GIET UNIVERSITY, GUNUPUR – 765022

M. Tech (First Semester – Regular) Examinations, June – 2021

MPCTE1010 - ADVANCED ENGINEERING THERMODYNAMICS

(Heat Power and Thermal Engineering)

Time: 2 hrs Maximum: 50 Marks

PART – A **(2 x 10 = 20 Marks)**

Q.1. Answer ***ALL*** questions

a. State first law of thermodynamics? Write application of first law to a process?
b. Define entropy?
c. Write the expression for Helmholtz function and Gibbs function?
d. Define adiabatic flame temperature?
e. Write the expressions for Maxwell relations?
f. Prove that the internal energy of an ideal gas is a function of temperature alone?
g. Expressions for evaluating fugacity of a single-component system?
h. Define Bose–Einstein statistics?
i. Calculate the density of N_2 at 260 bar and 15°C by using the compressibility chart?
j. Define molecular collisions?

PART – B **(6 x 5 = 30 Marks)**

Answer ***ANY FIVE*** questions

2. A cylinder contains 0.45 m^3 of a gas at 1×10^5 N/m^2 and 80°C. The gas is compressed to a volume of 0.13 m^3, the final pressure being 5×10^5 N/m^2. Determine:(i) The mass of gas ;(ii) The value of index 'n' for compression;(iii) The increase in internal energy of the gas;(iv) The heat received or rejected by the gas during compression. Take $\gamma = 1.4$, R = 294.2 J/kg°C. (6)

3. Derive the following relations: (6)

$$(i)\ u = a - T\left(\frac{\partial a}{\partial T}\right)_v \qquad (ii)\ h = g - T\left(\frac{\partial g}{\partial T}\right)_p$$

$$(iii)\ c_v = -T\left(\frac{\partial^2 a}{\partial T^2}\right)_v \qquad (iv)\ c_p = -T\left(\frac{\partial^2 g}{\partial T^2}\right)_p$$

where a = Helmholtz function (per unit mass), andg = Gibbs function (per unit mass).

4. Using the Maxwell relation derive the following relations: where β = Co-efficient of cubical expansion, and K = Isothermal compressibility. (6)

$$(i)\ \left(\frac{\partial T}{\partial p}\right)_s = \frac{Tv\beta}{c_p} \qquad (ii)\ \left(\frac{\partial T}{\partial v}\right)_s = -\frac{T\beta}{c_v K}.$$

5. The pressure on the block of copper of 1 kg is increased from 20 bar to 800bar in a reversible process maintaining the temperature constant at 15°C. Determine the following:(i) Work done on the copper during the process,(ii) Change in entropy, (iii) The heat transfer,(iv) Change in internal energy, and (v) (C_p – C_v) for this change of state. Given: β (Volume expansivity = 5×10^{-5}/K, K (thermal compressibility) = 8.6×10^{-12} m^2/N and v (specific volume) = 0.114×10^{-3} m^3/kg. (6)

6. A steel flask of 0.04 m^3 capacity is to be used to store nitrogen at 120 bar,20°C. The flask is to be protected against excessive pressure by a fusible plug which will melt and allow the gas to escape if the temperature rises too high.(i) How many kg of nitrogen will the flask hold at the designed conditions ?(ii) At what temperature must the fusible plug melt in order to limit the pressure of a full flask to a maximum of 150 bar ? (6)

7. Describe the statistical Bose–Einstein thermodynamic relations? (6)

8. A dilute system at thermodynamic equilibrium consists of 50 independent, indistinguishable particles. Each particle has three energy levels of energy 0, ε, and 2ε, with degeneracies of 300, 600, and 1200, respectively. The system is at a constant temperature T = ε/k, where k is Boltzmann's constant.(a) Calculate the molecular partition function for this thermodynamic system.(b)How many particles are in each energy level?(c) Using Boltzmann's relation, determine the entropy of this system. (6)

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