Code No: RR310803 **Set No.1**

III B.Tech. I Semester Regular Examinations, November -2005
HEAT TRANSFER
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive the expression for pin efficiency in case of a pin fin. [8]
   (b) Explain the advantages of entended surface heat exchangers. [8]

2. (a) Derive an equation for temperature distribution in a hollow sphere. [8]
   (b) Hot gas at a constant temperature of 400^oC is contained in a spherical shell (2000mm 1D, 50mm thick) made of steel. Mineral wool insulation (k=0.06 w/m-k) of thickness 100mm is wrapped all around it. Calculate the steady rate at which heat will flow out if the outside air is at a temperature of 30^oC. HTC on the inner surface of the steel shell and on the outer surface of the insulation is 15 w/m^2K. [8]

3. (a) Show that coefficient of thermal expansion of an ideal gas equals the reciprocal of absolute temperature. [5]
   (b) What is Peclet number? When is it computed? [5]
   (c) In a heat exchanger, water flows through a 0.02 m inner diameter copper tube at a velocity of 1.5 m/s. The water entering the tube at 15^0C is heated by steam condensing at 100^0C on the outside surface of the tube. What would be heat transfer coefficient for water if it is to leave the pipe at 45^0C? The physical properties of water at the bulk temperature 30^0C are as follows.
   Thermal conductivity is 0.6172 W/(m.K)
   Kinematic Viscosity 0.805×10^{-6} m^2/s
   Density 995 kg/m^3.
   Specific heat 4171 J/(kg.K) [6]

4. Benzene is cooled from 61^0C to 21^0C in the inner pipe of a double pipe heat exchanger. Cooling water flows countercurrently to the benzene, entering the jacket at 16^0C and leaving at 27^0C. The linear velocity of benzene is 1.52 m/s and that of the water is 1.25 m/s. Neglecting the wall and scale resistances, compute the film coefficients of the benzene and water and the overall coefficient based on the outside area of the inner pipe. The inner diameter and outer diameter of the inner tube are 0.0189 m and 0.0222 m respectively. The inside diameter of the jacket is 0.0409 m. The physical properties of benzene and water at the average temperatures are given in the table below: [16]

Property	Benzene	Water
Density kg/m^3	851	998
Viscosity kg/m-s	4.795×10^{-4}	9.67×10^{-4}
Thermal conductivity W/ (m.K)	0.1549	0.598
Specific heat kJ/(kg.K)	1.8212	4.187
Viscosity correction factor	0.969	1.018

5. (a) Write a short notes on condensation of superheated vapors. [8]

   (b) Explain the effect of non-condensable gases on rate of condensation. [8]

6. (a) Calculate the heat loss from an uninsulated 5 cm dia horizontal pipe at 220 C to the still air of a room at 30^0 C. The combined heat transfer coefficient is 20 W/m^2.K. [8]

   (b) Calculate the heat loss per linear square foot from a 10 Cm(11.4 cm outer dia) , nominal diameter horizontal pipe covered with 2.5 cm of insulation k = 0.07 W/m.K) assuming that the pipe and the still air temperatures of the room are 200 C and 30 C respectively. The combined heat transfer coefficient is 12 W/m^2. K [8]

7. (a) A heat exchanger of total outside surface area of 17.5 m^2 is to be used for cooling oil at 200^oC with a mass flow rate of 2.77 kg/s having a specific heat of 1.9 kJ/kgK. Water at a flow rate of 0.83 kg/s is available at 20^oC as a cooling agent. Calculate the exit temperature of the oil if the heat exchanger is operated in a parallel flow mode by NTU method. [8]

   (b) Explain the constructional features and working of plate type heat exchanger. [8]

8. (a) With a neat diagram explain a long vertical tube evaporator. [8]

   (b) Discuss the accessories used in evaporators. [8]

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Code No: RR310803 **Set No.2**

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HEAT TRANSFER
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. In order to measure the effective k of a powder, the material is packed in the annulus between two aluminium spheres. The OD of inner sphere is 60 mm and the ID of outer sphere is 80 mm. The core of the assembly is electrically heated. In a experiment, the power supply to the core is 100W when the temperatures of the aluminium surfaces are found to be 210 and 60^0C. What is the k of the sample? [16]

2. (a) Explain the critical radius concept in case of curved insulation. [8]
   (b) Derive an expression for critical radius for a tube lagged with an insulation material. [8]

3. (a) i. What do you understand by hydrodynamic and thermal boundary layers? Illustrate with reference to flow over a heated flat plate. How is the boundary layer thickness defined? [8]
   ii. A steam pipe 0.05 m diameter and 2.5 m long has been placed horizontally and exposed to still air at 25^0C. If the pipe wall temperature is 295^0C, determine the rate of heat loss. At the mean temperature of 160^0C, the thermo-physical properties of air are:
   Thermal conductivity is 0.036 W/(m.K)
   Kinematic viscosity is 30.09 $\times 10^{-6} m^2$/s
   Pr = 0.682.
   For laminar flow over horizontal cylinders within the range $10^3 < (Gr.Pr) <$ 109, use Nu = 0.53 $(GrPr)^{0.25}$. [8]

