Roll No. **Total No. of Pages : 02**

Total No. of Questions : 08

M.Tech (ME) (2017 Batch) (Sem.–1)

ADVANCED THERMODYNAMICS

Subject Code : MTME-105

Paper ID : [74719]

Time : 3 Hrs. **Max. Marks : 100**

INSTRUCTIONS TO CANDIDATES :

1. **Attempt any FIVE questions in all, out of EIGHT questions.**
2. **Each question carry TWENTY marks.**

1. a) Explain entropy using physical principles. What is an "Endoreversible" engine?

   b) Consider a cup full of coffee placed in room air. If the pressure and entropy are maintained constant within the rigid room, in practice how can there be a heat loss?

2. a) Heat (Q_H) is rejected from the condenser to the ambient in a refrigeration cycle for which the temperature T_H (ambience) is 10°C below the condenser temperature. Similarly, heat is added to the evaporator from a cold space at a temperature T_L. The evaporator coil is at a temperature that is 10°C below T_L. Is it possible to use the heat transfer Q_H to reduce the work input to the compressor? Comment.

   b) Obtain an expression for dh and du for a liquid in terms of c_p, β_P, β_T, c_v, dT and dP. Simplify the relations for an incompressible liquid.

3. A steady flow compressor for a gas turbine receives air at 1 bar and 15°C which it compresses to 7 bar with an efficiency of 83%. Based on surroundings at 5°C determine

   (a) The change of availability and the work for isentropic compression. For the actual process evaluate

   (b) The change of availability and work done,

   (c) The change of availability of the surroundings and

   (d) The irreversibility.

   Treat the gas as an ideal one, with the specific heat at constant pressure, c_p = 1.004 kJ/ kg K, and the ratio of specific heats, γ = 1.4.

4. a) Determine an expression for $\partial c_v / \partial v$ for a Clausius II fluid in terms of v and T.

   b) Show that generally real gases deliver a smaller amount of work as compared to an ideal gas during isothermal expansion for a (*i*) closed system from volume v_1 to v_2, and (*ii*) an open system from pressure P_1 to P_2.

5. a) Obtain an expression for the enthalpy change , dh in a Clausius I fluid that follows the relation $P = RT/(v-b)$, and show that c_p is a function of T alone.

   b) A substance undergoes an adiabatic and reversible, process. Obtain an expression for $(\partial T/\partial v)_s$ in terms of c_v β_P β_T and T. What is the value of $(\partial T/\partial v)_s$ for copper, given that $\beta_P = 5 \times 10^{-5}$ K^{-1}, $\beta^T = 8.7 \times 10^{-7}$ bar^{-1}, $c = c_v = 0.386$ kJ kg^{-1} K^{-1}, $v = 1.36 \times 10^{-4}$ m^3 kg^{-1}, and the temperature is 25°C? What is the temperature rise if $dv = -8.106 \times 10^{-7}$ m^3 kg^{-1}?

6. A dry gas analysis of the gas exhaled by a human lung is as follows– O_2:16.5% and CO_2:3.1%. Assume the "fuel" burned by humans is characterized by the chemical formula CH_X and is completely burned. Determine the values of "x" and (A:F).

7. a) The Joule Thomson effect can be depicted through a porous plug experiment that illustrates that the enthalpy remains constant during a throttling process. In the experiment a cylinder is divided into two adiabatic variable volume chambers A and B by a rigid porous material placed between them. The chamber pressures are maintained constant by adjusting the volume. Freon vapor with an initial volume $V_{A,1}$, pressure $P_{A,1}$ and energy $U_{A,1}$ is present in chamber A. The vapors penetrate through the porous wall to reach chamber B. The final volume of chamber A is zero. Determine the work done by the gas in chamber B, and the work done on chamber A Apply the First Law for the combined system A and B and show that the enthalpy in the combined system is constant.

   b) Obtain a relation for ds for an ideal gas. Using the criterion for an exact differential show that for this gas c_v is only a function of temperature.

8. a) Distinguish between an ideal and a perfect gas and show that in both cases the specific entropy, s, is given by

$$s = s_0 + \int_{\tau_0}^{\tau} \frac{dh}{T} - R\,ln\left(\frac{p}{p_0}\right)$$

   b) If a fluid, consisting of a single component, is contained in two containers at different temperatures, show that the difference in pressure between the two containers is given by

$$\frac{dp}{dT} = \frac{h - u^*}{vT}$$

   where h = specific enthalpy of the fluid at temperature T,

   u* = the energy transported when there is no heat flow through thermal conduction,

   v = specific volume,

   T = temperature.