

2025

M.Sc. 3rd Semester Examination

PHYSICS

Paper : PHS - 302

(Statistical Mechanics-I)

Full Marks : 25

Time : One Hour

The figures in the margin indicate full marks.

*Candidates are required to give their answers
in their own words as far as practicable.*

1. Answer any *two* questions :

2×2=4

(a) In Liouville's theorem, if ρ does not depend on q and p explicitly, then prove that $\rho = \text{constant}$.

(b) For ideal gas, find an expression of microstates $\Omega(E, N, V; \delta E)$.

(c) How concept of negative temperature is introduced?

(d) For spin $\frac{1}{2}$ particle $\hat{\rho} = a\hat{I} + b\vec{\sigma}$ show that $\hat{\rho} = \frac{1}{2}(\hat{I} + \vec{P}\vec{\sigma})$.

P.T.O.

2. Answer any *two* questions :

4×2=8

(a) If Hamiltonian of a single particle

$$H = \frac{p_\theta^2}{2mr^2} + \frac{p_\phi^2}{2mr^2 \sin^2 \theta}.$$

Find an expression of equation of state.

(b) Deduce an expression of canonical partition function for 3D quantum Harmonic oscillator.

(c) If $\hat{H} = \begin{pmatrix} \epsilon_1 & 0 \\ 0 & \epsilon_2 \end{pmatrix}.$

Prove that diagonal elements are stationary in time and the off-diagonal elements oscillate with frequency $(\epsilon_1 - \epsilon_2)/\hbar$.

(d) Find an expression of Fermi-Dirac distribution function from grand canonical ensemble.

3. Answer any *one* question :

8×1=8

(a) Prove that $\rho_{\bar{r}, \bar{r}'} = \frac{1}{V} e^{-\frac{mk_B T}{2\hbar^2} (\bar{r} - \bar{r}')^2}$ for a particle in a box of infinite potential.

(b) Consider a box containing an ideal classical gas at pressure P and temperature T . The walls of the box have N_0 absorbing sites, each of which can absorb

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one molecule of the gas. Let $-\epsilon$ be the energy of an absorbed molecule.

- (i) Find the fugacity of the gas in terms of T and P .
- (ii) Find the average number of absorbed molecules at low and high-pressure limits.

Internal Assessment : 5 marks
