RDN – 08

B.Sc. (Semester –VI) Examination, April/May 2019
PHYSICS (Paper – III)
Thermodynamics and Statistical Mechanics

Duration : 2 Hours | Max. Marks : 80

Instructions : *1) **All** questions are **compulsory**.*
*2) Figures to the **right** indicate marks.*
*3) **Symbols** have their usual meaning.*
*4) Use of non programmable **calculator** is allowed.*
*5) Draw **neat** diagrams **whenever** necessary.*

1. Answer **any four** of the following : **(4×4=16)**
   a) With the help of an indicator diagram, explain the four strokes of a Diesel Engine.
   b) Write a short note on Refrigerators based on vapour absorption.
   c) Explain the principle of regenerative and cascade cooling.
   d) With the help of a neat diagram, explain liquefaction process for hydrogen.
   e) A transformer producing company has four assembly plants which are working with efficiency of 30%, 20%, 40% and 10% respectively. If a transformer is chosen at random, what is the probability that it is defective ? If a transformer chosen at random is found to be defective, what is the probability that it came from the fourth plant.
   f) The weekly demand for a popular cold drink is a continuous random variable X having probability $f(x) = \begin{cases} 2(x-1), & 1 < x < 2 \\ 0 & \text{elsewhere} \end{cases}$
   calculate the mean and variance.

2. Answer **any four** of the following : **(4×4=16)**
   a) State various considerations of Fermi-Dirac statistics. Explain the term "Fermion". Give two examples of Fermi Particles and state the expression for occupation index of Fermions.
   b) Boltzmann argued that, there is a definite relationship between the thermodynamic entropy of a system and the probability of distribution of particles. Using mathematical logic, derive the Boltzmann relation $S = \ln W_{max}$.

P.T.O.

c) On basis of logical arguments, determine the thermodynamic probability of distributing N identical indistinguishable particles into K number of energy compartments characterized by average energies E_1, E_2,....,E_k and divided into cells g_1, g_2,..., g_k respectively of same size under the condition that number of cells is greater than the number of particles and that any number of particles may occupy a given cell.

d) Show that enthalpy remains unchanged during an adiabatic throttling process.

e) Using the Maxwell Boltzmann distribution law for molecular speed, compute the most probable speed of the molecules of a ideal gas.

f) State the properties of liquid He I and He II.

3. A) With the help of neat diagrams and suitable P-V indicator diagram, explain the working of a Otto Engine. Calculate its thermal efficiency. **6**

OR

A) Give three points of distinction between Otto and Diesel Engines. Calculate the ratio of mean effective pressure to maximum pressure for a Otto Engine. Explain its significance. **6**

B) Write down the Maxwell-Boltzmann distribution law for discrete energy states. Assuming the energywise distribution to be a continuous variation of molecular energies, evaluate the constants α and β. **6**

4. A) With the help of a neat diagram, explain the working of vapour compression refrigeration machine. Define Coefficient of Performance (COP) of refrigeration and establish relation between "COP" of refrigeration and the efficiency of Carnot cycle. Explain the physical significance of this relation. **6**

OR

A) With the help of a neat diagram, describe the process of liquefaction of Helium. Explain the significance of lamda (λ) transition from He I to He II. **6**

B) Derive the expression for Joule-Kelvin coefficient. When a gas is allowed to expand adiabatically passing through a throttle valve, show that Joule-Kelvin effect result from deviation from Boyle's law and Joule's Law. Hence show that Joule-Kelvin effect vanishes for a ideal gas. **6**

5. A) Derive the expression for the mean value of a binomial distribution. A bag contains 9 white and 6 black balls. If 3 balls are drawn at random, find the probablity that all of them are of the same colour. **6**

OR

A) Derive Stenling's approximation formula for lnN! using this approximation maximize the probability function given by $W = \prod_{i=1}^{k} \frac{g_i!}{n_i!(g_i - n_i)!} \times \text{constant}$

to get an expression for most probable distribution. 6

B) A drunkand starts out from a lamp-post in the middle of a large city-square. He is so completely under the influence of alcohol that the direction of each step to the right or left is completely independent of the preceding step. What is the probability that the drunkand after taking N steps will reach his destination which is at a distance x from the lamp post. 6

6. A) Using Maxwell-Boltzmann distribution law for molecular velocities, compute the average and r.m.s. speeds of molecules of Ideal gas. At what temperature will the average speed of hydrogen molecule be the same as that of oxygen which is at 27 °C ? Molecular weights of hydrogen and oxygen are 2 and 32 respectively. 6

OR

A) Draw diagram and describe the experimental method used by Zantman and KO for experimental verification of Maxwell Boltzmann law of distribution of molecular speeds. How the result of this experiment confirms the existence of most probable speed for gas molecules. 6

B) N number of identical indistinguishable Bosons are to be distributed into K number of energy compartments characterized by average energies $E_1, E_2, ..., E_k$ the compartments are divided into identical cells. Numbered $g_1, g_2, ...g_k$ respectly. So that number cells for exceed the number of particles in each compartment and that any number of particles can occupy a single cell. Obtain an expression for probability of distribution. 6