

Name of the Course: B.Sc. Physical Sciences - Core – CBCS

Semester: III

Name of the Paper: Thermal Physics and Statistical Mechanics

Unique Paper Code: 42224303

Duration: 3 Hours

Maximum Marks: 75

Instruction for candidates

Attempt any *five* questions in all. Question No.1 is compulsory. All questions carry equal marks.

1. Attempt any *five* of the following:

5x3 = 15

(a) A quantity of air at 27°C and at atmospheric pressure is suddenly compressed to half of its original volume. Find its final pressure.

(b) What do you mean by a thermodynamic system and thermodynamic coordinates? Give two examples of intensive and extensive coordinates.

(c) Draw and explain the T-S diagram of a Carnot's cycle.

(d) Define mean free path of a gas molecule. How does it vary with temperature and pressure?

(e) From Wein's displacement law, estimate the temperature of the Sun. Given $\lambda_m = 4900 \times 10^{-7} \text{ cm}$ and Wein's constant = 0.292 cm K .

(f) Define phase space. What is the significance of a point in a phase space?

2 (a) Mention four stages of a Carnot cycle. State and prove Carnot's theorem.

(b) A Carnot's engine whose cold reservoir is at 7°C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of hot reservoir be increased?

10,5

3 (a) What is entropy of a system? Give the mathematical form of the second law of thermodynamics. Show that the entropy of a system undergoing a reversible process remains constant whereas it always increases for an irreversible process.

(b) 10^{-3} kg of water at 20°C is converted into ice at -10°C at constant pressure. Calculate the total change in the entropy of the system. Given: sp. heat of ice = 0.5 cal/g/K , latent heat of ice = 80 cal/g ,

10,5

4 (a) What is Joule-Thomson effect? Show that enthalpy remains constant during the porous plug experiment. Derive an expression for the Joule-Thomson coefficient?

(b) Using Maxwell's thermodynamic relation, derive Clausius-Clapeyron equation for phase transition.

10,5

5 (a) Using Maxwell's law of velocity distribution, derive expressions for

(i) average speed (v_{av})

(ii) most probable speed (v_{mp})

(iii) root mean square speed (v_{rms})

and show graphically that $v_{rms} > v_{av} > v_{mp}$.

(b) Describe a method for the experimental verification of Maxwell's law of distribution of velocity.

10,5

6 (a) What is a black body? What are the salient features of black body radiation?

(b) Derive Planck's formula for the spectral distribution of black body radiation.

(c) Two stars radiate maximum energy at wavelengths $3.6 \times 10^{-7} \text{m}$ and $4.8 \times 10^{-7} \text{m}$ respectively. What is the ratio of their temperatures?

4,8,3

7 (a) What are Fermions? Write down the postulates of Fermi-Dirac statistics. Derive an expression for the probability distribution of particles obeying Fermi-Dirac statistics.

(b) Three Fermions are to be distributed in four non-degenerate energy levels: a , b , c and d . Calculate all possible ways of this distribution.

10,5