Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

Subject code: 712101N **Date: 08 -01-2013**

Subject Name: Applied Thermodynamics & Heat Transfer

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) Derive the expression for the availability associated with the closed system(ϕ) in the following form **07**

$$\phi = (u - u_0) - T_0(s - s_0) + P_0(v - v_0)$$

(b) Steam enters a turbine steadily at 3 Mpa and 450°C at a rate of 8 kg/s and exit at 0.2 Mpa and 150°C. The steam is losing heat to the surrounding air at 100 kPa and 25°C at a rate of 300 kW, and kinetic and potential energy changes are negligible. Calculate the irreversibility and the availability of the steam at the inlet condition. **07**

Q.2 (a) Using the Maxwell relations, determine a relation for $(\partial s/\partial p)_T$ for a gas whose equation of state is given by $P(v-b) = RT$ **07**

(b) Calculate the latent heat of vaporization (h_{fg}) and entropy change during phase change (s_{fg}) of steam at 150°C from the Clapeyron equation and compare them with the tabulated values. **07**

OR

(b) Derive a relation for the volume expansivity (β) and the isothermal compressibility (α) for an ideal gas and for the gas whose equation of state is **07**

$$P(v-b) = RT$$

Q.3 (a) Explain the concept of phase rule and phase equilibrium for multi component system. **07**

(b) Determine the mole fraction of sodium that ionizes according to the reaction $Na \rightleftharpoons Na^+ + e^-$ at 2000 K and 0.5 atm ($K_p = 0.668$ for this reaction). **07**

OR

Q.3 (a) For the case of solid cylinder having surface temperature T_s and generating heat at the rate of g_0 per unit volume, show that the temperature at the centre of the cylinder (T_c) is given by **07**

$$T_c = \frac{g_0 r_0^2}{4k} + T_s$$

Where r_0, the maximum radius of the cylinder and k is is the thermal conductivity of the cylinder.

(b) At a certain time, the temperature distribution in a long cylindrical tube with an inner radius of 250 mm and outside radius of 400 mm is given by **07**

$$T_r = 750 + 1000r - 5000r^2 \, (^0C)$$

Where r in meters. Thermal conductivity and thermal diffusivity of the tube material are

58 W/mK and 0.004 m^2/h respectively. Calculate
(i) rate of heat flow at inside and outside surfaces per unit length
(ii) rate of heat storage per unit length

Q.4 (a) If a thin and long fin is used, show that the heat transfer from the fin is given by **07**
$Q_{fin} = \sqrt{hPkA_c}\,(T_0 - T_\infty)$

(b) An aluminum sphere weighing 6 kg and initially at temperature of 350°C is suddenly immersed in a fluid at 30°C with convection coefficient of 60 W/m^2K. Estimate the time required to cool the sphere to 100°C. Take thermo physical properties as **07**
$C = 900$ J/kgK, $\rho = 2700$ kg/m^3, $k = 205$ W/mK

OR

Q.4 (a) Explain the Reynolds analogy for laminar flow over a flat plate. **07**

Q.4 (b) Water entering at 10°C is heated to 40°C in a tube of 0.02 m ID at a mass flow rate of 0.01 kg/s. The outside of the tube is covered with an insulated electric heating element that produces a uniform flux of 15000 W/m^2 over the surface. Neglecting any entrance effect, Determine the length of pipe needed for a 30°C increase in average temperature and the pressure drop in the pipe. Use the following properties of water **07**
ρ=997 kg/m^3, C_p=4180 J/kgK, k_f=0.608 WmK, μ=910×10^{-6} Ns/m^2

Q.5 (a) Physically, what does the Grashof number represents? How does the Grashof number differ from the Reynolds number? **04**

(b) Under what conditions can the outer surface of a vertical cylinder be treated as a vertical plate in natural convection calculations? **03**

(c) A hot plate 1 m × 0.5 m at 180°C is kept in still air at 20°C. Find **07**
(i) The heat transfer coefficient
(ii) Initial rate of cooling of the plate in °C/min
Mass of the plate is 20 kg and specific heat is 400 J/kgK. Assume that the 0.5 m side is vertical. Use following correlation.
$Nu_L = 0.59(Ra_L)^{1/4}$
k_f=0.0321 WmK, ν=23.18×10^{-6} m^2/s, Pr = 0.668

OR

Q.5 (a) Define the following term in relation with radiation **07**
(i) Solid angle
(ii) Spectral intensity of radiation $(I_{b\lambda})$
(iii) Radiosity
(iv)Grey body

(b) Calculate the following quantities for the industrial furnace (black body) emitting radiation at 2650°C. **07**
(i) Spectral emissive power at $\lambda = 1.2\mu m$
(ii)Wavelength at which the emissive power is maximum
(iii)Maximum spectral emissive power
(iv)Total emissive power

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