BPHE-106/PHE-06

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

THERMODYNAMICS AND STATISTICAL MECHANICS

Valid from January 1, 2023 to December 31, 2023

It is compulsory to submit the Assignment before filling up 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

2023

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, 2023 to December 31, 2023**. 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/2023
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) Define degree of freedom of a molecule. Write the formula for the number of degrees of freedom of a molecule. Calculate the degree of freedom for a rigid diatomic molecule. (5)

   b) The average energy of a helium molecules is 2.89×10^{-21} J. Calculate their most probable speed and average speed. (5)

   c) Write the van der Waals' equation of state. Using this equation, obtain the critical constants and show that

   $$\frac{RT_C}{p_c V_C} = \frac{8}{3}$$ (5)

   d) Derive an expression for survival equation for distribution of free paths. Also, plot survival equation. (5)

   e) Derive Einstein formula for mean square displacement of a Brownian particle. (5)

2. a) Describe the construction and working of a Platinum resistance thermometer. Write its two principal merits. (3+2)

   b) Define the followings with example: (i) Intensive variables (ii) Extensive variables (iii) Adiabatic boundary (iv) Open system (v) Isolated system. (1×5)

   c) Obtain the expression for isothermal compressibility (β_T) and coefficient of volume expansion (α) for a van der Waals' gas. (5)

   d) Obtain an expression for work done by an ideal gas in an adiabatic process. Two litre of an ideal gas at a pressure of 5 atm expands adiabatically to two times its initial volume. Calculate the work done by the gas. Given $\gamma = 1.4$. (3+2)

   e) Derive an expression for Clausius- Clayperon equation. (5)

3. a) Draw a *T*-*S* diagram of a Carnot cycle and derive an expression of efficiency of a heat engine working between T_1 and T_2. (5)

   b) A freezer operates between –15°C and 27°C. Calculate the maximum value of coefficient of performance (ω) for this refrigerator. With this ω, how much electrical energy would be required to freeze 0.8kg of water, initially at 0°C. Given specific latent heat of fusion = $334\,\text{kJ kg}^{-1}$. (5)

   c) Using Maxwell's relations, derive first and second *TdS* equations. (5)

   d) What is Joule-Thomson effect? Derive an expression of Joule-Thomson coefficient for a van der Waals' gas. (2+8)

4. a) The thermodynamic probability for a Boson system is given by

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

Using this relation, derive an expression for the Bose-Einstein distribution function. (10)

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

c) What is Gibbs paradox? Derive the Sackur-Tetrode equation for the entropy for an ideal monatomic gas. (5)

d) The expression for Planck's law for energy density is given by

$$u_\nu d\nu = \frac{8\pi h}{c^3} \frac{\nu^3 d\nu}{\exp\left[\frac{h\nu}{k_B T} - 1\right]}$$

Using this expression, obtain (i) Wien's law and (ii) Stefan-Boltzmann law. (5)

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