Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Regular Examination January / February 2011

Subject code: 712101N

Subject Name: Applied Thermodynamics & Heat Transfer

Date: 31 /01 /2011 **Time: 02.30 pm – 05.00 pm**

Total Marks: 70

Instructions:

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

Q.1 **(a)** Determine the maximum work obtainable by using one finite body at temperature T and a thermal energy reservoir at temperature T_0, $T > T_0$ **07**

(b) Two identical bodies of constant heat capacity are at the same initial temperature T_i. A refrigerator operates between these two bodies until one body is cooled to temperature T_2. If the bodies remain at constant pressure and undergo no change of phase, show that the minimum amount of work needed to do this is, **07**

$$W\,(\min) = C_p\left(\frac{T_i^{\,2}}{T_2} + T_2 - 2T_i\right)$$

Q.2 **(a)** The amount of entropy generation quantifies the intrinsic irreversibility of a process. Explain. **07**

(b) State and explain the following : **07**

(i) Joule-Thomson and Joule co-efficient. (ii) Clausius-Claperyon Equation.

OR

(b) Find the value of co-efficient of volume expansion β and isothermal compressibility K for a Van der Waals' gas obeying **07**

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT$$

Q.3 **(a)** Define the second law efficiency. How is it different from the first law efficiency for (i) a simple power plant (ii) a solar water heater. **07**

(b) Write down the first and second TdS equations, and derive the expression for the difference in heat capacities, C_p and C_v. What does the expression signify? **07**

OR

Q.3 **(a)** Prove that the temperature of a body at any time τ during Newtonian heating or cooling is given by the relation **07**

$$\frac{t - t_a}{t_i - t_a} = exp[-B_i\, F_o]$$

(b) An egg with mean diameter of 4 cm and initially at 25 ^{0}C is placed in a boiling water pan for 4 minutes and found to be boiled to the consumer's task. For how long should a similar egg for same consumer be boiled when taken for a refrigerator at 5 ^{0}C? Use lump theory and presume the following properties for egg : **07**

k = 12 W/m-deg; h = 125 W/m^2-deg; c = 2 kJ/kg K and ρ = 1250 kg/m^3.

Q.4 **(a)** Derive expression for temperature distribution and heat dissipation in a straight fin of rectangular profile for the cases : (i) Infinitely long fin, (ii) Fin insulated at tip. Also, define and write expression of (i) Efficiency of fin and (ii) Effectiveness of fin, in each of above cases. **07**

(b) Air is flowing over a flat plate 5 m long and 2.5 m wide with a velocity of 4 m/s at **07**

15 ^{0}C. If ρ = 1.208 kg/m^3 and v = 1.47 x 10^{-5} m^2/s, calculate :

(i) Length of plate over which the boundary layer is laminar, and thickness of the boundary layer (laminar)

(ii) Shear stress at the location where boundary layer ceases to be laminar, and

(iii) Total drag force on the both sides on that portion of plate where boundary layer is laminar.

OR

Q.4 **(a)** What are Heisler charts? Explain the significance of Heisler charts in solving transient conduction problems. **07**

(b) Calculate the heat transfer from a 60 W incandescent bulb at 115 ^{0}C to ambient air at 25 ^{0}C. Assume the bulb as a sphere of 50 mm diameter. Also, find the percentage of power lost by free convection. **07**

The thermo-physical properties of air at 70 ^{0}C are :

k = 2.964 x 10^{-2} W/m^{0}C, v = 20.02 x 10^{-6}, Pr = 0.694.

Use the correlation : Nu = 0.60 (Gr.Pr)$^{1/4}$

Q.5 **(a)** State and explain the following : **07**

(i) Nusselt number.

(ii) Reynold's number.

(iii)Prandlt number.

(iv)Peclet number.

(b) Derive necessary Von-Karnan's expression for convective heat transfer. **07**

OR

Q.5 **(a)** Consider a cylindrical furnace with r_0 = H = 1 m. The top surface (surface 1) and the base (surface 2) of the furnace has emissivities ε_1 = 0.8 and ε_2 = 0.4, respectively, and are maintained at uniform temperature T_1 = 700 K and T_2 = 500 K. The side surface closely approximates a black body and is maintained at a temperature of T_3 = 400 K. Determine the net rate of radiation heat transfer at each surface during steady state operation and explain how these surfaces can be maintained at specified temperatures. Take F_{12} = 0.38. **07**

(b) State and explain the following laws relating to thermal radiation and temperature of a radiating body : **07**

Planck's law, Stefan Boltzman law and Wien's displacement law.

****