BPHE-106/PHE-06

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

THERMODYNAMICS AND STATISTICAL MECHANICS

Valid from January 1, 2024 to December 31, 2024

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

2024

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, 2024 to December 31, 2024**. 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/2024
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. Answer any **four** parts. (4×5)

   a) A block of metal whose volume expansivity is $5.0 \times 10^{-5}\ °C^{-1}$ and isothermal compressibility is $1.2 \times 10^{-6}\ atm^{-1}$ has volume 5 litre at 1 atm and 20°C. On applying pressure, its temperature rises by 10°C and volume increases by 0.5 cm^3. Calculate the pressure applied.

   b) Define adiabatic lapse rate? Obtain an expression for adiabatic lapse rate for earth's atmosphere?

   c) A Carnot engine has an efficiency of 40%. Its efficiency is to be raised to 50%. By how much must the temperature of the source be increased if the sink is at 27°C.

   d) The mean speed of oxygen molecules is 450 ms^{-1}. If the radius of an oxygen molecule is 1.8 Å, calculate mean time between two successive collisions and mean free path. Take $n = 3\times10^{25}\text{m}^{-3}$.

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

2. a) A reversible process can only be idealised and cannot be achieved in practice. Justify. (5)

   b) Explain the working of a platinum resistance thermometer with the help of a neat and labelled diagram. State the reasons for using platinum for the construction of a resistance thermometer. (6+4)

   c) Write the expressions for the work done for (i) paramagnetic substance, and (ii) stretched wire. Calculate the work done on the steel wire of length 2.5 m and area of cross-section $2.5 \times 10^{-6}\ m^2$ is suspended from torsion head when a 5 kg weight is suspended at its free end. Take $Y = 2 \times 10^{11}\ Nm^{-2}$. (5)

3. a) Explain the statement "entropy of earth-sun system increases" in the light of the principle of increase of entropy. (5)

   b) Draw Carnot cycle on (i) p-V, and (ii) T-S diagrams. With the help of p-V diagram, show that $\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$, where Q_1 is the amount of heat absorbed at temperature T_1 and Q_2 is the amount of heat rejected at temperature T_2. (2,8)

   c) Using Maxwell's relations, prove second energy equation:

$$\left(\frac{\partial U}{\partial p}\right)_T = -T\left(\frac{\partial V}{\partial T}\right)_p - p\left(\frac{\partial V}{\partial p}\right)_T$$

   Discuss its physical significance. (4+1)

4. a) State the principle of equipartition of energy. Write a relation between number of degrees of freedom, number of particles constituting the system and the total number of constraints. Calculate the degrees of freedom for (i) single atom, (ii) diatomic molecule. (1+1+3)

   b) Derive Einstein's formula for mean square displacement of a Brownian particle. (10)

   c) Calculate the coefficient of viscosity of hydrogen at STP. Take $\rho = 8.90 \times 10^{-2}$ kg m^{-3}, $\lambda = 2 \times 10^{-7}$ m and $k_B = 1.38 \times 10^{-23}$ JK^{-1}. (5)

5. a) Establish Boltzmann relation between entropy (S), and thermodynamic probability (W):

   $$S = k_B \ln W.$$ (5)

   b) What is a Gibbs paradox? How did it arise? (5)

   c) Using the expression of Bose-Einstein distribution function for photons

   $$\frac{N_\nu}{g_\nu} = \frac{1}{e^{\beta h\nu} - 1}$$

   derive Plancks Law and show that (i) Rayleigh-Jeans Law, and (ii) Wien's Law follow from it at low & high frequencies. (6+4)

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