4. Benzene is cooled from 61^0C to 21^0C in the inner pipe of a double pipe heat exchanger. Cooling water flows countercurrently to the benzene, entering the jacket at 16^0C and leaving at 27^0C. The linear velocity of benzene is 1.52 m/s and that of the water is 1.25 m/s. Neglecting the wall and scale resistances, compute the film coefficients of the benzene and water and the overall coefficient based on the outside area of the inner pipe. The inner diameter and outer diameter of the inner tube are 0.0189 m and 0.0222 m respectively. The inside diameter of the jacket is 0.0409 m. The physical properties of benzene and water at the average temperatures are given in the table below: [16]

Property	Benzene	Water
Density kg/m^3	851	998
Viscosity kg/m-s	4.795×10^{-4}	9.67×10^{-4}
Thermal conductivity W/ (m.K)	0.1549	0.598
Specific heat kJ/(kg.K)	1.8212	4.187
Viscosity correction factor	0.969	1.018

5. A vertical tubular condenser is to be used to condense 650 Kg/hr. of ethyl alcohol, which enters at a atmospheric pressure. Cooling water is to flow through the tubes at an average temperature of 30^oC, The tubes are 2.5 cm OD and 2.1 cm ID. The waterside coefficient is 2440 Kcal/m^2 hr_oC. Neglect fouling factors and the resistance of the metal wall. If the available tubes are 2.5m long. Calculate the number of tubes required for the job.
Given condensation temperature of alcohol = 78^oC.
Heat of vaporization = 205 Kcal/Kg
Density of alcohol = 768 Kg/m^3
Water properties at 30^oC.
Specific heat : 4.174 kJ/kg^ok.
Viscosity : 6.5 x 10^{-4} N sec/m^2
k = 0.634 w/m.k

[16]

6. (a) Explain in detail how the combined heat losses by conduction, convection and radiation can be estimated. [6]
(b) Give three practical examples for the above situation. [5]
(c) Write a note on radiation in film boiling. [5]

7. (a) Write briefly about condensers used in evaporation [8]
(b) Derive an expression for LMTD in case of a counter - current flow double pipe heat exchanger [8]

8. A solution of organic colloids is to be concentrated from 20 to 70 percent solids in a vertical tube evaporator. The solution has a negligible elevation in boiling point, and the specific heat of the feed is 0.93. Saturated steam is available at 0.7 atm abs, and the pressure in the condenser is 100 mm Hg abs. The feed enters at 25^oC. The overall coefficient is 1700 W/m^{2o}C. The evaporator must evaporate 20,000 kg of water per hour. How many square meters of surface are required and what is the steam consumption in kg per hour? [16]

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Code No: RR310803 **Set No.3**

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HEAT TRANSFER
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. Find the steady state heat flux through the infinite composite slab made up of two materials. Also find the interface temperature T_1. The thermal conductivities of the two materials vary linearly with temperature as
k_1= 0.05 (1+0.008T) w/mK
k_2= 0.04 (1+0.075T) w/mK
Where T is ^oC
As shown in the Figure 1 [16]

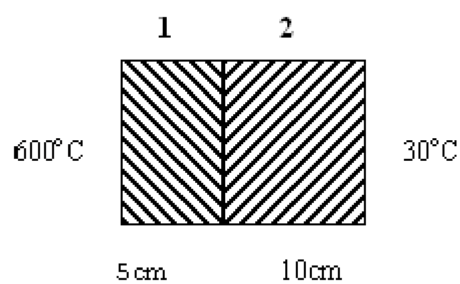

Figure 1:

2. The outside and inside surface temperatures of a 20cm outer diameter and 18cm inner diameter pipe (k=40W/mK) are 400^oC and 460^oC respectively. Calculate the reduction in heat loss if a 5cm layer of insulation (k=0.06 W/mK) is put on the pipe. Assume that the inner and outer surface temperature of insulation is 390^oC and 140^oC . What is the inside surface temperature of this pipe in this case? [16]

3. (a) How the local and average convection coefficients for flow past a flat plate are related? Derive the relationship. [8]
   (b) Water at 75^0C flows through a 0.005 m diameter tube with a velocity of 1m/s. If the tube wall temperature is 25^0C, 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/m^3 Specific heat 4.187 kJ/(kg.K)
   [8]

4. (a) What is viscosity correction factor? When and where this factor is employed? [5]

(b) What is the effect of roughness of tube on heat transfer coefficient? [5]

(c) Crude oil at 160^0C is flowing through a 0.075 m diameter tube at the rate of 1600 kg/h. The pipe is 20m long and its surface temperature is maintained at a temperature of 100^0C. The properties of oil are:
Thermal conductivity is 0.1163 W/m^0K
Kinematic viscosity is 5×10^{-6} m^2/s
Density is 800 kg/m^3.
Pr = 80
μ at $100^0C = 4 \times 10^{-3}$ kg/m.s
μ at $100^0C = 8.9 \times 10^{-3}$ kg/m.s
[6]

