Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER • 2013

Subject code: 712101N Date: 23-12-2013

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)** Derive the expression for the useful work done for the system undergoing a steady flow process in the following form **07**

$$\dot{W} = \sum \dot{m}_i \left(h_i + \frac{V_i^2}{2} + gz_i - T_0 s_i \right) - \sum \dot{m}_e \left(h_e + \frac{V_e^2}{2} + gz_e - T_0 s_e \right) - T_0 \dot{S}_{gen}$$

(b) A piston cylinder device contains 0.05 kg of steam at 1 MPa and 300ºC. The steam now expands to a final state of 200 kPa and 150˚C, during work. Heat losses from a system to the surroundings are estimated to be 2 kJ during this process. Assuming the surroundings to be at T_0 = 25ºC and P_0 = 100 kPa. Determine the availability of steam at the initials and the final states. **07**

Q.2 **(a)** Derive a relation for the Jule-Thomson coefficient and the inversion temperature for a gas whose equation of state is $\left(P + a/v^2\right) = RT$ **07**

(b) Estimate the Joule-Thomson coefficient of steam at (*a*) 3 MPa and 300°C and (*b*) 6 MPa and 500°C. **07**

OR

(b) Using the Maxwell relations and the ideal gas equation of state, show that **07**

$$\left(\frac{\partial s}{\partial v}\right)_T = \frac{R}{v}$$

Q.3 **(a)** Explain the concept of Phase equilibrium for single component system. **07**

(b) A mixture of 3 kmol of CO, 2.5 kmol of O_2 and 8 kmol of N_2 is heated to form CO_2 and CO. Assumed that the remaining O_2 and N_2 will not dissociate, determine the equilibrium composition of the mixture. Take the value of equilibrium constant *Kp* = 16.46. **07**

OR

Q.3 **(a)** A long solid cylinder of radius r_o having uniform heat generation at the rate of g_0. Its outer surface is maintained at temperature T_s. If the center temperature is T_c, show that the temperature distribution in radial direction is given by **07**

$$\frac{T - T_s}{T_c - T_s} = 1 - \frac{r^2}{r_o^2}$$

(b) A plane wall of thickness 0.1 m and thermal conductivity 25 W/m K having uniform volumetric heat generation of 0.3 MW/m^3 is insulated on one side while the other side is exposed to a fluid at 92ºC. The convection heat transfer coefficient between the wall and the fluid is 500 W/m^{2}K. Determine the maximum temperature in the wall. **07**

Q.4 **(a)** If a thin and long fin, insulated at its tip is used, show that the heat transfer from the fin is given by **07**

$$Q_{fin} = \sqrt{hPkA_c}\left(T_0 - T_\infty\right)\tanh mL$$

	(b)	Aluminum sphere weighing 6 kg and initially at temperature of 350ºC is suddenly immersed in a fluid at 30ºC with convective coefficient of 60 W/m^2K. Estimate the time required to cool the sphere to 100ºC. take thermodynamic properties of aluminum as $C = 900$ J/kgK, ρ=2700 kg/m^3, k=205 W/mK	**07**

OR

Q.4	**(a)**	Explain the Prandtl mixing length concept to describe turbulent flow over a flat surface.	**07**
	(b)	Air at 10ºC and at a pressure of 100 kPa is flowing over a plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60ºC. Calculate the following quantities at x = 0. 3. 1. Boundary layer thickness 2. Thermal boundary layer thickness 3. Heat transfer from the plate	**07**
Q.5	**(a)**	Explain the following term in relation with natural convection heat transfer including its physical significance 1. Buoyancy force 2. Rayleigh number 3. Grashof number	**07**
	(b)	Explain the following terms in relation with radiation heat transfer. 1. Solid angle 2. Radiosity 3. Radiation intensity	**07**

OR

Q.5	**(a)**	Explain Wien's displacement law of radiation.	**07**
	(b)	A grey, diffuse opaque surface (α = 0.8) is at 100ºC and receives an irradiation 1000 W/m^2. If the surface area is 0.1 m^2. Calculate 1. Radiosity of the surface 2. Net radiative heat transfer rate from the surface 3. Calculate above quantity if surface is black.	**07**

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