M.E. First Semester (Mechanical Engineering (Thermal Engg.)) (New-CGS)

13506 : Advanced Thermodynamics : 1 MTE 2

P. Pages : 2

Time : Three Hours

0328

AU - 3360

Max. Marks : 80

Notes :
1. Answer **three** question from Section A and **three** question from Section B.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Use of slide rule logarithmic table, Steam table, Mollier's Chart, Drawing instrument, Thermodynamic table for moist air, Psychrometric Charts and Refrigeration charts is permitted.

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SECTION – A

1. a) Using Maxwell's equation, show that for a van der waal's gas. 7

$$Cp - Cu = \frac{R}{1 - 2a\left(u - b^2\right)/R \cdot T \cdot v^3}$$

b) For the Berthelot equation of state, prove that Boyle temperature 7

$$T_B = \sqrt{\frac{a}{b \cdot R}}$$

2. a) A large insulated vessel is divided into two chambers one containing 5kg of dry saturated steam at 0.2 MPa and other 10kg of steam 0.8 dry at 0.5 MPa. If partition between chambers is removed and steam is mixed thoroughly and allowed to settle, find final pressure, steam quality and entropy change in the process. 7

b) Derive the Stefan – Boltzman Law by using thermodynamic relations. 6

3. a) Two kg of air at 500 kPa, 80°C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surrounding which is at 100kPa, 5°C. For this process determine 7
   a) Maximum Work
   b) The change in availability
   c) The irreversibility

   Assume air to be an ideal gas and take suitable values for property of air.

b) A heat engine receives half of its heat supply at 1000k and half at 500k while rejecting heat to a sink at 300k. What is max^{m} thermal efficiency of the heat engine? 6

4. a) An adiabatic turbine receives gas at 700 kPa and 1000°C and discharges it at 150 kPa and 665°C. Taking $T_0 = 25°C$, determine second law and isentropic efficiency of turbine (Take - $C_p = 1.09\,kJ/kg \cdot k$, and $\gamma = 1.3$). 7

b) Derive the expression for irreversibility or exergy loss in a process executed by 6
   i) Closed system   ii) a steady flow system in a given environment.

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5. a) Prove that enthalpy change in reversible adiabatic process is given by 7

$$h_2 - h_1 = \frac{\gamma \cdot R \cdot T_1}{\gamma - 1}\left[\left(\frac{P_2}{P_1}\right)^{\left(\frac{\gamma-1}{\gamma}\right)} - 1\right]$$

b) The specific heats, of gas are given by $C_p = a + kT$ and $C_v = b + kT$ where a, b and k are constants. Show that for isentropic exp^n of this gas $T^b \cdot v^{a-b} \cdot e^{KT}$ = constant. 6

SECTION – B

6. a) Derive the expression for mixture of ideal gases for the following 7
i) Gas constant
ii) Internal energy
iii) Enthalpy
iv) specific heat

b) Discuss the details of Dalton's and Amagat's Model. State how these are dependent. 6

7. a) Gaseous carbon and oxygen are supplied in an equimolar ratio at 25°C and 1 atm to a combustion vessel in a steady state steady flow process. The heat exchanger is used to maintain the combustion process at 2300°K. Determine the heat transferred from the combustion gases to the heat exchanger per mole of carbon supplied if the combustion product exhaust from the system at 2300K and 1 atm. No work is done during the process. 7

b) Show that in a diffusion process at constant temperature the entropy increases and the Gibbs function decreases. 6

8. a) State and derive Gibb's theorem. 7

b) How does the percentage of moisture in air affect the outcome of a combustion process? 6

9. a) An insulated rigid tank is divided into two compartment by partition. One compartment contains 7 kg of oxygen gas at 40°C and 100 kPa, and the other compartment contains 4 kg of nitrogen gas at 20°C and 150 kPa. Now the partition is removed and the two gases are allowed to mix. Determine : 7
i) The mixture temperature
ii) The mixture pressure after equilibrium has been established.

b) Discuss with all attributes the energy analysis of a steam power plant operating on a simple Rankine cycle. 7

10. a) How the second law efficiency of ideal Rankine cycle can be improved? 6

b) Consider steam power plant working on the ideal Rankine cycle. The steam enters at 3 MPa and 350°C and it is condensed in the condenser at a pressure of 75 kPa. Heat is transferred in the boiler furnace at 1600K and the heat is rejected to the sink at the temperature of 290K. Consider the atmospheric temp 290K. Determine the irreversibility for each process and cycle, also the work potential of steam leaving the turbine. 7

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