RN-8173/200

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B. E. - II (Sem. IV) (Chemical) Examination

May / June – 2010

Process Heat Transfer

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :
☛ **B. E. - 2 (Sem. 4) (Chemical)**

Name of the Subject :
☛ **Process Heat Transfer**

☛ Subject Code No. : **8 1 7 3** ☛ Section No. (1, 2,.....) : **1&2**

Seat No. :

Student's Signature

(2) Answer to the **two** section must be written on **separate** answer books.
(3) Assume suitable data when necessary.
(4) Graph, data sheet etc. will be provided wherever necessary.
(5) Draw neat sketches wherever necessary. Figures to the right indicate full marks.

SECTION - I

1 (a) Answer the following : **10**
- (i) What is Fourier's law of heat conduction?
- (ii) Heat transfer co-efficient for liquids increases with _____ temperature. (Increasing/decreasing)
- (iii) What is the absorpitivity of a black body?
- (iv) What is the unit of heat conductance?
- (v) Solid angle subtended by the finit surface at the radiating element is called _____.
- (vi) Heat flux, as defined in heat flow is analogous to ______ in electricity flow.
- (vii) Define : Critical radius of insulation.
- (viii) Which law gives the monochromatic emissive power for black body radiation?
- (ix) The main purpose of providing fins on heat transfer surface is to increase the _______.
- (x) Define : Natural convection.

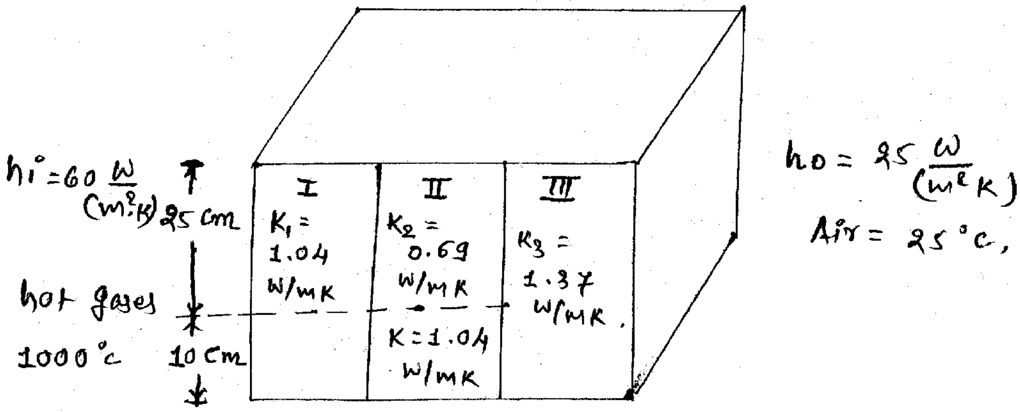
(b) What are extended surfaces? Draw the different types of extended surfaces and give the different applications of extended surfaces in different areas. **4**

(c) An aluminium rod 25 mm in diameter and 100 mm long protrudes from a wall which is maintained at 525k (250°C) into the environment maintained at 29\88 k (15°C). Estimate the heat lost by rod assuming that rod end is insulated. Also find the fin efficiency and temperature at the end of the fin. **6**

Data : K for aluminium = 200 W/(mk)
h between rod surface and environment = 15 W/(m^2.k)

2 Attempt any **two** : **16**

(a) A large furnace has a composite wall, the details of which are given in figure. The interior surface of the furnace wall is exposed to hot gases at 100°C while the exterior surface is exposed to the atmospheric air at 25°C. If the thermal coefficient are 60 W/m^2K abd 20 W/m^2K respectively. Calculate the rate of heat transfer per unit area of the furnace wall, from the hot gases to atmospheric air.



| ← 10 cm * 25 cm * 5 cm → |

(b) The iron pipe having 80 mm diameter of circular cross section and with wall 5 mm thick is covered with two concentric layer of lagging, the inner layer having a thickness of 25 mm and a thermal conductivity of 0.08 W/m.k, and outer layer having thickness of 60 mm and a thermal conductivity of 0.04 W/m.k. Estimate the rate of heat loss per meter length of pipe. If the temperature inside the pipe is 560 K (287°C) and the outside surface temperature is 340 K (67°C) thermal conductivity for pipe is 45 W/m.k.

