

GUJARAT TECHNOLOGICAL UNIVERSITY
M. E. - SEMESTER – I • EXAMINATION – WINTER • 2013

Subject code: 711101N**Date: 23-12-2013****Subject Name: Advanced Thermodynamics and 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)** Discuss: **07**
- i) “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.”
 - ii) “All reversible engines working between the same temperature reservoirs have the same efficiency.”
- (b)** The amount of entropy generation quantifies the intrinsic irreversibility of a process. Explain. **07**
- Q.2 (a)** Derive the expression for the availability associated with the fluid stream from open system in steady state condition in the following form **07**
- $$\psi = (h - h_0) - T_0 (s - s_0) + \frac{V^2}{2} + gz$$
- (b)** By burning a fuel the rate of heat release is 500 kW at 2000 K. What would be the first law and the second law efficiencies if (a) energy is absorbed at the rate of 450 kW for generation of steam at 500 K and (b) energy is absorbed in a chemical process at the rate of 300 kW at 320 K? Take $T_0 = 300$ K. **07**
- OR**
- (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.3 (a)** 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 $P(v - b) = RT$ **07**
- (b)** Show that the rate of heat conduction through a hollow sphere is given by, **07**
- $$Q_k = -kA_{gm} \frac{T_2 - T_1}{x_w}$$
- Where, $A_{gm} = (A_1 A_2)^{1/2}$, A_1 and A_2 being the areas of inside and outside surfaces of the sphere and x_w = wall thickness.
- OR**
- Q.3 (a)** Derive generalized equation for changes in internal energy and entropy changes. **07**
- (b)** Determine the optimum shape of a fin having the minimum weight for a given heat flow. Explain how the triangular fin is of the best shape. **07**
- Q.4 (a)** What is the physical significance of Biot number? Is the Biot number more likely to be large for highly conducting solids or poorly conducting ones? **07**
- (b)** An egg with a mean diameter of 40 mm and initially at 20 °C is placed in a boiling water pan for 4 minutes and found to be boiled to consumer's taste. For how long should a similar egg for the same consumer be boiled when taken **07**

from a refrigerator at 5 °C. Take the following properties for egg:
 $k = 10 \text{ W/mK}$; $h = 100 \text{ W/m}^2\text{K}$; $c = 2 \text{ kJ/kgK}$ and $\rho = 1200 \text{ kg/m}^3$.
 Use lump capacity method.

OR

- Q.4 (a)** Explain Hottel's crossed string method for estimating shape factor for infinitely long surfaces. Derive the expression for F_{12} in terms of areas and lengths of surfaces. **07**
- (b)** In a 25 mm diameter tube the pressure drop per meter length is 0.0002 bar at a section where the mean velocity is 24 m/s and the mean specific heat of the gas is 1.13 kJ/kg K. Calculate the heat transfer coefficient. **07**
- Q.5 (a)** Determine the mean heat transfer coefficient for natural convection from the surface of a cabinet. The cabinet is mounted on a vertical wall. Its surface temperature is 125 °C and the ambient temperature is 25 °C. What is the rate of heat loss from the surface? **07**
- (b)** Derive an expression for the shape factor in case of radiation exchange between two surfaces. **07**

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)** A long cylindrical heater 2.5cm in diameter is maintained at 660 °C and has surface emissivity of 0.8. The heater is located in a large room whose walls are at 27°C. How much will the radiant transfer from the heater be reduced if it is surrounded by a 30cm diameter radiation shield of aluminum having an emissivity of 0.2? What is the temperature of shield? **07**
