derive an expression for the work done by a gaseous system for an isothermal expansion of an ideal gas. (5)

   c) Using the first law of thermodynamics for an adiabatic process, establish the relation $PV^{\gamma} = K$, where γ is the ratio of heat capacity at constant pressure to that at constant volume. Plot this equation on a p-V diagram. What will be its slope? (5+3+2)

3. a) i) Draw a Carnot cycle on p-V diagram. Show that the amount of heat absorbed (rejected) in a reversible cycle is proportional to the temperature of source (sink). (1+4)

      ii) The efficiency of a Carnot engine is 30%. Its efficiency is to be raised to 60%. By how much must the temperature of the source be increased if the sink is at 27°C? (5)

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

   c) List the differences between first and second order phase transitions. What are the characteristics of lambda transition? (3+2)

4. a) Calculate the temperature at which the root mean square speed of hydrogen and oxygen molecules will be equal to their escape velocities from the earth's gravitational field. The radius of the earth is 6400 km.

      Take $N_A = 6 \times 10^{26}\,\text{mol}^{-1}$, $g = 9.8\,\text{ms}^{-2}$, $k_B = 1.38 \times 10^{-23}$ JK^{-1}. (10)

   b) Define mean free path of a molecule in a gas. Derive the law of distribution of free paths. (1+4)

c) Establish van der Waals' equation of state for a real gas. Plot van der Waals' equation of state on p-V diagram. (5)

5. a) Explain the following: (5+5)

   i) Bose-Einstein condensation.
   ii) Gibbs paradox.

   b) Derive Planck's law of blackbody radiation using Bose-Einstein statistics. Using this law, obtain (i) Rayleigh-Jeans Law and (ii) Wien's Law. (10)

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