5. (a) Write a short notes on pool boiling of saturated liquid. [8]

(b) Explain the effect of pressure on maximum boiling heat flux and critical temperature drop. [8]

6. (a) Making use of the Plank's law of distribution, establish the relation for the Wein's displacement law. [5]

(b) The sun emits maximum radiation at $\lambda = 0.52$ μ. Assuming the sun to be a black body, calculate the surface temperature of sun and the emissive ability of the sun's surface at that temperature. [5]

(c) Determine the maximum monochromatic emissive power of the sun's surface. [6]

7. Cold water at the rate of 4 Kg/sec is heated from30^oC to 50^oC in a single shell and two tube pass heat exchanger. Heating medium is hot water supplied at 95^oC at the rate of 2 Kg / sec. Cold water flows through the tubes. The overall heat transfer coefficient is 1330 W/m^{2o}C. The average water velocity is 0.38 m/sec inside the tubes. The diameter of tube is 2 cms. Calculate

(a) Number of tubes in each pass [8]

(b) Length of tube in each pass
Take specific heat of water to be constant at 4.17 kJ/kg.k. [8]

8. (a) What is meant by economy in evaporation and how does it vary with multiple effect evaporation? [8]

(b) What are the advantages and disadvantages of multipass heat exchangers over single pass heat exchangers? [4]

(c) Explain the functions of baffles in shell and tube heat exchangers? [4]

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Code No: RR310803 **Set No.4**

III B.Tech. I Semester Regular Examinations, November -2005
HEAT TRANSFER
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive an equation for rate of heat loss through a composite cylinder. [8]
   (b) A pipe carrying condensing steam has unit surface conductance of the steam side film 5655 w/m^2K and that of the outside air film 7.85 w/m^2 K. Calculate the temperature of outer surface of the pipe laid in a room at temperature 30^0C. Take thermal resistance of pipe is 1.85 x 10^{-4} K / w per m^2 of pipe. [8]

2. (a) Derive an equation for temperature distribution in a hollow sphere. [8]
   (b) Hot gas at a constant temperature of 400^oC is contained in a spherical shell (2000mm 1D, 50mm thick) made of steel. Mineral wool insulation (k=0.06 w/m-k) of thickness 100mm is wrapped all around it. Calculate the steady rate at which heat will flow out if the outside air is at a temperature of 30^oC. HTC on the inner surface of the steel shell and on the outer surface of the insulation is 15 w/m^2K. [8]

3. (a) Show that coefficient of thermal expansion of an ideal gas equals the reciprocal of absolute temperature. [5]
   (b) What is Peclet number? When is it computed? [5]
   (c) In a heat exchanger, water flows through a 0.02 m inner diameter copper tube at a velocity of 1.5 m/s. The water entering the tube at 15^0C is heated by steam condensing at 100^0C on the outside surface of the tube. What would be heat transfer coefficient for water if it is to leave the pipe at 45^0C? The physical properties of water at the bulk temperature 30^0C are as follows.
   Thermal conductivity is 0.6172 W/(m.K)
   Kinematic Viscosity 0.805×10^{-6} m^2/s
   Density 995 kg/m^3.
   Specific heat 4171 J/(kg.K) [6]

4. Air flowing at 4.75 m/s through a pipe of inner diameter of 0.025 m is used for cooling a nuclear reactor. Air enters the pipe at 15^0C and the surface temperature of the pipe is maintained at 150^0C. Find the following: [8+8]
   (a) the exit temperature of air, and
   (b) the total heat transfer rate for a pipe length of 5 m using Colburn analogy.

   The average fluid properties may be taken as:
   Thermal conductivity is 0.03 W/(m.K)

Viscosity is 2.03×10^{-5} PaS
Density is 1.00 kg/m^3.
Specific heat 1.01 kJ/(kg.K)
The skin friction may be computed from f = 0.0014 + 0.125 $Re^{-0.32}$

5. (a) Explain about film boiling. [6]
   (b) Discuss the merits and demerits of film wise and drop wise condensation. [10]

6. Write short notes on: [4+4+4+4]
   (a) Angle of vision
   (b) Diffuse reflection
   (c) Attenuation
   (d) View factor

7. (a) Discuss the advantages of NTU method over the LMTD method in the design of heat exchanger [8]
   (b) Classify various types of evaporators with industrial applications. [8]

8. A solution is concentrated from 20 % to 65% solids. (Specific heat of feed 0.3) Steam at 2 atm is used. Pressure in the condenser is 100 mm Hg absolute. Feed enters at 25^{o}C, overall heat transfer coefficient is 1800 W/m^{2o}C. The evaporator must evaporate 20,000 kg/hr of water as vapour. Calculate the steam needed, economy and heat transfer area required. λ_s = 2197 kJ/kg, λ = 2375 kJ/kg. [16]

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