1. What do you understand by lumped capacity analysis?

2. Define fin efficiency and effectiveness.

3. Distinguish between free and forced convection

4. State Buckingham's n theorem. What are n -terms?

5. Indicate the difference between boiling and condensation.

6. What is fouling? [1] Ty ai[1] f^uli ng factors taken into account in the design of heat exchangers?

7. Sta[f]e the Stefan-Boltzmann and Wien's displacement laws of radiation.

8. Calculate the total rate of energy emission of a body having an area of 0.12 m^2 maintained at a temperature of 527°C.

9. State Fick's law of diffusion. Give its expression.

10. Define equimolar counter diffusion.

PART B — (5 x 16 = 80 Marks)

11. (a) (i) State Fourier's law of heat conduction. Give Fourier's, Poisson's and Laplace equation from the general heat conduction equation. (8)

(ii) A steel rod of diameter 12 mm and 60 mm long with an insulated end that has a thermal conductivity of 32 W/(m.°C) is to be used as a spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of 55 W/(m^2.°C). The temperature at the base of the fin is 95°C. Calculate the fin efficiency, the temperature at the edge of the spine and the heat dissipation. (8)

Or

(b) (i) Two slabs each of 120 mm thick have thermal conductivities of 14.5 W/m°C and 210 W/m°C. These are placed in contact but due to roughness only 30% of area is in contact and the gap in the remaining area is 0.025 mm thick and is filled with air. If the temperature of the face of the hot surface is at 220°C and the outside surface of other slab is at 30°C, calculate the heat flow through the composite system. Assume that the conductivity of air is 0.032 W/m°C and that half of the contact (of the contact area) is due to either metal. (8)

(ii) A 60 mm thick large steel plate [k = 42.6 W/m.℃), $a =$ 0.043 m^2/h] initially at 440℃ is suddenly exposed on both sides to an ambient with convective heat transfer coefficient 235 W/(m^2.℃) and temperature 50℃. Determine the centre line temperature and the temperature inside the plate 15 mm from the mid plane after 4.3 minutes. (8)

12. (a) (i) Define Reynold's, Prandtl, Nusselt and Grashoff number and give their expressions. (8)

(ii) Air is flowing over a flat plate 5 m long and 2.5 m wide with a velocity of 4 m/s at 15℃. If p= 1.208 kg/m^3 and $u=$ 1.47 x 10^{-5} m^2/s, calculate the length of plate over which the boundary layer is laminar and thickness of the boundary layer (laminar), shear stress at the location where boundary layer ceases to be laminar and the total drag force on the both sides on that portion of the plate where boundary layer is laminar. (8)

Or

(b) (i) Draw the profile of a boundary layer on a flat plate showing the velocity profiles and explain the significance of boundary layer. Define thermal boundary layer. (6)

(ii) A vertical cylinder 1.5 m high and 180 mm in diameter is maintained at 100℃ in an atmosphere of 20℃. Calculate the heat loss by free convection from the surface of the cylinder. Assume properties of air at me U t n perature as p = 1.06 kg/m^3 and u = 18.97x 10^{-6} m^2/s, c_p = 1.004kJ/kg℃and k = 0.1042 kJ/m.h.■ C.

(10)

13. (a) (i) Explain briefly the various regimes of pool boiling. (10)

'ii) A vertical cooling fin approximating a flat plate 40 cm in height is exposed to saturated steam at atmospheric pressure (T_{sat} = 100℃, h_{fg} = 2257 kJ/kg). The fin is maintained at a temperature of 90℃. Calculate the thickness of the film at the bottom of the fin and overall heat transfer coefficient.
The relevant fluid properties are p_1 = 965.3 kg / m^3,
k_1 = 0.68 W/m℃ and j = 3.153 x 10-^{4} Ns/m^2. (6)

Or

(b) (i) Explain how heat exchangers are classified? (6)

(ii) The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperatures on the hot and cold sides are 75℃ and 25℃ respectively. The exit temperature of hot water is 45℃. If the individual heat transfer coefficients on both sides are 650 W/m℃, calculate the area of the heat exchanger. (10)

14. (a) (i) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500 ℃ :

(1) Monochromatic emissive power at 1.2 $/jm$ length

(2) Wavelength at which the emission is maximum

(3) Maximum emissive power

(4) Total emissive power

(5) Total emissive power of the furnace if it is assumed as a real surfacemissivity equal to

1.9. (10)

Define the following :

(1) Black body

(2) Grey body

(3) Opaque body

(4) White body

(5) Specular reflection

(6) Diffuse reflection.

Or

(b) (i) Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperatures of 427℃ and 27℃ respectively. The emissivity of hot and cold plate is 0.9 and 0.6 respectively. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer. The emissivity of shield is 0.4. (6)

(ii) The radiation shape factor of the circular surface of a thin hollow cylinder of 10 cm diameter and 10 cm length i (.1/16. What is the shape factor of the curved surface of the cylinder with respect to itself? (10)

15. (a) (i) Define mass concentration, molar concentration, mass fraction and mole fraction. (4)

(ii) Derive the general mass transfer equation in Cartesian coordinates. (12)

Or

(b) (i) A vessel contains binary mixture of O_2 and N_2 with partial pressures in the ratio 0.21 and 0.79 at 15℃. The total pressure of the mixture is 1.1 bar. Calculate the following :

(1) Molar concentrations,

(2) Mass densities,

(3) Mass fractions and

(4) Molar fractions of each species. (10)

(ii) Air at 1 atm and 25℃ containing small quantities of iodine, flows with a velocity of 6.2 m/s inside a 35 mm diameter tube. Calculate the mass transfer coefficient for iodine. The thermo-physical properties of air are $u = 15.5 \times 10^{-6}\ m^2/s$; $D = 0.82 \times 10^{-5}\ m^2/s$. (6)