Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Remedial Examination April 2010

Subject code:712101

Subject Name: Applied Thermodynamics and Heat Transfer

Date: 06 / 04 / 2010 **Time: 12.00 noon – 02.30 pm**

Total Marks: 60

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Justify with appropriate illustration the Carnot theorem: "No engine working in a cycle between two constant temperature reservoirs can be more efficient than a reversible engine working between the same two reservoirs." **06**

(b) Derive one dimensional time dependent heat conduction equation with internal heat generation and variable thermal conductivity in rectangular coordinate system. **06**

Q.2 **(a)** Describe an imaginary process that satisfies the second law but violates the first law of thermodynamics. **06**

(b) Discuss irreversibilities in a system with example. Distinguish between internal and external irreversibilities. **06**

OR

(b) Define Maxwell equation. Using Maxwell equation, determine a relation for $\left(\partial S/\partial P\right)_T$ for the case of gas whose equation of state is P(V-b) = RT. **06**

Q.3 **(a)** Discuss entropy generation in a closed system and justify that the second law of thermodynamics can also be stated as "Any thermodynamic process is accompanied by entropy generation." Is entropy generation a property? Discuss in brief. **06**

(b) Discuss Clapeyron equation in thermodynamic? Using the Clapeyron equation, estimate the enthalpy of vaporization of steam at 300 kPa, and compare it to the tabulated value. **06**

OR

Q.3 **(a)** Derive expression for temperature distribution, heat dissipation and effectiveness in a straight fin of rectangular profile for the cases of fin insulated at tip. **06**

(b) A 1 m long, 5 cm diameter, cylinder placed in an atmosphere of 40^0C is provided with 12 longitudinal straight fins (k = 75 W/m-K), 0.75 mm thick. The fins protrude 2.5 cm from the cylinder surface. The heat transfer coefficient is 23.3 W/m^2-K. Calculate the rate of heat transfer if the surface temperature of cylinder is at 150^0C. **06**

Q.4 **(a)** How does transient heat conduction differ from steady state heat conduction? State physical significance of Biot number. Explain the applications of Heisler and Grober charts in transient heat conduction. **06**

(b) A solid cylinder, 100 mm in diameter generating heat at a uniform rate of 7 × 10^6 W/m^3. Ther thermal conductivity of solid is 190 W/m-K and its surface temperature is maintained at 100 ^{0}C. Calculate (i) temperature at the centre of cylinder, (ii) temperature at the distance 25 mm from the centre, and temperature gradient at 25 mm radius, (iii) heat flux at the surface. **06**

OR

Q.4 **(a)** Discuss critical radius of insulation? Explain it with help of material and surface resistances. **06**

(b) An aluminum wire, 1 mm in diameter at 200 ^{0}C is suddenly exposed to an environment at 30 ^{0}C with h = 85.5 W/m^2-K. Estimate the time required to cool the wire to 90 ^{0}C. If the same wire were to place in air stream (h = 11.65 W/m^2-K). What would be the time required to reach it to 90^{0}C. Take thermo-physical properties of aluminum as, C = 900 J/kg-K, ρ = 2700 kg/m^3, k = 204W/m-K. **06**

Q.5 **(a)** Derive an expression for Colburn equation with the help of Chilton Colburn analogy. **06**

(b) A flat plate 1 m wide and 1.5 m long is maintained at 90 ^{0}C in air with free stream temperature of 10 ^{0}C flowing along 1.5 m side of the plate. Determine the velocity of the air required to have a rate of energy dissipation as 3.75 kW. Use correlations **06**

$$Nu_L = 0.664\,\mathrm{R_e}^{1/2}\,\mathrm{Pr}^{1/3}$$ - for laminar flow;

$$Nu_L = \left(0.036\,\mathrm{R_e}^{0.8} - 836\right)\mathrm{Pr}^{1/3}$$ - for turbulent flow

Take properties of air: ρ = 1.0877 kg/m^3, μ = 2.029×10^{-5} kg/m-s, k_f = 0.028 W/m-K, Pr = 0.703, Cp = 1.007kJ/kg-K.

OR

Q.5 **(a)** Explain Stefan Boltzmann law. Derive an expression for total emissive power of a blackbody. **06**

(b) Two parallel discs 50 mm in diameter are spaced 40 cm apart with one disc located directly above the other disc. One disc is maintained at 500 ^{0}C and other at 227 ^{0}C. The emissivities of the discs are 0.2 and 0.4 respectively. The disc are located in a very large room whose walls maintained at 67 ^{0}C. Determine the rate of heat loss by radiation from the inside surfaces of each disc. **06**

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