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

III B.Tech I Semester Regular Examinations, November 2006
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 15mm dia steel sphere ,k = 42W/m^{0}C, is exposed to cooling airflow at 20^{0}C resulting in the convective coefficient h = 120 W/m2.C. Determine
   (a) Time required to cool the sphere from 550 to 90^{0}C
   (b) Instantaneous H T rate 2 min. after the start of the cooling
   (c) Total energy transferred from the sphere during the first 2 min.
   Data: Density = 7850 kg/m^3, C$_p$ = 475 J/kg^{0}C and α=0.045 m^2/h [8+4+4]

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) Determine the hydraulic radius for the following cross sections:
      i. Circular tube of diameter D
      ii. Square tube of dimensions s × s. [4+4]
   (b) Estimate the heat transfer from a 40 W incandescent bulb at 125^0C to 25^0C in quiescent air. Approximate the bulb as a 0.05 m diameter sphere. What percentage of the power is lost by free convection? The appropriate correlation for the free convection coefficient is Nu=0.60$(GrPr)^{0.25}$ where the different parameters are evaluated at the mean film temperature and the characteristic length is diameter of the sphere. The properties at mean temperature are
   Thermal conductivity is 0.03 W/(m.K)
   Kinematic viscosity is 20.55 × 10^{-6} m^2/s
   Pr = 0.693. [5]

5. Steam saturated at 68.9kPa (10 psia) is condensing on a vertical tube 1.22m, high, having an OD of 0.0254m and a surface temperature of 86.11^oC. Calculate the average heat-transfer coefficient using English and SI units. [16]
   Properties of water
   $\rho = 968$ kg/m^3
   k = 0.58 w/m^oC
   $C_p = 4180$ j/kg^oC
   $\mu = 1.14$ x 10^{-6} N.sec/m^2

6. (a) A surface, upon which radiant energy of intensity 600 W/m^2 strikes, absorbs 400 W/m^2, transmits 50 W/m^2 and reflects the remainder. Compute the values for the absorptivity, reflectivity and transmissivity. [8]
   (b) 1500 W/m^2 energy strikes a gray surface where 1000 W/m^2 are reflected and 300 are transmitted through the surface of the material. Compute the absorptivity of the material. [8]

7. (a) Derive an expression for LMTD for a parallel flow double pipe heat exchanger [6]
   (b) Explain the method of correcting LMTD for a multipass shell and tube heat exchanger. [5]
   (c) Why is a counter current flow heat exchanger more suitable than a parallel flow heat exchanger. [5]

8. A solution is to be concentrated from 10 % to 50% solids in a single effect evaporator. Steam is available at 2 bar absolute. The vapour space inside the evaporator is at 100 mm Hg vacuum. The feed rate to the evaporator is 25,000 kg/hr. Overall heat transfer coefficient is 2840 W/m^2o^C. Specific heat of solution is 3700 J/Kg^oC. Calculate the area of heating surface required if the feed is at 50^oC. Latent heat of vaporization at steam temperature = 2197 kJ/kg, at temperature in vapour space = 2375 kJ/kg. Specific whose feed solution in 3.77 kJ/kg k. [16]

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Answer any FIVE Questions
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1. Liquid N_2 is stored in a spherical container 0.35 m diameter at one atmosphere total pressure.. The saturation temperature of N_2 is 7704 K, the latent heat of evaporation is 200 KJ/kg and the specific volume of saturated liquid and saturated vapor are 0.00125 and 0.127 m^3/kg respectively.
   It is desired to insulate the outside of the spherical steel container with asbestos such that some liquid N_2 will remain 36 hours after the vessel is filled. How thick should the asbestos insulation layer be? The vessel is vented to the atmosphere at 2974 K and the outside surface co-efficient is 45 w/m2 K?
   How fast will half of the liquid N_2 in the specific vessel be lost if the 6.35mm steel container is not insulated with the same h_o 45 w/m K? [16]

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) What is a dimensionless number? How and why they are used in heat transfer? [5]
   (b) Differentiate bulk mean temperature and film temperature. [5]
   (c) The sloping roof of a house receives energy by radiation from the sun. The roof surface reaches a steady uniform temperature of 60^0C, and the ambient air temperature is 32^0C. For roof dimensions of 9 m by 5.5 m, and a convection heat-transfer coefficient of 11 W/ (m^2.K), determine the heat transferred by convection to the air. [6]

4. (a) Determine the hydraulic radius for the following cross sections:
      i. Circular tube of diameter D
      ii. Square tube of dimensions s × s. [4+4]
   (b) Estimate the heat transfer from a 40 W incandescent bulb at 125^0C to 25^0C in quiescent air. Approximate the bulb as a 0.05 m diameter sphere. What percentage of the power is lost by free convection? The appropriate correlation for the free convection coefficient is Nu=$0.60(GrPr)^{0.25}$ where the different parameters are evaluated at the mean film temperature and the characteristic length is diameter of the sphere. The properties at mean temperature are
      Thermal conductivity is 0.03 W/(m.K)
      Kinematic viscosity is 20.55 × 10^{-6} m^2/s
      Pr = 0.693. [5]

5. (a) Explain about nucleate boiling. [8]
   (b) Explain about Heat Transfer in boiling. [8]

