Reg. No. : | | | | | | | | | | |

Question Paper Code: 55093

B.E. / B.Tech. DEGREE EXAMINATION, NOV 2017

Fifth Semester

Chemical Engineering

15UCH503 - HEAT TRANSFER

(Data book are permitted)

(Regulation 2015)

Duration: Three hours Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. Fourier's law applies to the heat transfer by

   (a) convection (b) radiation
   (c) conduction (d) all the above

2. With increase in porosity, the thermal conductivity of a solid substance

   (a) increases (b) decreases
   (c) remains unchanged (d) may increase or decrease; depends on the solid

3. With the increase of temperature, the Col-burn *jH* factor

   (a) increases (b) decreases
   (c) remains unchanged (d) may increase or decrease; depending on temperature

4. The dimensionless group in mass transfer that is equivalent to Prandtl number in heat transfer is

   (a) Nusselt number (b) Sherwood number
   (c) Schmidt number (d) Stanton number

5. The absorptivity of a grey body at a given temperature _____ with increasing wavelength of radiation.

   (a) increases (b) decreases
   (c) remains constant (d) may increase or decrease ; depends on the material

6. Which one gives the monochromatic emissive power for black body radiation?

(a) Planck's law (b) Kirchhoffs law
(c) Wien's law (d) Stefan-Boltzman law

7. When vaporisation takes place through a blanketting film of gas, the phenomenon is termed as _____ boiling.

(a) pool (b) nucleate
(c) transition (d) film

8. The number of kg of water vaporised per hour fed to the evaporator is defined as

(a) economy (b) capacity
(c) rate of evaporation (d) rate of vaporisation

9. In the equation $Q = UA\Delta t$; Δt is

(a) geometric mean temperature difference
(b) arithmetic mean temperature difference
(c) logarithmic mean temperature difference
(d) the difference of average bulk temperatures of hot and cold fluids

10. Shell side pressure drop in a shell and tube heat exchanger does not depend upon the

(a) baffle spacing & shell diameter
(b) tube diameter & pitch
(c) viscosity, density & mass velocity of shell side fluid
(d) none of these

PART - B (5 x 2 = 10 Marks)

11. Define thermal conductivity. Write its S.I. unit.

12. Define Prandtl number. What is its physical significance.

13. State the Kirchoff's law on radiation heat transfer.

14. What is meant by evaporator economy? Mention any two methods of increasing the economy of evaporator?

15. Draw temperature profile curve for parallel flow in heat exchanger.

PART - C (5 x 16 = 80 Marks)

16. (a) The inner and outer surfaces of a hollow cylinder are maintained at unit temperature T_1 and T_2 respectively. The cylinder of length L has r_1 and r_2 as inside and outside radii. If the thermal conductivity of the material of cylinder is temperature dependent and given by the equation $k = k_o (1+aT+bT^2)$ Where, k_o, a, and b are constants and T

is the temperature. Derive the equation for steady state rate of heat flow through the cylinder. (16)

Or

(b) A 300 mm outer diameter pipe is covered with two layers of insulation (k_1=0.105 W/m.K and k_2=0.07 W/m.K) the better insulating material is on the outside and is 40 mm thickness. The other insulating material is of 50 mm thickness. The inner and outer surface temperatures of the insulation are 350°C and 50°C. Calculate (i) Heat loss per meter length (ii) Heat loss per square meter of outer insulation surface (iii) Temperature of the surface between the two layers of insulation. (16)

17. (a) By dimensional analysis show that for forced convection $N_{Nu} = f(N_{Re}, N_{Pr})$. Discuss the significance of these dimensionless groups. (16)

Or

(b) A 20 mm diameter horizontal heater is maintained at a surface temperature of 40°C and submerged in water at 25°C. Estimate the heat loss per unit length of the heater by free convection. Use the following data:

$N_{Nu} = 0.53\ (N_{Gr}, N_{Pr})^{1/4}$; $\rho = 1000\ kg/m^3$;

$\mu = 8 \times 10^{-4}\ kg/ms$; $\beta = 3.04 \times 10^{-4}\ K^{-1}$

$C\rho = 4.187\ kJ/kgK$; $k = 063\ W/mK$ (16)

18. (a) (i) Discuss briefly the main laws of black body radiation. (6)

(ii) Calculate the rate of heat loss from a thermo-flask if the polished silvered surfaces have emisssivities of 0.05. The liquid in the flask is at 95°C and the casing is at 20°C. Calculate the loss if both surfaces were black. Assume steafan-Boltzmann constant is 5.67 X 10^{-8} W/(m^2.K^4). (10)

Or

(b) Drive an expression for the total transfer of energy between two parallel plates with planes of different emissivities by multiple reflection method. (16)

19. (a) (i) Draw a neat sketch for different feed condition of multiple effect evaporation system commonly used in chemical industries. (12)

(ii) How does Film-wise condensation differ from Drop-wise condensation? (4)

Or

(b) A single-effect evaporator is fed with 5000 kg/h of solution containing 1% solute by weight. Feed temperature is 30°C and is to be concentrated to a solution of 2% solute by weight. The evaporation is at atmospheric pressure (101.325 kPa) and area of evaporator is 69 m^2. Saturated steam is supplied at 143.3 kPa as a heating medium. Calculate steam economy and overall heat transfer coefficient. Data given:

Enthalpy of feed at 303 K = 125.79 kJ/kg
Enthalpy of vapour at 101.325 kPa = 2676.1 kJ/kg
Enthalpy of saturated steam at 143.3 kPa = 2691.5 kJ/kg
Saturation temperature of steam = 110 °C
Boiling point of saturation = 100°C
Enthalpy of product = 419.04 kJ/kg
Enthalpy of saturated water at 110 °C = 461.30 kJ/kg

(16)

20. (a) It is required to cool 250 kg/h of hot liquid with inlet temperature of 120°C using a parallel flow arrangement. 1000 kg/h of cooling water is available for cooling purpose at a temperature of 10°C. Calculate the outlet temperature of liquid and water and the effectiveness of the heat exchanger if the overall heat transfer coefficient is 1160 W/m^2K and the heat transfer surface of the exchanger is 0.25 m^2. Data given:
Specific heat of water = 4187 J/kg.K
Specific heat of liquid = 3350 J/kg.K (16)

Or

(b) Derive an expression to evaluate the effectiveness of parallel flow heat exchanger by NTU method. (16)