Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

ME Semester –I Examination Feb. - 2012

Subject code: 712101N **Date: 11/02/2012**
Subject Name: Applied Thermodynamics & Heat Transfer
Time: 10.30 am – 01.00 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)** Explain significance and importance of "Critical thickness of Insulation". Also derive expression for "Critical thickness of Insulation" for a pipe. **07**

(b) Explain: **07**

1) Kelvin-Plank statement of second law
2) Clausius statement of the second law
3) Equivalence of Kelvin-Plank and Clausius statement.

Q.2 **(a)** Write Vander Wall's equation. Find the value of constant in equation and derive expression of the law of corresponding state. **07**

(b) At 2 kg/sec gas is flowing through pipe. Gas temperature at inlet of pipe is 800 °C and its reduced to 790 °C at exit of pipe. Calculate Irreversibility rate due to heat loss occurred in the pipe. **07**
For same temperature drop when gas cools from 80 °C to 70 °C, what is the rate of irreversibility? Assume T_0 = 300 °C, C_p = 1.1 kJ/kg.K and negligible pressure drop.

OR

(b) Prove that maximum work obtainable from a finite body at temperature T and TER at temperature at T_0 is, **07**

$$W_{\max} = C_p\left[(T - T_0) - T_0 \ln\frac{T}{T_0}\right]$$

Q.3 **(a)** State and explain Clausius-clapeyron theorem. **07**

(b) Derive generalized equation for changes in internal energy and entropy changes. **07**

OR

Q.3 **(a)** Derive expressions for the difference in heat capacities and the ratio of heat capacities, C_p and C_v in term of Volume expansivity (β), isothermal compressibility (K_T), and adiabatic compressibility (K_S). **07**

(b) Derive an expression of Exergy balance for closed system. **07**

Q.4 **(a)** Prove that in case of a fin insulated at tip, temperature distribution along the length of the fin is given by expression, **07**

$$\frac{\theta}{\theta_0} = \frac{\cosh m(1 - x)}{\cosh ml}$$

(b) Water at 80 ^oC is pumped through 100 m of stainless steel pipe, k = 16 W/m K of inner and outer radii 47 mm and 50 mm respectively. The heat transfer coefficient due to water is 2000 W/m^2 K. The **07**

outer surface of the pipe loses heat by convection to air at 20 ^{o}C and the heat transfer coefficient is 200 W/m^2 K. Calculate the heat flow through the pipe. Also calculate the heat flow through the pipe when a layer of insulation, k = 0.1 W/m K and 50 mm radial thickness is wrapped around the pipe.

OR

Q.4 **(a)** Explain Hydrodynamic boundary layer, boundary layer thickness and thermal boundary layer with neat sketch. **07**

(b) A 50 cm x 50 cm copper slab 6.25 mm thick has a uniform temperature of 300 ^{o}C. Its temperature is suddenly lowered to 36 ^{o}C. Calculate time required for the plate to reach temperature 108 ^{o}C by lumped analysis method. Take ρ = 9000 kg/m^3, C_p = 0.38 kJ/kg. ^{o}C, k = 370 W/m. ^{o}C and h = 90 W/m^2. ^{o}C. **07**

Q.5 **(a)** State and explain the following laws of radiation: Planck's law, Stefan Boltzman law and Wien's displacement law. **07**

(b) A square flat plate of 2 meter each side is maintained at uniform temperature of 250 ^{o}C by means of an electric wire heater. If the atmospheric air is flowing at 25 ^{o}C over the plate with a velocity of 60 m/s, what is the electrical power (Watt) required. Take μ = 2.301 x 10^{-5} Ns/m^2, ρ = 0.871 kg/m^3, Cp = 1014 J/kg.K, k = 0.0338 W/m.K. Use correlation: **07**

$$Nu_L = \left(0.037\,\mathrm{Re}_L^{0.8} - 871\right)\mathrm{Pr}^{\frac{1}{3}}$$

OR

Q.5 **(a)** Write Von-karman momentum integral equation, for hydrodynamic boundary layer. Considering cubic velocity profile in boundary layer, derive expression for boundary layer thickness in laminar region. **07**

(b) Two large parallel plates with ϵ = 0.5 each, are maintained at different temperature and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net heat transfer by radiation. **07**

****