**IMP QUESTIONS**

# PART - A

**(25 Marks)**

1.a) Give an example of combined conduction and convection mode of heat transfer. [2]

1. What are the applications of heat transfer? [3]
2. What is the concept of critical thickness? [2]
3. What is critical radius of insulation? [3]
4. Differentiate the free and forced convection. [2]
5. Discuss the advantage of NTU method over the LMTD method. [3]
6. What is film wise condensation? [2]
7. What is the concept of shape factor? [3]
8. What is the difference between Conduction and Convection? [2]
9. What is a grey body? [3]

# PART - B

**(50 Marks)**

2.a) a) Discuss about the thermal properties of matter.

b) An ice chest whose outer dimensions are 300mm × 400mm × 400mm is made of 30 mm thick Styrofoam (k =0.033W/m 0C). Initially the chest is filled with 40 kg of ice at 00C, and the inner surface temperature of the ice chest can be taken to be 00C at all times. The heat of fusion of ice at 00C is 333.7kJ/kg, and the surrounding ambient air is at 300C. Neglecting any heat transfer from the 400mm × 400mm base of the ice chest, determine how long will it take for the ice in the chest to melt completely if the outer surfaces of the ice chest are at 80C. [5+5]

# OR

1. Derive the general conduction equation for
   1. Cylindrical co-ordinate
   2. Spherical co-ordinates, the system being with uniform heat generation and unsteady state. [5+5]

4.a) Explain why the conductivity of metals decreases and conductivity of insulating material increases with increases in temperature.

b) A metallic plate, 3cm thick is maintained at 4000C on one side and 1000C on the other side. How much heat is transferred through the plate? Take k for the metallic plate as k=370 W/m-K. [5+5]

# OR

5.a) What is critical thickness of insulation on a small diameter wire or pipe, explain its physical significance and derive an expression for the same.

b) Calculate the rate of heat loss for a red brick wall of length 5m, height 4m, and thickness 0.25m, the temperature of the inner surface is 1100C and that of the outer

surface is 400C. The thermal conductivity of red brick k = 0.70 W/m-K. Calculate also

the temperature at an interior point of the wall, 20cm distance from the inner wall[5+5]

6.a) Differentiate between mechanisms of heat transfer by free and forced convection.

Mention some of the areas where these mechanisms are predominant.

b) Water at 750C flows through a 0.005 m diameter tube with a velocity of 1m/s. If the tube wall temperature is 250C, make calculations for the heat transfer coefficient. Use the correlation, St = 0.023 Re 0.2 Pr – 0.667.

The thermo-physical properties of water are:

Thermal conductivity is 0.647 W/(m.K); Viscosity is 1.977 kg/h.m;

Density is 1000 kg/m3; Specific heat 4.187 kJ/(kg.K). [5+5]

# OR

7.a) What are the advantages and limitations of dimensional analysis?

b) Determine the thickness of velocity boundary layer and local shear stress at x=2m from the leading edge of the plate for the boundary layer flow of air at atmosphere pressure of 800C with a velocity of 2m/s.

8.a) Draw the boiling curve for pool boiling of water and explain flow regimes.

b) Saturated steam at a temperature of 650C condenses on a vertical surface at 550C. Determine the thickness of the condensate film at locations 0.2 m and 1.0 m from the top. Also calculate condensate flow rate at these locations. [5+5]

# OR

9.a) Derive an expression for the shape factor in case of a radiation exchange between two surfaces.

b) Show that the emissive power if a black body is π – times the intensity of emitted radiation. [5+5]

10.a) Derive an expression for LMTD in case of a counter - flow heat exchanger.

b) A cross-flow heat exchanger with both fluids unmixed is used to heat water (Cp= 4.18 kJ/kgK) from 500C to 900C, flowing at the rate of 1.0 kg/s. Determine the overall heat transfer coefficient if the hot engine oil (Cp= 1.9 kJ/kgK) flowing at the rate of 3 kg/s enters at 1000C. The heat transfer area is 20 m2. [5+5]

# OR

1. A chemical having specific heat of 3.3 kJ/kg k flowing at the rate of 20000 kg/hr enters a parallel flow heat exchanger at 1200C. The flow rate of cooling water is 50000 kg/hr with an inlet temperature of 200C. The heat transfer area is 10 m2 and the overall heat transfer coefficient is 1050 W/m2K. Find
   1. The effectiveness of the heat exchanger
   2. The outlet temperature of water and chemical.

