I-E- V Sem- Chem.

Heat Transfer Operations-I

(17)

TE/I / CBGS / CHEM. / HTO-I

QP Code : 31106

(3 Hours) [Total Marks : 80

N.B. : (1) Question No.1 is **compulsory.**
(2) Attempt any **Three** out of remaining questions.
(3) Assume any suitable data if necessary and indicate it clearly.
(4) Draw neat sketches wherever required.
(5) Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other.

1. Solve all subquestions:
   (a) Derive for critical thickness for the insulation applied over hollow cylinder. 5
   (b) State the laws of radiation. 5
   (c) State (only) assumptions for Nusselt theory for condensation. 5
   (d) Explain thermal boundary layer in convection. 5

2. (a) A furnace is constructed with a 230 mm thick layer of fire brick, 115 mm thick Layer of insulating brick and followed by a 230 mm thick layer of building brick. The inside temperature of the furnace is 1213 K (940°C) and the outside temperature is 318 K (45°C).The thermal conductivities of fire brick, insulating brick and building brick are 6.047, 0.581 and 2.33 W/m.K. Find the heat loss per unit area and the temperature at the interfaces. 10
   (b) A cylindrical tube of length L having inside radius r_1 and outside radius r2 is lagged by insulating material with r_3 as the outer radius of insulation. Thermal conductivity of the wall material is k_1 and thermal conductivity of Insulation is k_2. T_1, T, T_2 are the temperatures at inside the tube, at the interface between the tube and insulation and at the outer edge of insulation respectively. $T_1 > T_2$. Derive an expression for rate of heat flow. 10

3. (a) Air at 101.325 Kpa and 300K (27°C) blows across a 12mm diameter sphere at a free stream velocity of 4 m/sec.A small heater inside the sphere maintains the surface temperature at 350K(77°C).Estimate the heat lost by the sphere. 10
   Data: The properties of air at the film temperature of 325 K are:
   Kinametic Viscosity = 18.23 x 10^{-6} m^2/sec, k=0.02814 W/m.K
   (b) Derive design equation for heat exchanger "Q = U.A.T Δ lm'. 10

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4. Calculate the total length of a double pipe heat exchanger required to cool 5500 Kg/hr of ethylene glycol from 358 K (85°C) to 341 K (68°C) using toluene as a cooling medium which flows in a counter current fashion. Toluene enters at 303 K (30.°C) and leaves at 335K (62°C). 20

Data:

Outer diameter of outer pipe = 70 mm

Outer diameter of inner pipe = 43 mm

Wall thickness of both pipess = 3 mm

Me an properties of two fluids are as given below:

Property	Ethylene glycol	Toulene
Density	1080 Kg/m³	840 Kg/m³
Specific heat	2.680 KJ/Kg.K	1.80 KJ/Kg.K
Thermal conductivity	0.248 W/m.K	0.146 W/m.K
Viscosity	3.4×10^{-3} Pa.s	4.4×10^{-4} Pa.s

Thermal conductivity of the pipe material is 46.52 W/m.K and ethylene glycol is flowing through the inner pipe.

5. (a) A 30 cm long glass plate is hung vertically in the air at 300 K (27°C). The plate is maintained at 356 K (77°C). Calculate the average heat transfer Coefficient for natural and force convection. Take free stream velocity of air = 4 m/sec. 10

Data: The properties of air at 325 K (52°C) are:

β	3.077×10^{-3} K^{-1}
N_{pr}	0.7
Thermal conductivity	28.15×10^{-3} W/m.K
Kinametic Viscosity	18.41×10^{-6} m²/sec

(b) Dry steam at 373 K (100°C) condenses on the outside surface of a horizontal Pipe of 25mm outside diameter. The pipe surface is maintained at 357 K (84°C) by circulating water through the pipe. Find the mean heat transfer coefficient, the heat transfer per unit length of the pipe and the condensate rate per unit length of the 10

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pipe.

Data: The properties of the condensate at the film temperature of 350 K are:

Density	974 Kg/m^3
β	2225 KJ/Kg
Thermal conductivity	0.668 W/m.K
Viscosity	306 x 10^{-6} N.s/m^2

6. Write short note on (any **four**) 20

(a) Wilson plot
(b) Boiling regimes in pool boiling
(c) Unsteady state heat transfer with negligible internal resistance
(d) Extended surface for heat exchanger
(e) Significance of Biot Number and Fourier Number.
