BITS, PILANI-DUBAI CAMPUS, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008

CHE UC351 Heat Transfer Operations

Comprehensive Examination

DATE: 26-12-07

DURATION: 3 hours **MAXIMUM MARKS: 110**

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1 (a) The insulation boards for air conditioning purposes are made of three layers, middle being of packed glass 10 cm thick (k = 0.02 W/m.K) and the sides are made of plywood each of 2 cm thickness (k = 0.12 W/m.K). One surface is at 35 ^oC and the other is at 20 ^oC. Determine the heart flow per unit area. [8]

1 (b) A wire of 6.5 mm diameter at a temperature of 60 ^oC is to be insulated by a material having k = 0.174 W/m.K. Convection heat transfer coefficient (h_0) is 8.722 W/m^2.K. The ambient temperature is 20 ^oC. For maximum heat loss, what is the minimum thickness of insulation and heat loss per meter length? [12]

2 (a) One meter long Nichrome wire of resistivity 1 micro-ohm is to dissipate power of 10 kW in the surrounding fluid which is at 80 ^oC. Find the diameter of wire if the maximum operating temperature of the wire is 1000 ^oC. Given h = 1000 W/m^2.K, k (wire) = 60 W/m.K. [8]

2 (b) A very long 25-mm diameter copper rod (k = 380 W/m.K) extends horizontally from a plane heated surface at 120 ^oC. The temperature of the surrounding air is 25 ^oC and the convective heat transfer coefficient is 9.0 W/m^2.K. Determine the heat loss. How long the rod should be in order to be considered infinite? [12]

3 (a) A solid copper sphere of 10 cm diameter (density = 8954 kg/m^3, heat capacity = 383 J/kg.K, thermal conductivity = 383 W/m.K), initially at a uniform temperature of 250 ^oC, is suddenly immersed in a fluid maintained at 50 ^oC. The heat transfer coefficient between the sphere and the fluid is 200 W/m^2.K. Determine the temperature of the copper block 5 minutes after immersion. [8]

3 (b) Consider two large parallel plates one at 727 ^{o}C (emissivity = 0.8) and the other at 227 ^{o}C (emissivity = 0.4). An aluminum radiation shield with an emissivity of 0.05 on both sides is placed between the plates. Calculate the percent reduction in heat transfer rate between the two plates as a result of the shield. [12]

4 (a) Air at 20 ^{o}C and at atmospheric pressure flows over a flat plate at a velocity of 1.8 m/s. the length of the plate is 2.2 m and it is maintained at 100 ^{o}C. Calculate the heat transfer rate per unit width using Blasius' exact solution. [8]

4 (b) A vertical plate 500 mm high and maintained at 30 ^{o}C is exposed to saturated steam at atmospheric pressure. Calculate the rate of heat transfer, and the condensate rate per hour per meter of the plate width for film-wise condensation. [12]
The properties of water film at the mean temperature are:
density = 980.3 kg/m^3, thermal conductivity = 66.4 X 10^{-2} W/m.K,
viscosity = 434 X 10^{-6} kg/m.s, h_{fg} = 2257 kJ/kg.
Assume vapor density is small compared to that of the condensate.

5 (a) Cold water enters a counter-flow heat exchanger at 10 ^{o}C at a rate of 8 kg/s, where it is heated by a hot water stream that enters the heat exchanger at 70 ^{o}C at a rate of 2 kg/s. Assuming specific heat of water remains constant at C_p = 4.18 kJ/kg.K, determine the maximum heat transfer rate and the outlet temperatures of the cold and the hot water streams for this limiting case. [8]

5 (b) An oil cooler for a lubrication system has to cool 1000 kg/hr of oil (specific heat = 2.09 kJ/kgK) from 80 ^{o}C to 40 ^{o}C by using cooling water flow of 1000 kg/hr at 30 ^{o}C. Give your choice for a parallel or counter-flow exchanger, giving reasons. If overall heat transfer coefficient is 24 W/m^{2}K, calculate the heat exchanger surface area. [12]

6 Draw the boiling curve and identify the different boiling regimes. Identify the burnout point on the curve. Explain how burnout is caused. [10]

***

BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008

CHE UC351 Heat Transfer Operations

Test - 2
(Open Book)

DURATION: 50 MINUTES **DATE: 18.10.2007**
MAXIMUM MARKS: 45

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1. Air at atmospheric pressure and 40 ^oC flows with a velocity of 5 m/s over a 2 m long flat plate kept at a uniform temperature of 120 ^oC. Determine the average heat-transfer coefficient over the two meter length of the plate. Also calculate the rate of heat transfer between the plate and the air per meter width of the plate. [15]

   Properties of air at 1 atm and 80 ^oC:

   kinematic viscosity = 2.107 X10^{-5} m^2/s, k = 0.03025 W/m.K, Pr = 0.6965.

2. Air flows over a heated plate at a velocity of 50 m/s. The local skin friction coefficient a point on the plate is 0.004. Using *Reynolds – Colburn analogy* estimate the local heat transfer coefficient at this point. [10]

   Properties of air: density = 0.88 kg/m^3, viscosity = 2.286 X 10^{-5} kg.m/s, specific heat = 1.001 kJ/kg.K, thermal conductivity = 0.035 W/m.K

3. Two large parallel plates with e = 0.5 each are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with e = 0.05 are introduced between the plates. Calculate the percent reduction in net radiative heat transfer. [15]

4. What is the physical significance of Grashof number? What functional form of equation is normally used for correlation of free-convection data? [05]

***

BITS, PILANI-DUBAI CAMPUS, ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008

CHE UC351 Heat Transfer Operations

Test - 1
(Closed Book)

DATE: 30.09.2007
DURATION: 50 MINUTES **MAXIMUM MARKS: 45**

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1 (a) Discuss the mechanism of thermal conduction in gases. [5]

1(b) A thick-walled tube of stainless steel with 2-cm inner diameter and 4-cm outer diameter is covered with a 3-cm layer of insulation (k = 0.2 W/m.K). If the inside wall temperature of the pipe is maintained at 600 ^{o}C, calculate the heat loss per meter of length. Also calculate the tube-insulation interface temperature. Thermal conductivity of steel = 19 W/m.K. [5+5]

2(a) A longitudinal copper fin (k = 280 W/mK) 600-mm long and 5-mm diameter is exposed to air stream at 20 ^{o}C, with h = 20 W/m^{2}K. If the fin base temperature is 150 ^{o}C, determine
(a) The heat transferred,
(b) The efficiency of the fin.
Neglect the heat loss from the fin tip. [10]

2(b) Define and differentiate fin efficiency from fin effectiveness. [5]

3 (a) A 3-kW resistance heater wire (k = 12 W/m.K) has a diameter of 4 mm and a length of 0.5 m, and is used to boil water. If the outer surface temperature of the resistance wire is 104 ^{o}C, determine the temperature at the center of the wire. [7]

3(b) A copper sphere having a diameter of 3 cm is initially at uniform temperature of 50 ^{o}C. It is suddenly exposed to an air stream of 10 ^{o}C with h = 15 W/m^{2}K. How long does it take the sphere temperature to drop to 25 ^{o}C?
Copper: ρ = 8950 kg/m^3, C_p = 383 J/kg.K, k = 380 W/m.K [8]

***