ME (Mech) Sem I Thermal Engg (R)
Advanced Thermodynamics

Con. 2989-09. **BB-5616**

(4 Hours) **[Total Marks : 100**

N.B.: (1) Question No. **1** is **compulsory**.
(2) Attempt any **four** questions out of remaining **six** questions.
(3) Answers of **all parts** of the question should be written **together** and **one** below the **other**.
(4) Assume any **suitable data** whenever **required** but **justify** the **same**.
(5) Use of **thermodynamic table** and chart is **permitted**.

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1. Answer the following questions :—
   (a) Develop the transient form of mass, energy and entropy equation for an open system interacting with surrounding in the form of heat and work.
   (b) Sate the significance of second law of thermodynamics. How does it help us in the analysis of the thermodynamic system ? Give examples and explain.
   (c) 10 kg of water at 273 K is brought into contact with a surrounding at 373 K. Find the net entropy exchange, when water reaches to 373 K.
   (d) What do understand by property relations ? Derive Maxwell's equations.
   (e) Define following terms:
      (i) Equivalent ratio,
      (ii) HHV and LHV
      (iii) Complete and incomplete combustion
      (iv) Adiabatic Flame temperature.

2. (a) A rigid vessel containing gas at pressure P_1 and temperature TI is charged to a pressure P_2. Find the final temperature and the average gas mass flow rate entering the tank. **10**
   (b) A I-m^3, 40-kg rigid tank contains air at 800 kPa, and both tank and air are at 20°C. The tank is connected to a line flowing air at 2 MPa, 20°C. The valve is opened, allowing air to flow into the tank until the pressure reaches 1.5 MPa and is then closed. Assume the air and tank are always at the same temperature and the final temperature is 35°C. Find the final air mass and the heat transfer. **10**

3. (a) Explain the principle of increase of entropy ? How does this principle helps in the analysis of a thermodynamic system ? **10**
   (b) Two 10 kg blocks of steel, one at 400°C the other at 50°C, come in thermal contact. Find the final temperature and the change in entropy of the steel ? Assume specific heat of steel is 0.46 kJ/kgK. **10**

4. (a) What do you mean by irreversibility of a thermodynamic process ? What is its significance in thermodynamics ? Discuss about the factors which make a process irreversible. **10**
   (b) Liquid water at 200 kPa and 20°C is heated in a chamber by mixing it with superheated steam at 200 kPa and 150°C. Liquid water enters the mixing chamber at a rate of 2.5 kg/s, and the chamber is estimated to lose heat to the surrounding air at 25°C at a rate of 1200 kJ/min. If the mixture leaves the mixing chamber at 200 kPa and 60°C, determine (i) the mass flow rate of the superheated steam and (ii) the rate of entropy generation during this mixing process. **10**

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5. (a) What is meant by exergy ? Derive the expression for exergy loss in a process executed by : (i) closed system, (ii) open system. 10

(b) A rigid tank initially contains saturated liquid water. A valve at the bottom of the tank is opened, and half of mass in liquid form is withdrawn from the tank. The temperature in the tank is maintained constant. Determine the amount of heat transfer, the reversible work, and the exergy destruction during this process. 10

6. (a) What does the Joule-Thomson coefficient represent ? Derive a relation for the Joule-Thomson coefficient and the inversion temperature for a gas whose equation of state is pv = RT. 10

(b) C_4H_{10} (l) enters a combustion chamber at 25°C at a rate of 0.05 kg/min where it is mixed and burned with 50 percent excess air that enters the combustion chamber at 7°C. An analysis of the combustion gases reveals that all the hydrogen in the fuel bums to H_2O but only 90 percent of the carbon burns to CO_2, with the remaining 10 percent forming CO. If the exit temperature of the combustion gases is 1500 K, determine (i) the mass flow rate of air and (ii) the rate of heat transfer from the combustion chamber. 10

Substance	$\bar{h}_f^0$ *(kJ / kmole)*	$\bar{h}_{280}$ *(kJ / kmole)*	$\bar{h}_{298}$ *(kJ / kmole)*	$\bar{h}_{1500K}$ *(kJ / kmole)*
C_4H_{10} (l)	-118,910	-	-	-
O_2	0	8150	8682	49,292
N_2	0	8141	8669	47,073
H_2O	-241,820	-	9904	57,999
CO_2	-393,520	-	9364	71,078
CO	-110,530	-	8669	47,517

7. (a) Prove that for an van der Waals gas— 10

$$c_p - c_v = \frac{T}{1 - 2a(v - b)^2 / RTv^3}$$

(b) Over a certain range of pressure and temperature of the equation of a certain substance is given by the following relation— 10

$$v = \frac{RT}{p} - \frac{C}{T^3}$$ were C is a constant.

Derive an expression for change of h and s of this substance in an isothermal process.

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