Kadi Sarva Vishwavidyalaya

M.E. Sem I (Thermal Engineering)

Subject: Advanced Thermodynamics and Heat Transfer

Date: 25^{th} May, 2013 Max. Marks: 70

Time: 3 Hrs

Instruction: (1) Answer each section in separate Answer sheet.
(2) Use of Scientific calculator is permitted.
(3) Assume suitable data if necessary.

Section – I

Q.1 Each carries equal marks **[15]**

[A] Determine the maximum work obtainable by using one finite body at temperature T and a thermal energy reservoir at temperature T_0, $T > T_0$

[B] Show that the adiabatic mixing of two fluids is irreversible.

[C] Define unsteady flow process. Explain bottle filling and emptying processes.

OR

[C] Define the second law efficiency. How is it different from the first law efficiency in the case of a simple power plant?

Q.2 **[10]**

[A] Calculate the decrease in available energy when 25 kg of water at 95 ^{0}C mix with 35 kg of water at 35 ^{0}C, the pressure being taken as constant and the temperature of the surroundings being 15 ^{0}C. Take c_p of water is 4.2 kJ/kg K.

[B] The amount of entropy generation quantifies the intrinsic irreversibility of a process. Explain.

OR

Q.2

[A] Three identical finite bodies of constant heat capacity are at temperatures 300, 300 and 100 K. If no work or heat is supplied from outside, what is the highest temperature to which any one of the bodies can be raised by the operation of heat engines or refrigerator?

[B] Derive expressions for the irreversibility of a,
(1) Steam Turbine. (2) Compressor. (3) Heat Exchanger. (4) mixer.

Q.3 **[10]**

[A] 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?

[B] What is law of corresponding state? Explain Van Der Waal's equation as law of corresponding state.

OR

Q.3

[A] Derive the Maxwell relations and explain their importance in thermodynamics.

[B] Find the value of co-efficient of volume expansion β and isothermal compressibility K for a Van der Waals' gas obeying

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

P.T.O.

Section – II

Q.4 **Each carries equal marks** **[15]**

[A] What is lumped capacity? What are the assumptions for lumped capacity analysis?

[B] Explain the relaxation technique to solve the heat transfer problem on two-dimensional steady state conduction with neat sketch.

[C] 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.

OR

[C] What is critical thickness of insulation on a small diameter wire or pipe, Explain its physical significance and derive an expression for the same

Q.5 **[10]**

[A] Derive the equation for Reynold's analogy between fluid friction & Newton's Law of Viscosity.

[B] A short cylinder initially at a uniform temperature T_i is subjected to convection from all of its surfaces to a medium at temperature T_∞. Explain how you can determine the temperature of the midpoint of the cylinder at a specified time.

OR

Q.5

[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.

[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?

Q.6 **[10]**

[A] State and explain Wien's displacement law and define Lambert's cosine law of radiation.

[B] Derive the Von Karman momentum equation for boundary layer flow.

OR

Q.6

[A] Derive an expression for the shape factor in case of radiation exchange between two surfaces.

[B] State and explain Stefan Boltzmann law. Derive an expression for total emissive power of a blackbody.

*******END OF PAPER*******

Kadi Sarva Vishwavidyalaya

M.E. Sem (Thermal Engineering)

Subject: Advanced Thermodynamics and Heat Transfer

Date: 19th January, 2013 Max. Marks: 70

Time: 3 Hrs

Instruction: (1) Answer each section in separate Answer sheet.
(2) Use of Scientific calculator is permitted.
(3) Assume suitable data if necessary.

Section - I

Q.1 Each carries equal marks **[15]**

[A] Show that S_{gen} is not a thermodynamic property.

[B] 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.

[C] State and prove Clausius's theorem.

OR

[C] What is the maximum work obtainable from two finite bodies at temperatures T_1 and T_2?

Q.2 **[10]**

[A] State and explain the Clausius-Claperyon Equation.

[B] The amount of entropy generation quantifies the intrinsic irreversibility of a process. Explain.

OR

Q.2

[A] 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.

[B] What are the causes of entropy increase?

Q.3 **[10]**

[A] Find the value of co-efficient of volume expansion β and isothermal compressibility K for a Van der Waals' gas obeying

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

[B] What is Joule- Thomson coefficient? Why is it zero for an ideal gas?

OR

Q.3

[A] 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?

[B] Define Volume expansivity and isothermal compressibility.

Section - II

Q.4 Each carries equal marks **[15]**

[A] Prove that the temperature of a body at any time τ during Newtonian heating or cooling is given by the relation

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

[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.

[C] An egg with a mean diameter of 40 mm and initially at 20 ^{0}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 from a refrigerator at 5 ^{0}C. Take the following properties for egg: $k = 10$ W/mK; $h = 100$ W/m^{2}K; $c = 2$ kJ/kgK and $\rho = 1200$ kg/m^3.

OR

[C] 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?

Q.5 **[10]**

[A] Derive expression for temperature distribution and heat dissipation in a straight fin of rectangular profile for the case of infinitely long fin,

[B] Show that the rate of heat conduction through a hollow sphere is given by,

$$Q_k = -kA_{gm}\frac{T_2 - T_1}{x_w}$$

Where, $A_{gm} = (A_1A_2)^{1/2}$, A_1 and A_2 being the areas of inside and outside surfaces of the sphere and x_w = wall thickness.

OR

Q.5

[A] State and explain the following :

(i) Nusselt number.

(ii) Prandlt number.

[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.

Q.6 **[10]**

[A] Derive necessary Von-Karnan's expression for convective heat transfer.

[B] 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.

OR

Q.6

[A] State and explain the following laws relating to thermal radiation and temperature of a radiating body :
Planck's law and Wien's displacement law.

[B] 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 $\varepsilon_1 = 0.8$ and $\varepsilon_2 = 0.4$, 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 $F_{12} = 0.38$.

*******END OF PAPER*******