6. Two parallel square plates, each 4 m^2 area, are large compared to a gap of 5 mm separating them. One plate has a temperature of 800 K and surface emissivity of 0.6 while the other has a temperature of 300 K and a surface emissivity of 0.9.
   (a) Find the net energy exchange by radiation between the plates. [8]
   (b) if a thin polished sheet of surface emissivity 0.1 on both sides is located centrally between the two plates, what will be its steady state temperature? [8]

7. (a) Derive an expression for LMTD for a parallel flow double pipe heat exchanger [6]
   (b) Explain the method of correcting LMTD for a multipass shell and tube heat exchanger. [5]
   (c) Why is a counter current flow heat exchanger more suitable than a parallel flow heat exchanger. [5]

8. A solution is to be concentrated from 10 % to 50% solids in a single effect evaporator. Steam is available at 2 bar absolute. The vapour space inside the evaporator is at 100 mm Hg vacuum. The feed rate to the evaporator is 25,000 kg/hr. Overall heat transfer coefficient is 2840 W/$m^2 o^C$. Specific heat of solution is 3700 J/Kg^oC. Calculate the area of heating surface required if the feed is at 50^oC. Latent heat of vaporization at steam temperature = 2197 kJ/kg, at temperature in vapour space = 2375 kJ/kg. Specific whose feed solution in 3.77 kJ/kg k. [16]

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

III B.Tech I Semester Regular Examinations, November 2006
HEAT TRANSFER
(Chemical Engineering)

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

Answer any FIVE Questions
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1. A 15mm dia steel sphere ,k = 42W/m^{0}C, is exposed to cooling airflow at 20^{0}C resulting in the convective coefficient h = 120 W/m2.C. Determine
   (a) Time required to cool the sphere from 550 to 90^{0}C
   (b) Instantaneous H T rate 2 min. after the start of the cooling
   (c) Total energy transferred from the sphere during the first 2 min.
   Data: Density = 7850 kg/m^3, C$_p$ = 475 J/kg^{0}C and α=0.045 m^2/h [8+4+4]

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) 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) How is Stanton number computed? Explain its physical significance. [5]
   (b) Explain in detail liquid metal heat transfer. [5]
   (c) A plate 0.6 m high and 0.3 m wide, having a surface temperature of 35^0C, is in contact with air at 20^0C. If the observed convective heat transfer rate is 45W for each side, compute the average convection coefficient. [6]

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

6. A polished metal pipe 5 cm outside diameter and 370 K temperature at the outer surface is exposed to ambient conditions at 295 K temperature. The emissivity of the surface is 0.2 and the convection coefficient of heat transfer is 15 W/m^2.K. calculate the heat transfer by radiation and natural convection per meter length of the pipe. Take the thermal radiation constant $\sigma = 5.67 \times 10^{-8}$ W/m^2 K^4. [16]

7. (a) Derive the relationship between effectiveness and number of transfer units for a parallel flow heat exchanger. [8]

   (b) Determine the heat transfer area required for a heat exchanger constructed from a 2 cm OD tube to cool 26,000 kg/hr of an alcohol solution (C_p =3.81 kJ/kgK) from 90 to 50^oC, using H_2O which enters at 20^oC and leaves at 40^oC and for the following arrangements: [4]

      i. co current shell and tube

      ii. counter current shell and tube heat exchanger, alcohol in shell and H_2O through the tubes. (Assume correction factor for LMTD = 0.95). Assume that the overall heat transfer coefficient based on the outer tube area is 830 kJ/hrm^2K. [4]

8. (a) With a neat diagram, explain the working of a Floating head Heat Exchanger. [8]

   (b) With a neat diagram, explain the working of a forced circulation evaporator. [8]

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

III B.Tech I Semester Regular Examinations, November 2006
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) 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) What is dimensional analysis? Explain any one method of dimensional analysis? [8]
   (b) Ethylene glycol enters a 5 m length of 0.1m diameter copper tube in a cooling system at a velocity of 5 m/s. Estimate the heat transfer rate if the average bulk temperature is 20^0C and the tube wall is maintained at 100^0C. The properties of ethylene glycol at 20^0C are as follows.
   Thermal conductivity is 0.249 W/m^0K
   Kinematic viscosity is 1.92 $\times$ 10^{-5} m^2/s
   Pr = 204. [8]

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 $\times$ 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 nucleate boiling. [8]
   (b) Explain about Heat Transfer in boiling. [8]

6. (a) State Stefan-Boltzman law of total radiation from a black body. [5]
   (b) How this law can be modified to take into account radiation from a non-black body? [5]
   (c) A steel plate is placed on a non-conducting opaque surface normal to incident solar radiation of 750 W/m^2. Neglecting convection effects, Calculate the equilbrium temperature of the plate when the emissivity is 0.8 [6]

7. (a) A heat exchanger heats 25000 kg/hr of water entering at 15^oC while cooling 20,000 kg/hr of water from 100^oC to 75^oC. Determine the heat transfer area necessary for C_p = 4.18 kJ/kg^oC
      i. Parallel flow arrangement [4]
      ii. Counter flow arrangement
      Given: Overall heat transfer coefficient, U = 6280 kJ/hr$m2^oC$ [4]
   (b) Discuss the construction and working of a climbing film evaporator with the help of a neat sketch. [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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