Assumptions made should be clearly **stated** and **justified.**
Figures to the **right** indicates **full** marks.

Consider the composite cylinder made up of three diffeent materials in series. Assume K_1, K_2, K_3 be the thermal conductivities of materials and r_1, r_2, and r_3 be inner, second material and outermost materials. Assume the hot face and cold temperature be T_1 and T_2 respectively. 'L' be the length of cylinder. **10**
Derive the expression for steady state heat transfer rate thro' this composite materials cylinder.

(i) The inside and outside surfaces of hallow sphere : **5**
$a \leq r \leq b$ at $r = a$ and $r = b$ are mantained at a temperature T_1 and T_2 respectively.
The Thermal conductivities varies with temperature as—
$K(T) = K^\circ (1 + \alpha T + \beta T^2)$
Derive an expression for total steady state heat flow thro' the sphere.

(ii) Distinguish betwen arithmatic and logarithemic means, in cylinder used in Heat Transfer Operation. **5**

Define the following terms— **10**
(i) Wien's Displacement law and Plank's law
(ii) Monochromatic emissive power and monochromatic emissivity
(iii) Grey and black body
(iv) Radiosity and Irradiation
(v) Shape factor.

(b) Calculate the rate of heat loss from 60 cms long horizontal steam pipe, 60 mm o.d. carrying a steam at 800 kN/m^2. **10**
Data :
(i) Take the surrounding temperature as 17 °C
(ii) Take emissivity e = 0·85
(iii) Take $\sigma = 5{\cdot}67 \times 10^{-8}$ w/m^{2}k^4.
(iv) Film transfer coefficient (h) for heat loss by natural convection is given by—
$h = 1{\cdot}65(\Delta T)^{0{\cdot}25}$
(v) Steam is saturated at 800 kN/m^2 and 170 °C.

(a) It is required to heat 1 MT of mass of the reactant in batch reactor from 17 °C to 87 °C; by steam heating thro' coil. (coil area 1 m^2) and steam is fed at 117 °C. **10**
Data :
(i) Specific heat capacity of mass of reactant is 3·8 $\frac{kJ}{kgK}$.
(ii) Assume No. heat loss to surrounding at 290 K.
(iii) The overall heat transfer coefficient is 600 $\frac{W}{m^2 K}$.

Calculate the time required.

If the external area of the vessel is 10 m^2 and outside heat transfer coefficient is 8·5 $\frac{W}{m^2 K}$ what will be the time taken to heat the reactant over the same temperature range ?

(b) 250 mm diameter circular disc is exposed to atmospheric air at 298 K(25 °C). **10**
One surface of a disc is insulated and other surface is maintained at 403 K.
Calculate the amount of heat transferred from the disc when it is :—
(i) Horizontally, with hot surface facing up
(ii) Horizontally, with hot surface facing down.
Data : The properties of air at mean film temperature are—
Kinematic viscosity $\gamma = 2 \times 10^{-5}$ m^2/sec.
Prandtl Number = 0·70
K = 0·03 w/mK
Take characteristics length L = 0·90 D.

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which acid flows is 75 mm bore and the outer one 125 mm bore.
The o.d. of inner pipe is 100 mm
The physical properties of the fluid at mean temperature are as follows :—

Property	Acid	Water
Density in kg/m^3	1800	998·2
Heat capacity in kJ/kg/K	1·465	4·187
Thermal conductivity in w/mK	0·302	0·669
Viscosity N.S./h^2	0·0112	0·0011

Thermal conductivity of pipe material is 46·52 $\frac{w}{mK}$. Calculate the length of the pipe required

5. (a) Derive for parallel flow heat exchanger :

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

where ϵ = effectiveness
C = capacity ratio.

(b) Water enters a counter flow, double pipe heat exchanger at 288 K, flowing at the rate o 1300 kg/hr. It is heated by oil flowing at the rate of 550 kg/hr. from inlet temperature of 94 °C For 1 m^2 area of heat exchanger, determine the total heat transfer and outlet temperature of oil and water-and effectiveness.

Data :

Cp of oil = 2000 J/kg K
Cp of water = 4187 J/kg K
Overall heat transfer coefficient = 1075 w/m^2 K

6. A single effect evaporator is used to produce 5000 kg/h of NaOH thick liquor. Evaporation is carried out in evaporator of 10% by weight NaOH solution to obtain 50% (by wt). Evaporator is of calendria type consists of number of tubes (verticle) which are 32 mm in o.d. and 28 i.d. and 2·5 m long. This solution is pumped thro' the tubes whereas 'steam is fed the steam chest around the tubes. Due to fouling, the inside the surface of the tube is layered with 0·25 mm thick layer of thermal conductivity 2·25 w/mK. Saturated steam is supplied as the heating medium at a pressure of 357 kN/m^2 absolute and the evaporator is operated under a vacuum of 250 mm of Hg. There is a negligible entrainment and condensate is removed at saturated temperature of steam.

If the heat transfer coefficient of solution side and steam side are 4500 and 9000 w/m^{2}K.

Determine :

(a) Capacity of an evaporator
(b) Steam consumption
(c) Economy
(d) Number of tube required for calendria.

Data : (1) Boiling point rise of 50% NaOH solution is 18·5 K
(2) Enthalpies of feed solution, vapour, thick liquor are 138, 2675, 568 J/kg respectively.

Thermal conductivity of tube is 45 w/m^2 K.

7. Write a short notes on any **four** :—

(a) Wilson plot
(b) Multiple effect evaporator
(c) Concept of Critical insulation thickness
(d) Spiral heat exchanger
(e) Assumptions (only) of Nussullt theory for Condensation.