Total Pages—6

(Set-R)

B.Tech-6th (Chemical)

Transport Phenomena

Full Marks : 70

Time : 3 hours

Answer **all** questions

The figures in the right-hand margin indicate marks

Symbols carry usual meaning

1. Answer *all* questions : 2×10

(*a*) Define kinematic viscosity and its significance.

(*b*) Discuss the various Non-Newtonian fluids with the corresponding rheological equations.

(*c*) State Hagen-Poiseulle's equation and write its applications.

(*d*) Write generalized boundary conditions used in solving momentum transfer problems, using shell momentum balance principles.

(*Turn Over*)

(e) To what extent are the turbulent momentum flux, heat flux and mass flux similar in form ?

(f) Define diffusion and explain various factors that influence the diffusion of gasses.

(g) Explain the concept of Colburn's analogy.

(h) How is the stream function defined, and why is it useful ?

(i) In what way are Newton's law of viscosity and Fourier's law of heat conduction are similar.

(j) Describe rotational and irrotational flow.

2. (a) Derive an expression for maximum velocity, average velocity and volumetric rate of flow and film thickness for flow of a falling film by setting up momentum balances. 6

(b) An oil has a kinematic viscosity of 2×10^{-4} m^2/s and a density of $0{\cdot}8 \times 10^3$ g/m^3. If we want to have a falling film of thickness of 2·5 mm on a vertical wall, what should the mass rate of flow the liquid be ? 4

Or

Water is flowing at steady state in the annular region between two coaxial circular cylinders of radii KR and R. Obtain expressions to find out momentum flux distribution and velocity distribution. 10

3. Derive an expression for the calculation of heat transfer rate through a composite cylindrical wall of a furnace consisting of three different walls, closely packed. What is the temperature between the layers 1 and 2 ? 10

Or

Copper wire with a diameter of 0·5 cm is covered with a 0·65 cm layer of insulating material having a thermal conductivity of 0·242 W/mk. The air adjacent to the insulation is at 290 K. If the wire carries a current of 400 amp; determine :

(i) The convective heat transfer coefficient between the insulation surface and the surrounding air.

(*ii*) The temperatures at the insulation-copper interface and at the outside surface of the insulation. The resistivity of copper is $1{\cdot}72 \times 10^{-6}$ ohm-cm. 10

4. Derive an expression for diffusion under isothermal steady state condition through a spherical shell. Extend these results to describe the diffusion in a non-isothermal film in which temperature varies radially as $T/T_1 = (r/r_1)^n$ where T_1 is temperature at $r = r_1$. Also assume that D_{AB} varies as 3/2 power of temperature. 10

Or

Derive an expression for concentration profile for diffusion of gas *A* and undergoing chemical reaction inside a porous catalyst to form product *B*. Derive an expression for effectiveness factor. 10

5. Large volume of pure nitrogen gas (N_2), at atmospheric pressure is flowing over a pool of liquid of methanol, which is evaporating and

nitrogen is assumed to be insoluble in liquid. The gas phase mass transfer coefficient of methanol is given $kG = 2 \times 10^{-5}$ kmol/m^{2}s. kPa. Assume vapor pressure of methanol at 298 Kelvin is 10 kPa.

(*i*) Calculate k_y, k_c, k_Y and F.

(*ii*) If the diffusivity of methanol at 298 kelvin is 2×10^{-5}m^2/s, calculate the thickness of the gas film. 10

Or

How is binary diffusivity and self - diffusion defined ? Give typical orders of magnitude of diffusivity for gases, liquids and solids. 10

6. Write short notes on : 10

(*i*) Equation of Continuity

(*ii*) Navier Stokes equation.

Or

A fluid with density ρ and viscosity μ is placed between two vertical walls which are at a distance of $2b$ apart. The heated wall is maintained at a temperature T_2 at $y = -b$ and the cold wall is maintained at a temperature T_1 at $Y = +b$. The plates can be assumed to be very long so that temperature and velocity are functions of Y only. Derive the expressions for temperature and velocity distribution between the walls. 10
