Question bank - Heat Transfer

Chapter 1: Conduction

Short questions:

1. Define conduction with examples.
2. State Fourier's law of heat conduction.
3. What do you mean by thermal conductivity ?
4. Differentiate between steady state and unsteady state heat flow.
5. What is the unit of thermal conductivity ?
6. Give some examples of heat insulators.
7. Write few requirements of insulating material.

Long questions:

1. Derive the heat flow through composite wall.
2. Calculate the rate of heat loss (Q), through a wall of red brick (K = 0.70 w/mK), 5m in length, 4m in height and 250 mm in thickness, if the wall surfaces are maintained at 373 K and 303 K respectively.
3. Estimate the heat loss per m2 of the surface through a brick wall 0.5 m thick when the inner surface is at 400K and the outside surface is at 310K. The thermal conductivity of the brick may be taken as 0.7 W/(m·K).
4. A steam pipeline, 150/160 mm in diameter, is covered with a layer of insulating material of thickness 50 mm. The temperature inside the pipeline is 393K and that of the outside surface of insulation is 313K. Calculate the rate of heat loss per 1m length of pipeline.
   Data: k for pipe is 50 W/(m·K) and k for insulating material is 0.08 W/(m·K).
5. A furnace is constructed with 225mm thick of fire brick, 120mm of insulating brick and 225 mm of the building brick. The inside temperature is 1200K and the outside temperature is 330K. Find the heat loss per unit area and the temperature at the junction of the fire brick and insulating brick.
   Data: k for fire brick = 1.4 W/(m·K)
   k for insulating brick = 0.2 W/(m·K)
   k for building brick = 0.7 W/(m·K)
6. A cylindrical tube has inner diameter of 20 mm and outer diameter of 30 mm. Find out the rate of heat flow from tube of length 5 m if inner surface is at 373K and outer surface is at 308K. Take the thermal conductivity of tube material as 0.291 W/(m·K).

Chapter 2: Convection and Heat Exchangers

Short questions:

1. Define natural convection.
2. Define forced convection.
3. What is a heat exchanger ?
4. Define co-current flow.
5. Define counter current flow.
6. Define LMTD.
7. What is condensation ?
8. What is dropwise condensation?
9. What is filmwise condensation ?
10. What do you mean by heat transfer coefficient ?
11. Write the Sieder-Tate equation.
12. Write the Dittus-Boltier equation.

Long questions:

1. Derive the log mean temperature difference.
2. Write down the construction and working principle of shell and tube heat exchanger.
3. Water enters a two fluid heat exchanger at 328 K and leaves at 358 K. Hot gases enter at 578 K and leave at 433 K. If the total heat transfer area is 500 m^2 and the overall heat transfer coefficient is 700 W/m^2K, determine the total heat transfer for parallel flow of the two fluids ?
4. Hot oil at a rate of 1.2 kg/s (C_p = 2083 J/kgK) flows through double pipe heat exchanger. It enters at 633 K and leaves at 573 K. The cold fluid enters at 303 K and leaves at 400 K. If the overall heat transfer coefficient is 500 W/m^2K, calculate the heat transfer area for; (i) Parallel flow and (ii) Counter current flow.
5. Differentiate between dropwise and filmwise condensation.
6. Write short notes on parallel, counter current and cross current flow.
7. Differentiate between single pass and multi pass heat exchanger.
8. A hot fluid enters a double pipe heat exchanger at a temperature of 423K and is to be cooled to 367K by a cold fluid entering at 311K and heated to 339K. Shall they be directed in parallel or counter-current flow?
9. Thermic fluid flowing at a rate of 5000 kg/h is to be cooled from 423K to 363K by circulating water at a rate of 15000 kg/h. If the water is available at 303K , find the outlet temperature of water.

   Data: Specific heat of water = 4.187 kJ/(kg·K)

   Specific heat of thermic fluid = 2.72 kJ/(kg·K)
10. Draw and explain temperature-length curve fir parallel flow and countercurrent flow heat exchanger.

11. Differentiate between range and approach.
12. What are the assumptions made during derivation of LMTD.
13. Differentiate between dropwise condensation and film condensation.
14. Describe the application of dimensional analysis in convection.

Chapter 3: Radiation

Short questions:

1. Define black body.
2. State Kirchhoff's law.
3. State Wien's displacement law.
4. What is Planck's law?
5. State Stefan-Boltzmann's law.
6. Differentiate between black body and grey body.
7. What is emissivity ?
8. Define absorptivity.
9. Define reflectivity.
10. Define transmissivity.
11. Give examples of radiation.

Long questions:

1. Explain in details the concept of black body.
2. Explain briefly the laws of black body radiation.
3. Calculate the rate of heat transfer by radiation from an unlagged steam pipe, 50 mm, outside diameter at 393K to air at 293K. Assume emissivity emissivity=0.9.
4. Estimate the total heat loss by convection and radiation from an unlagged steam pipe, 50 mm outer diameter at 415 K to air at 290 K.
   Data: Take emissivity, ε=0.90
   Film coefficient (h_c) for calculation of heat loss by natural convection is given by $h_c = 1.18\ (\Delta T/D_0)^{0.25}$ w/m²K.

Chapter 4: Evaporation

Short questions:

1. Define evaporation.
2. Differentiate between capacity and economy of an evaporator.
3. Differentiate between evaporation and drying.
4. Differentiate between evaporation and distillation.
5. Differentiate between evaporation and crystallisation.
6. Give two examples of evaporators.
7. What is boiling point elevation ?

8. What are the common method used for feeding a multiple effect evaporator ?
9. What are the two ways of vapour recompression ?
10. What is steam consumption ?

Long questions:

1. Calculate the boiling point elevation of a solution and the driving force for heat transfer using the following data.
   Data: Solution boils at a temperature of 380K
   Boiling point of water at a pressure in the vapour space is 373K
   Temperature of condensing steam is 399K.
2. Write down the principle of single and multiple effect evaporator.
3. Briefly explain the material and energy balance of single effect evaporator.
4. Explain in details thermal recompression.
5. Explain in detail the construction, working, advantages and disadvantages of a long tube forced circulation type evaporator.
6. Explain in detail the construction, working, advantages and disadvantages of a standard basket evaporator.
7. Explain in detail mechanical recompression.
8. Describe different types of feed arrangement with suitable diagram.
9. Compare forward feed and backward feed evaporator.
10. An evaporator operating at atmospheric pressure (101.325 kPa) is fed at the rate of 10000 kg/h of weak liquor containing 4% caustic soda. Thick liquor leaving the evaporator contains 25% caustic soda. Find the capacity of the evaporator.
11. An evaporator is operating at atmospheric pressure. It is desired to concentrate a feed from 5% solute to 20% solute (by weight) at a rate of 5000 kg/h. Dry saturated steam at a pressure corresponding to the saturation temperature of 399K is used. The feed is at 298K and the boiling point rise (elevation) is 5 K. The overall heat transfer coefficient is 2350 W/(m2 ·K). Calculate the economy of the evaporator and the area of heat transfer to be provided.
12. Write the advantages of multiple effect evaporator over single effect evaporator.
13. What are the advantages of forced circulation evaporators ?
14. Write down the construction and working principle of jacketed pan evaporator.