Take for water, specific heat=4.186KJ/kg K. [5+5]

**IMP QUESTIONS**

**(25 Marks)**

1.a) What is the convection mode of heat transfer? [2]

1. What is thermal diffusivity? [3]
2. What is the function of fin?. [2]
3. What is infinite long cylinder in analysis of transient heat conduction? [3]
4. How Prandtl number links the velocity and temperature fields. [2]
5. What is hydrodynamic layer while analyzing convective heat transfer? [3]
6. What are the advantages of dimensional analysis? [2]
7. What are the advantages of NTU method over the LMTD method? [3]
8. How LMTD and AMTD differs. [2]
9. What is NTU method of a heat exchanger? [3]

# PART - B

**(50 Marks)**

2. A Stainless steel plate is of 2 cm thick is maintained at a temperature of 5500C at one face and 500C on the other. The thermal conductivity of stainless steel at 3000C is

19.1 W/m K. Calculate the heat transferred through the material per unit area.

b) In what way is the science of heat transfer different from thermodynamics? Explain.

[5+5]

# OR

3. Derive the heat conduction equation in a cartesian coordinate system. [10]

4 a) Derive the expression for heat transfer in fins in case of (i) Rectangular plate fin of uniform cross section (ii) insulated end.

b) Determine the heat transfer rate from the rectangular fin of length 20 cm, width 40 cm and thickness 2 cm. The tip of the fin is not insulated and the fin has a thermal conductivity of 150 W/m K. The base temperature is 1000C and the fluid is 200C. The heat transfer coefficient between the fin and the fluid is 30 W/m2K. [5+5]

# OR

1. Briefly describe about lumped heat capacity system. Give its examples. [10]
2. Air at 270C and 1 atm flows over a flat plate at a speed of 2m/s. calculate the boundary layer thickness at a distance of 20 and 40 cm from the leading edge of the plate. Calculate the mass flow which enters the boundary layer between x= 20 cms and x = 40 cms. The viscosity of the air is at 270C is 1.85 × 10-5 kg/m s. Assume the unit depth in the z- direction. [10]

# OR

1. Liquid bismuth flows at a rate of 4.5 kg/s through a 5 cm diameter stainless steel tube. The bismuth enters at 4150 C and is heated to 4400C as it passes through the tube. If a constant heat flux is maintained at along the tube and the tune wall is at a temperature 200C higher than bismuth bulb temperature, calculate the length of the tube required to affect the heat transfer. [10]
2. How the condensation and boiling phenomenon heat transfer takes place. Give basic equations. [10]

# OR

1. Two perfectly black parallel planes 1.2 by 1.2 m are separated by a distance of 1.2 m. one plane is maintained at 800 K and the other at 500 K. The plates are located in a large room whose walls are at 300K. What is the net heat transfer between the planes?

[10]

10.a) What are compact heat exchangers?

b) What is the purpose of a regenerator? [5+5]

# OR

11. Hot oil (cp = 2.09 kJ/kg K) flows through a counter flow heat exchanger at the rate of 0.7kg/s. it enters at 2000C and leaves at 700C. the cold oil (cp = 1.67 kJ/kg K ) exits at 1500C at the rate of 1.2 kg/s. Determine the surface area of the heat exchanger required for the purpose if the overall heat transfer coefficient is 650W/m2K. [10]

**IMP QUESTIONS**

1.a) Give an example of combined convection and radiation mode of heat transfer. [2]

1. What are the different modes of heat transfer? Explain. [3]
2. How the fin thickness influences the efficiency of a fin [2]
3. What is film wise and drop wise condensation. [3]
4. Define an ideal fluid and a real fluid. [2]
5. Differentiate between laminar and turbulent flow. [3]
6. Why drop wise condensation is preferred to film wise condensation? [2]
7. What are the types of condensation processes? Explain. [3]
8. What is fouling factor? [2]
9. How are heat exchangers classified? [3]

# PART - B

2. Derive the heat conduction equation in Spherical coordinates. [10]

# OR

3.a) Define thermal diffusivity? What is the significance of thermal diffusivity in heat conduction process?

b) A plane wall is 150mm thick and its wall area is 4.5m2. Its conductivity is 9.35W/m-K and temperatures are steady at 1500C and 450C on both sides. Determine the temperature gradient in flow direction. [3+7]

1. A long cylinder of (α= 6.11×10-6m2/s, k= 21W/m-K) 12 cm in diameter, initially at

200C, is placed into a furnace at 8000C. Calculate the time required for the centre to reach 7600C. Also calculate the temperature at a radius of 5.4 cm at the same time. (Take h= 140W/m2-K). [10]

# OR

1. A steel pipe (k= 43.25 W/m-K) of 5cm inner diameter and 7.5cm outer diameter is covered with 2.5cm layer of asbestos insulation (k= 0.205W/m-K). The inside surface

of the pipe receives heat by convection from a hot gas at a temperature of 3150C with a heat transfer coefficient of 285W/m2-K while the outer surface is exposed to ambient air at 370C with a heat transfer coefficient of 17W/m2-K.

