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

13506 : Advanced Thermodynamics : 1 MTE 2

P. Pages : 2 **AW - 3800**

Time : Three Hours Max. Marks : 80

Notes :
1. Answer **three** question from Section A and **three** question from Section B.
2. Assume suitable data wherever necessary.
3. Diagrams and chemical equations should be given wherever necessary.
4. Use of slide rule logarithmic tables, Steam tables, Moller's Chart, Drawing instrument, Thermodynamic table for moist air, Psychrometric Charts and Refrigeration charts is permitted.
5. Discuss the reaction, mechanism wherever necessary.

SECTION – A

1. a) A gas is flowing through a pipe of the rate of 2 kg per second. Because of inadequate insulation the gas temperature decreases from 800°C to 790°C between two sections in the pipe. Neglecting pressure losses, calculate the irreversibility rate due to this heat loss. Take $T_0 = 300$ K and $C_p = 1.1$ kJ/kgK. **6**

b) Show that it is impossible by any procedure to reduce the temperature of any system to absolute zero by performing any number of finite operations. **7**

2. a) Show that for a system to be stable these conditions are satisfied :- **7**

i) $C_v > 0$ (thermal stability) ii) $\left[\frac{\partial P}{\partial V}\right]_T < 0$ (mechanical stability)

b) A quantity of gas has a pressure of 800 kN/m^2 and it occupies a volume of 0.011 m^3 at 145°C. The gas expands isothermally to 0.09 m^3. Determine change in entropy. **7**

3. a) A rigid tank of volume 0.5 m^3 is initially evacuated. A tiny hole develops in the wall, and air from the surroundings at 1 bar, 21°C leaks in. Eventually the pressure in the tank reaches 1 bar. The process occurs slowly enough that heat transfer between the tank and the surroundings keeps the temperature of the air inside the tank constant at 21°C. Determine the amount of heat transfer. **6**

b) A heat engine receives half of it's heat supply at 1000 K and half at 500 K while rejecting heat to a sink at 300 K. What is max^m. thermal efficiency of heat engine? **7**

4. a) Show that the minimum theoretical work input required by the refrigeration cycle to bring two finite bodies from the same initial temperature to the final temperature of T_1 and T_2 ($T_2 > T_1$) is given by :- **7**

$$w_{min} = mc\left[2(T_1T_2)^{1/2} - T_1 - T_2\right]$$

b) A mass of 6.98 kg of air is in a vessel at 200 kPa, 27°C. Heat is transferred to the air from reservoir at 727°C until the temperature of air raises to 327°C. The environment is at 100 kPa, 17°C. Determine **6**

i) initial and final availability of air.

ii) the maximun useful work associated with the process.

5. a) Prove that for Vander Waals gas :- 7

$$C_p - C_v = \frac{R}{1 - \frac{2a(v-b)^2}{RT_v^3}}$$

b) The Joule-Kelvin coefficient (μ_J) is a measure of the temperature change during a throttling process. A similar of the temperature change produced by an isentropic change of pressure is provided by the coefficient (μ_S), where, 6

$\mu_S = \left[\frac{\partial T}{\partial P}\right]_S$ prove that, $\mu_S - \mu_J = \frac{V}{C_p}$.

SECTION – B

6. a) Show that in a diffusion process a gas undergoes a free expansion from the total pressure to the relevant partial pressure. 7

b) What is Dalton's and Amagat's model for multiphase system? Discuss. 7

7. a) State the derive Gibbs theorem. 7

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

8. a) How does the percentage of moisture in air affect the outcome of a combustion process? 7

b) Prove that, $\Delta G = \Delta H + T\left[\frac{\partial \Delta G}{\Delta T}\right]_P$ 6

9. a) Show that the efficiency of Otto cycle is a function of compression ratio. 6

b) At 35°C and 1 atm. the degree of dissociation of N_2O_4 at equilibrium is 0.27. 7

i) Calculate K.
ii) Calculate E at the same temperature when the pressure is 100mm Hg.
iii) The equilibrium constant for the dissociation of N_2O_4 has the values 0.664 and 0.414 at temperatures 318 and 298K respectively.
Calculate the average heat of reaction within this temperature range.

10. a) Discuss the guidelines for improving the effectiveness of the Rankine cycle. 6

b) A reversible heat engine operates on a carnot cycle with the upper temperature limit of 400°C and has a thermal efficiency of 55%. The volume ratio of the expansion of the isothermal process is 2.8. Determine the overall volume expansion ratio. 7
Take $\left(C_p / C_v\right) = 1.4$.

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