1. Solve any Five :- [20]

(a) What do you mean by Convection? How do you differentiate between Free and Forced Convection?

(b) How does thermal conductivity for solids, liquids, and gases depend upon temperature?

(c) How is LMTD defined? How does its magnitude compare with the arithmetic average temperature?

(d) What factors are responsible for the deterioration of a heat exchanger with time?

(e) What are the basic assumptions of Nusselt's theory of film condensation?

(f) What do you mean by a Black body? Why does cavity with a small hole behave as a black body?

(g) Which evaporator – 'Natural Circulation' or 'Forced Circulation'- needs more frequent tube cleaning when used for processing the same solution? For which type downtime is more?

2. (a) What is mean by Critical Radius of insulation? Derive an expression for the same? [10]

(b) A heat generating slab A (thickness = 0.25 m, k_A = 15 W/m^{0}C) is sandwiched between two other slabs B (thickness = 0.1 m, k_B = 10 W/m^{0}C) and C (thickness = 0.15 m, k_C = 30 W/m^{0}C) There is no heat generation in slab B or C. The temperature distribution in slab A is known to be $T_A = 90 + 4500X - 11{,}000X^2$, Where T is in ^{0}C and X is the distance in m from the left surface of B. The wall B is in contact with fluid at temperature T_1 = 40^{0}C, similarly, the free surface of C loses heat to a medium at a temperature 35^{0}C. Assume steady state heat condition. [10]

(a) Calculate the temperatures at the surface of slab A. What is the maximum temperature in A and where does it occur?

(b) Determine the temperature gradients at both surfaces of each of the slabs A, B and C?

3. (a) Show by dimensional analysis, Nusselt Number is function Prandtl Number and Grashoff Number for the case of **Natural** Convection. [10]

(b) A circular disc insulated from other side of diameter (d = 0.25 m) is exposed to air at 20^0C. If the disc surface is maintained at 120^0C. Estimate the amount of heat transfer from it when

(a) The disc is horizontal with hot surface facing upwards.
(b) The disc is horizontal with hot surface facing downwards.
(c) Disc is vertical. [10]

Data: - For air at 70^0C

K= 0.03 W/mK Npr = 0.697 $\upsilon = 2.076*10^{-6}\ m^2/sec$ $\beta = 0.00295K^{-1}$

4. (a) What is Nusselt's theory of condensation? Derive the Nusselt's equation to calculate the heat transfer coefficient from the properties of condensing film. [10]

(b) A heat exchanger has a mean overall heat transfer coefficient of 400 W/m^2K based on side whose surface area is 100 m^2. Find the outlet of hot and cold fluids for both counter and parallel flow. [10]

Properties	Hot	Cold
T_{inlet} ^0C	700	100
m (Kg/min)	1000	1200
C_p (Kj/Kg K)	3.6	4.2

5. (a) For Parallel flow heat exchanger Show that - (08)

$$\varepsilon = \frac{1 - e^{-(1+C)NTU}}{1+C}$$

(b) Fuel oil at the rate of 1.1 Kg/sec is heated passing through the annulus of a counter flow double pipe heat exchanger from 10^0C to 20^0C by using hot water available from the engine at 71^0C. The water flows through copper tube at (OD = 2.13 cm and ID = 1.86cm) with a velocity of 0.76 m/sec. The oil passes through the annulus formed by inner copper tube and outer steel pipe (OD = 3.34cm and ID = 3cm).

Waterside fouling factor $hd_w = 0.0004\ m^{2\,0}C/m$

Oilside fouling factor $hd_o = 0.0009\ m^{2\,0}C/m$

Properties of water and oil are-

Property	Water	Oil
P (Kg/m^3)	982	854
C_p (KJ/Kg °C)	4.187	1.884
K (W/m°C)	0.657	0.138
υ (m^2/sec)	$4.18*10^{-7}$	$7.43*10^{-6}$

Neglect the resistance of copper tube.

For Calculation of film transfer coefficients of both sides, use-

$N_{Nu} = 0.023(N_{Re})^{0.8} (N_{Pr})^{0.3}$ (12)

6. (a) (i) What is radiation shield?

(ii) Derive Q with 'n' shields = (1/ n+1) Q without shield. (10)

(b) Determine the net radiant interchange between two parallel oxidized iron plates placed at distance of 25 mm having sides 3m x 3m. The surface temperatures of two plates are 373K and 313K respectively.

Emissivity of plates are equal = 0.74 (10)

7. (a) A cylindrical rod of 2 cm diameter and 25 cm long projects from a well insulated steel Vessel (T_s = 100°C) into air at 30°C. The free end of the rod is insulated. Determine the temperature at free end if rod is made of –

(i) Cu with K = 330 W/m^{2}K

(ii) Steel with K = 49 W/m^{2}K

(iii) Glass with K = 1 W/m^{2}K

Take h = 7 W/m^{2}K

Also calculate heat transfer in each? Make your comment on result. (10)

(b) An evaporator is to be fed with 5000 Kg/hr solution containing 10% solutr by weight. The feed at 313K is to be concentrated to a solution containing 50% solute by weight. Steam is available at an absolute pressure of 303Kpa, Saturation Temperature of 410K. The overall heat transfer coefficient is 1750W/m^2K. Calculate-

(a) Heat transfer area that should be provided.

(b) Economy of an evaporator.

C_p of feed = 4.187 KJ/Kg

At 313 K Enthalpy of Feed = 170 KJ/Kg

At 373 K Enthalpy of Vapour = 2676 KJ/Kg

At 373 K Enthalpy of Liquid = 419 KJ/Kg

At 410 K Enthalpy of Vapour = 2725 KJ/Kg

At 410 K Enthalpy of Liquid = 563 KJ/Kg (10)