Estimate: (a) The heat loss to ambient air for 3m length of the pipe and

(b) The temperature drop across the pipe material and the insulation layer. [5+5]

1. Determine the heat transfer rate by free convection from a plate 0.3m × 0.3m for which one surface is insulated and the other surface is maintained at 1100C and exposed to atmosphere air at 300C for the following arrangements:
   1. The plate is vertical
   2. The plate is horizontal with the heating surface facing up
   3. The plate is horizontal with the heating surface facing down. [10]

# OR

7. Describe Buckingham’s method of π-terms to formulate a dimensionally homogenous equation. b) A flat plate 1m wide and 1.5 m long is to be maintained at 900C in air when free stream temperature is 100C. Determine the velocity at which air must flow over the plate so that the rate of energy dissipation from the plate is 3.75kW. [5+5]

[3+7]

8.a) What are the types of boiling processes?

b) Saturated water at 1000C is boiled inside a copper pan having a heating surface area 5×10-2m2 which is maintained at uniform surface temperature of 1100C. Calculate the surface heat flux and the rate of evaporation. [3+7]

# OR

9.a) Define radiation shape factor.

b) Two circular disc of diameter 20cm each are placed 2m apart. Calculate the radiant heat exchange for these plates if these are maintained at 8000C and 3000C respectively and their corresponding emissivities are 0.3 and 0.5. [2+8]

10.a) What is a heat exchanger?

b) In a counter flow double pipe heat exchanger, water is heated from 250C to 650C by oil with a specific heat of 1.45kJ/kg-K and mass flow rate of 0.9kg/s. the oil is cooled from 2300C to 1600C. If overall heat transfer coefficient is 420W/m2-K. Calculate the rate of heat transfer, mass flow rate of water and surface area of heat exchanger. [2+8]

# OR

11. In a food processing plant, a brine solution is heated from 80C to 140C in a double pipe heat exchanger by water entering at 550C and leaving at 400C at the rate of 0.18kg/s. if the overall heat transfer coefficient is 800 W/m2K, determine the area of heat exchanger required

* 1. For a parallel flow arrangement, and
  2. For counter flow arrangement. Take cp for water = 4.18kJ/kgK. [5+5]

**IMP QUESTIONS**

1.a) Differentiate between Steady, Unsteady and Periodic heat transfer. [2]

1. State Fourier’s law of heat conduction? Why the negative sign is used. [3]
2. Define thermal conductivity. [2]
3. What is the difference between the fin effectiveness and the fin efficiency? [3]
4. Differentiate between Natural and Forced convection. [2]
5. Sketch the temperature and velocity profiles in free convection on a vertical wall. [3]
6. What is condensation? How does it occur? [2]
7. Discuss some methods of enhancing pool boiling heat transfer permanently. [3]
8. What is a heat exchanger? What are its applications? [2]
9. Briefly explain lumped heat capacity method. [3]

# PART - B

2.a) Derive conduction equation for spherical coordinate systems.

b) An insulated pipe of 50 mm outside diameter (€=0.8) is laid in a room at 30 0C. If the surface temperatures is 250 0C and the convective heat transfer coefficient is 10 W/m2K. Calculate the heat loss per unit length of pipe. [5+5]

# OR

3.a) Does any of the energy of the sun reach the earth by conduction or convection?

Explain.

b) A pipe 2 cm in diameter at 300 C is placed in (i) an air flow at 500C with h=20 W/m2K and in (ii) water at 300C with h=70W/m2K. Find the heat transfer rate per unit length of the pipe. [5+5]

4. .a) What criteria’s are considered while deigning and selecting a fin?

b) Define the effectiveness of a fin while justifying its usage

5.a) Derive the expression for heat transfer under transient mode.

b) Two large steel plates at temperatures of 1200C and 800C are separated by a steel rod 300 mm long and 25 mm in diameter. The rod is welded to each plate. The space between the plates is filled with insulation, which also insulates the circumference of the rod. Because of a voltage difference between the two plates, current flows through the rod, dissipating electrical energy at a rate of 150W. Find out the maximum temperature in the rod and the heat flux. Take k for the rod as 47 W/m K. [5+5]

6.a) State Buckingham pi theorem . What are the merits and demerits?

b) Air at 200kPa and 2000C is heated as it flows through a tube with a diameter of 25 mm at a velocity of 10 m/sec. The wall temperature is maintained constant and is 200C above the air temperature all along the length of tube. Calculate: (i) The rate of heat transfer per unit length of the tube. (ii) Increase in the bulk temperature of air over a

3 m length of the tube. [5+5]

# OR

7.a) A 2.2cm outer diameter pipe is to cross a river at a 30m wide section while being completely immersed in water The average flow velocity of water is 4 m/s and the water temperature is 150C. Determine the drag force exerted on the pipe by the river.

b) A steam pipe 10 cm OD runs horizontally in a room at 230 C. Take outside temperature of pipe as 1650 C. Determine the heat loss per unit length of the pipe. Pipe surface temperature reduces to 800 C with 1.5 cm insulation. What is the reduction in heat loss?

