First Semester M.Tech. Degree Examination, February 2015
(2013 Scheme)
(Thermal Sciences)
MTC 1001 : ADVANCED THERMODYNAMICS

Time : 3 Hours Max. Marks : 60

***Instruction** : Answer **any two** questions from **each** Module.*

MODULE – 1

1. a) Define molecular flux and obtain an expression for this. 5

   b) Approximately what fraction of the molecules of a gas have velocities for which the azimuthal angle $\varnothing$, lies between 29.5° and 30.5°, while polar angle, θ lies between 44.5° and 45.5°. What fraction have speed for which $\varnothing$ lies between 29.5° and 30.5° regardless of θ ? 5

2. a) For a two component open system $dU = TdS - PdV + \mu_1 dn_1 + \mu_2 dn_2$. Derive a similar expression for dG. 5

   b) Show that $-SdT + VdP - \Sigma_i n_i d\mu_i = 0$. 5

3. a) State and explain Nernst theorem. 5

   b) Derive the expression for the differential of thermodynamic potentials. 5

MODULE – 2

4. a) Define collision cross section and obtain an expression for survival equation. 5

   b) A group of oxygen molecules start their free path at the same instant. The pressure is such that the mean free path is 3 cm. After how long a time will half of the group still remain unscattered. Assume all the particles have a speed equal to the r.m.s. speed. The temperature is 300 K. 5

P.T.O.

5. a) Obtain an expression for temperature dependence of thermal conductivity of an ideal gas. 5

   b) Given that the density of air is 1.29 kg/m^3, $\bar{v} = 460$ m / s and $l = 6.4 \times 10^{-8}$ m at standard conditions, determine the coefficient of viscosity, diffusion and thermal conductivity. Assume that air is a diatomic ideal gas. 5

6. Define thermodynamic probability. Obtain the most probable distribution function of Bose-Einstein particles. 10

MODULE – 3

7. Methane gas enters a steady flow adiabatic combustion chamber at 25°C and 1 atm. It burned with 50% excess air that also enters at 25 °C and 1 atm. Assuming complete combustion, determine temperature of products, entropy generation, reversible work and exergy destruction. Also assume that $T_0 = 298$ K and the products leave the combustion chamber at 1 atm pressure. 10

8. A certain hydrocarbon fuel is burned with excess air, and the analysis of the dry products of combustion yields the following volumetric proportions : $CO_2 = 10.4\%$, $CO = 1\%$, $O_2 = 5\%$, $N_2 = 83.6\%$. Estimate the approximate composition of the fuel and the percentage of theoretical air. 10

9. a) Describe in detail :
      a) Adiabatic flame temperature
      b) Enthalpy of formation.
      c) Chemical potential. 6

   b) Derive an expression for temperature dependence of the equilibrium constant. 4