B. E.T.C.E SUPPLEMENTARY EXAMINATION 2018
(1^{st} year, 1^{st} Semester)
PHYSICS IB

Time : Three hours Full Marks: 100

Answer any five

1. (a) Write down the basic postulates of statistical mechanics. 3

   (b) Consider two macroscopic systems A and B are interacting each other? What are the different ways of interaction possible between two systems ? 5

   (c) If the two systems can interact all possible ways where the composite system is isolated from the rest of the universe. Establish the statistical definition of temperature, pressure and chemical potential. 6 + 3 + 3

2. (a) In canonical ensemble, derive the probability P_r that the system is in the energy E_r and hence define the partition function. 5

   (b) Calculate the canonical partition function of an ideal classical gas 5

   (c) Starting from the ideal gas partition function, calculate the average energy and equation of state of of an ideal gas. 5 + 5

3. (a) Use general expression of entropy to derive the expression for entropy of a canonical ensemble. 5

   (b) Consider a system of N spin $\frac{1}{2}$ particles under the influence of an applied enternal magnetic field H. The system is characterized by parameter magnetic moment μ and temperature T. Derive the expression for partition function of this system, hence find the average energy $\bar{E}$ of the system. 5 + 5

   (c) Calculate the partition function of a one dimensional simple harmonic oscillator 5

4. (a) Explain working principle of a Carnot's heat engine for an ideal gas and calculate its efficiency. Show that all reversible engines working between two constant temperatures will have the same efficiency 10 + 2

   (b) State Kelvin-Planck and Clausius statements of the second law of thermodynamics. 3

   (c) Two Carnot engines A and B are operated in series. A receives heat at 900° K and rejects at T° K. B receives heat rejected by A and in turn rejects at 400° K. Calculate the value of T when (i) the work outputs of A and B are equal, and (ii) the efficiencies of A and B are equal. 5

5. (a) What do you mean by International Practical Temperature scale? 3

   (b) First and second law of thermodynamics together provide the internal energy as $dU = TdS - PdV$. Hence obtain the expression for Gibbs and Helmholtz free energies and also the enthalpy the system 5

(c) Derive the Maxwell's thermodynamic relations. Using Maxwell's relation show that the ratio of adiabatic to isothermal elasticity (bulk modulus) is γ, the ratio of two specific heats $(\frac{C_P}{C_V})$. 8+ 4

6. (a) If $\vec{r}$ is the position vector of a particle of mass m relative to point O and $\vec{F}$ is the external force on the particle, show that torque or moment of $\vec{F}$ about O is $M = \frac{d\vec{H}}{dt}$, where $\vec{H} = \vec{r} \times m\vec{v}$ and $\vec{v}$ is the velocity of the particle. 5

(b) Find the velocity and acceleration of a particle which moves along the curve $x = 2sin3t$, $y = 2cos3t$, $z = 8t$ at any time $t > 0$. Find the magnitude of the velocity and accelearation. 5

(c) Show that $\bigtriangledown r^n = nr^{n-2}\vec{r}$ 5

(d) Find the work done in moving a particle from point (1,1) to (2, 8) in the XY plane along the curve $y = x^3$ under the action of a force $\vec{F} = (5xy - 6x^2)\hat{i} + (2y - 4x)\hat{j}$. 5

7. (a) Define unit vector $\hat{r}$ and $\hat{\theta}$ in plane motion in terms of their cartesian counterparts $\hat{i}$ and $\hat{j}$. Also show that that $\frac{d\hat{r}}{d\theta} = \hat{\theta}$ and $\frac{d\hat{\theta}}{d\theta} = -\hat{r}$ 4 + 4

(b) Find the expression for velocity and acceleration in plane polar coordinate system. 4 + 4

(c) Give an example of a conservative force field . Show that angular momemtum is conserved in a central force field. 1 + 3