(c) A steam pipe with 100 mm I.D. and 110 mm O.D. is covered with an insulating material having thermal conductivity of 1.0 W/m.k. The steam temperature is 473 K and ambient temperature is 293 K. Taking the convective heat transfer coefficient between the insulation surface and air as 8.0 w/m^{2}K. Find the critical radius of insulation. For this value (r_c), calculate the heat loss per meter of pipe and outer surface temperature. Neglect the resistance of pipe wall.

3 Answer any **two** : **14**

(a) Derive an expression for the net exchange of heat flux between two infinite flat parallel diffuse gray surfaces which are maintained at absolute temperatures T_1 and T_2 and have emissivities E_1 and E_2 respectively.

(b) Consider two large parallel plates, one at T_1 = 750 K (477°C) with emissivity e_1 = 0.75 and other at 500 K (227°C) with emissivity e_2 = 0.50. All aluminium radiation shield with an emissivity (on both sides) e_3 = 0.05 is placed between the plates.
Calculate the percent reduction in heat transfer rate as a result of radiation shield.

(c) Write Plank's law, derive the Stefan Boltzmann law from the Planks law equation.

SECTION - II

4 (a) Answer the following : **5**

(i) What is nucleate boiling?
(ii) Give expression for Prandtl number.
(iii) Define economy of an evaporator.
(iv) What is tube pitch in a heat exchanger?
(v) What is Sieder and Tate equation for laminar flow?

(b) Answer the following : **10**

(i) What is Boiling Point elevation?
(ii) Explain fouling factors.
(iii) Define free convection and forced convection.
(iv) Draw temperature length curve for condensors and evaporators.
(v) What is Boundary layer?

(c) A hot fluid enters a double pipe heat exchanger at a temperature of 150°C and is to be cooled to 94°C by a cold fluid entering at 38°C and heated to 66°C. Calculate LMTD for counter current flow heat exchanger and parallel flow.

5 Answer any **two** of the following : **8×2=16**

(a) Explain in detail various regimes of pool boiling of a saturated liquid.

(b) A single effect evaporator is to concentrate 20000 kg/h of a concentration of 20% salt by weight. Steam is fed to the evaporator at a pressure

corresponding to the saturation temperature of 126°C. The evaporator is operating at atmospheric pressure and boiling point rise is 7K. Calculate heat load and steam economy.
Feed temperature = 25°C
Specific heat of feed = 4.0 kJ/(Kg.K)
Latent heat of condensation of steam at 126°C = 2185 kJ/Kg
Latent heat of vaporisation of water at 100°C = 2257 kJ/Kg.

(c) Estimate the average value of convective film coefficient on the inside surface of a tube of 50 mm i.d. meant for heating water. The mass flow rate of water is 20000 Kg/hr, which enters at a temperature of 20°C and leaves at 60°C. Calculate also the heat transferred per unit length of the tube is the wall temperature is 10°C above the bulk temperature of the fluid.
Physical properties of water at 40°C is :
S = 992.2 kg/m^3
K = 54.5×10^{-2} Kcal/hr m °C
V = 0.659×10^{-6} m^2/sec
Pr = 4.31

6 Answer any **two** of the following : **7×2=14**

(a) Derive an equation for calculating LMTD for parallel flow. State the assumptions.

(b) A single pass steam condensor has to be designed to condense 35000 kg/hr of dry saturated steam at 2.77 cm Hg pressure (saturation temperature = 27.6°C). The cooling water enters the tubes at 16°C and leaves at 21°C. The tubes are 2.25 cm I.D. and 2.5 cm O.D. The thermal conductivity of tube material is 105 W/cm k). The water and steam side film coefficients are 6960 and 5800 W/cm^2 K respectively. Determine the surface area of tubes required. Neglect scale resistance.

(c) A vertical plate 30 × 30 cm, is exposed to steam at atmospheric pressure. The plate is at 371 K. Calculate the mean heat transfer coefficient and heat transfer rate and mass of steam condensed per hour.
Properties of condensate at film temperature are :
ρ = 960 kg/m^3
μ = 2.82×10^{-4} kg(m.s)
k = 0.68 W (cm.k)
λ = 2255 Kj/kg
Saturation temperature of steam = 373 K
Assume that condensate film is laminar.