(vi) For non circular pipe, the equivalent diameter is
(a) twice the hydraulic radius (b) four times the hydraulic radius
(c) half of the hydraulic radius (d) none of the above.

(vii) Temperature profile for heat conduction in a flat wall is
(a) linear (b) parabolic
(c) non regular (d) none of the above.

(viii) The transfer of heat by convection implies
(a) the transfer of heat by bulk transport and mixing of macroscopic element of warmer portions with cooler portions of a gas or a liquid
(b) the transfer of motion between adjacent molecules
(c) the transfer of energy through space by means of electromagnetic waves
(d) none of the above.

(ix) In a packed bed absorption column loading indicates
(a) onset of flooding (b) tower cannot be operated
(c) very high pressure drop in the tower (d) none of the above.

(x) An ideal plate in a rectification column is defined as a plate where
(a) liquid entering and vapour entering are in equilibrium
(b) liquid leaving and vapour entering are in equilibrium
(c) liquid leaving and vapour leaving are in equilibrium
(d) liquid entering and vapour leaving are in equilibrium.

Group – B

2. Define the local and average skin drag coefficients for flow over a flat plate. Show that the average drag coefficient for laminar boundary layer flow over a flat plate according to Von-Karman momentum integral equation is $\overline{C_f} = \frac{1.328}{\sqrt{\mathrm{Re}_l}}$. Also show that for turbulent flow it is given by $\overline{C_f} = \frac{0.072}{(\mathrm{Re}_l)^{1/5}}$.

8 + 4 = 12

3. (a) Water at 25°C is to flow through a horizontal steel pipe having a length of 350 m at a rate of 36 m³/h. A head of 6 m is available to overcome the friction loss in the pipe. Suggest an appropriate pipe diameter.

(b) Water at 20°C is being pumped from a tank to an elevated tan rate of 5 l/s as shown in the figure below. Diameter of the entir length is 100 mm. The pump has an overall efficiency of Calculate the total power needed to drive the pump.

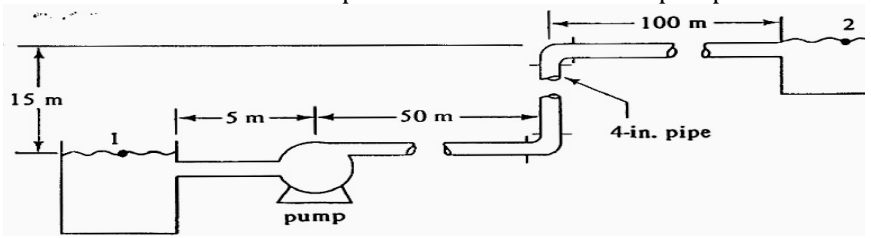

Figure for Q.3(b)

5 + 7

Group – C

4 (a) Show that for an incompressible homogeneous fluid with no in heat generation, the energy equation can be expressed as

$$\frac{DT}{Dt} = \alpha \nabla^2 T$$

Where, T, t and α respectively denotes the temperature, tim thermal diffusivity; and ∇^2 represent the Laplacian operator.

(b) Show that in a long-cylinder of radius R with uniformly distri heat sources, the temperature distribution is expressed b relation:

$\frac{T - T_w}{T_{\max} - T_w} = 1 - \left(\frac{r}{R}\right)^2$ where, T_w and T_{max} are the temperature a outer surface of the cylinder and the maximum tempe respectively.

6 + 6

5. (a) Show that Nusselt number is constant for laminar flow through where heat is transferred by conduction into and out of the t radial direction and the value of Nusselt number is 4.364 for this c

(b) Nitrogen gas at 0°C is flowing over a 1.2 m long, 2 m wide maintained at 80°C with a velocity of 2.5 m/s. Find the tota transfer rate from the plate. Given ρ = 1.142 kg/m³ C_p = 1.04 kJ ν = 15.63×10⁻⁶ m²/s and k = 0.0262 W/m K.

8 +

Group – D

6. (a) For a binary system two components are diffusing in each other under steady state condition. Show that $D_{ij} = D_{ji}$.

   (b) Oxygen (A) is diffusing through carbon monoxide (B) under steady state conditions with carbon monoxide non-diffusing. The total pressure is 1×10^5 Pa and the temperature 0°C. The partial pressure of oxygen at two planes 0.2 mm apart is respectively 13000 and 6500 Pa. The diffusivity of the mixture is 1.87×10^{-5} m^2/s. Calculate the rate of diffusion of oxyen in kmol/s through each square meter of the two planes.

6 + 6 = 12

7. (a) Discuss briefly the concept of mass transfer coefficient. Derive the relationship between overall mass transfer coefficient and individual film coefficients in a two phase gas liquid absorption system.

   (b) Calculate the value of the mass transfer coefficient and the flux for mass transfer from a sphere of naphthalene to air at 45°C and 1 atm flowing at a velocity of 0.305 m/s. The diameter of the sphere is 25.4 mm. The diffusivity of naphthalene in air at 45°C is 6.92×10^{-6} m^2/s and the vapour pressure of solid naphthalene is 0.555 mm Hg.
   Data: $N_{sh} = 2 + 0.552 (N_{Re})^{0.53} (N_{Sc})^{0.33}$

6 + 6 = 12

Group – E

8. Explain in detail the design procedure of plate type rectification column using McCabe-Thiele method.

12

9. Explain in detail the design procedure of packed tower absorption column for lean gas mixture.

12

TRANSPORT PROCESSES
(REEN 5103)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

   (i) Hagen – Poiseuille equation relates
   (a) the pressure drop and average velocity for laminar flow in a horizontal pipe
   (b) the pressure drop and average velocity for turbulent flow in a horizontal pipe
   (c) the pressure drop and average velocity for creeping flow in a horizontal pipe
   (d) none of the above.

   (ii) For Laminar flow, Fanning friction factor is related to Reynolds number as follows
   (a) f = 8/Re (b) f = 16/Re
   (c) f = 32/Re (d) none of the above.

   (iii) For laminar flow between two horizontal plates, the velocity profile is
   (a) parabolic (b) circular
   (c) linear (d) none of the above.

   (iv) For rotating liquid in a cylindrical container, free surface is
   (a) circular (b) elliptical
   (c) parabolic (d) hyperbolic.

   (v) In fully developed laminar flow through a circular pipe the average velocity is
   (a) same as the maximum velocity
   (b) two third of the maximum velocity
   (c) one third of the maximum velocity
   (d) half of the maximum velocity.