[5+5]

8.a) Explain what do you mean by absorptive, reflectivity and transmissivity.

b) Estimate the power required to boil water in a copper pan, 0.35m in diameter. The pan is maintained at 1200C by an electric heater. What is the evaporation rate? Estimate the critical heat flux. [5+5]

# OR

9.a) Write expression for blackbody radiation.

b) A thin aluminium sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures Tl = 800 K and

T2 = 500 K and have emissivities 1 = 0.2 and 2

= 0.7 respectively. Determine the net

rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without shield. [5+5]

10.a) Derive NTU of parallel flow and counter flow heat exchangers.

b) In a Double pipe counter flow heat exchanger 10000 kg/h of an oil having a specific heat of 2095 J/kgK is cooled from 800C to 500C by 8000 kg/h of water entering at 250C. Determine the heat exchanger area for an overall heat transfer coefficient of 300 W/m2K. Take Cp for water as 4180 J/kgK. [5+5]

# OR

11.a) Derive an expression for effectiveness of counter flow heat exchanger.

b) After a long time in service, a counter flow oil cooler is checked to ascertain if its performance has deteriorated due to fouling. In the heat transfer surface is 3.33 m2 and the design value of the overall heat transfer coefficient is 930 W/m2K, how much has it been reduced by fouling? Cp of oil as 2330 J/kg K and cp of water as 4174 J/kgK. [5+5]

# MODELPAPER -5

# PART - A

**(25 Marks)**

1.a) Give some examples of heat transfer in engineering. [2]

1. What is thermal contact resistance? [3]
2. What is heat generation in a solid? Give examples. [2]
3. What is infinite plate in analysis of transient heat conduction? [3]
4. How Reynolds number is a criterion for dynamic similarity. [2]
5. What is Buckingham’s Π theorem? [3]
6. What is radiation shape factor? [2]
7. What are the various radiation properties? [3]
8. Describe the selection criteria of heat exchanger. [2]
9. What is the range of effectiveness of a heat exchanger? [3]

# PART - B

**( 50 Marks)**

2.a) Describe the boundary conditions for steady, unsteady and periodic heat transfer.

b) An aluminum pan whose thermal conductivity is 237W/(m0C) has a flat bottom with diameter 100mm and thickness 6 mm. Heat transferred steadily to boiling water in the pan through its bottom at a rate of 500W. If the inner surface of the bottom of the pan is at 1500C, determine the temperature of the outer surface of the bottom of the pan.

[5+5]

# OR

1. Derive the heat conduction equation in a cylindrical coordinate system. [10]
2. Describe the temperature distribution along the length of a fin for four various boundary conditions at tip. [10]

# OR

1. A very long, 10 mm diameter cooper rod (k= 370W/mK) is exposed to an environment at 200 C. the base temperature of the rod is maintained at 1200C. The heat transfer coefficient between the rod and the surrounding air is 10 W/m2 K.
   1. Determine the heat transfer rate for finite lengths, 0.02, 0.04,0.08,0.2,0.4,0.8,1 and 10 meters assuming heat loss at the end, and
   2. Compare the result with that of an infinitely long fin whose tip temperature equals the environment temperature of 200C

[5+5]

1. Estimate the heat loss from a vertical wall exposed to nitrogen at one atmospheric pressure and 40C. The wall is 0.2m high and 2.5 m wide, and is maintained at 560C. The average Nusselt number NuH over the height of the plate for natural convection is given by NuH = 0.13(Gr. Pr) 1/3. The properties for nitrogen at a mean film temperature of (56 + 4)/2 = 300C are given as ρ= 1.142 kg/m3, k = 0.026 W/m K,

v = 15.63 × 10-6 m2/s, Pr = 0.713. [10]

# OR

1. Derive the expression for boundary layer thickness for free convection heat transfer on a vertical flat plate. [10]
2. Water at 1atm boils in a stainless steel kitchen pan with ΔTx = 80C. Estimate the heat flux which will be obtained if the same pan operates as a pressure cooker at 0.17MPa, what percentage increases in heat flux might be expected? [10]

# OR

1. A room 4×4 m square by 3 × 3 m height has one side wall maintained at 2600C; the floor is maintained at 900C. The other four surfaces are perfectly insulated assume that all surfaces are black. Calculate the net heat transfer between the hot wall and the cool floor. [10]
2. Describe the process followed in design of a simple shell and tube heat exchanger. [10]

# OR

11. .a) Define effectiveness of heat exchanger.

b)Derive the equation for parallel flow heat exchanger using NTU method. [2+8]