Exam. Code: 0909
Sub. Code: 6311

2123

B.E. (Biotechnology) Fifth Semester

BIO-514: Transport Phenomena

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section. State all assumptions.

x-x-x

1a). What is Reynolds number? What is its significance in momentum transfer?

b). Consider a fluid confined between two parallel plates. The lower plate moves with a velocity 0.31 m/s in the positive x-direction. The separation between the plates is 0.31 mm, and the fluid viscosity is 0.7 centipoise. Calculate the steady-state momentum flux.

c). Explain the Fick's law of diffusion.

d). Verify that Prandtl number is a dimensionless quantity.

e). Compare the temperature dependence of thermal conductivity of gases and liquids. (10)

SECTION-A

2a). Examine the similarity between the transport mechanism and governing equations for heat transfer and mass transfer,

b). A drug with an initial concentration of 40 mg/L and a final concentration of 200 mg/L diffuses through a stomach lining that is 7 mm thick. The drug's diffusivity constant is 1.8×10^{-10} cm^2/s. calculate the rate of diffusion through the stomach lining? (5,5)

3. In a gas absorption experiment a viscous fluid of density ρ and viscosity μ flows upwards through a small circular tube of radius R, length L, and then downward in laminar flow on the outside of the tube. The fluid forms a uniform thin film of radius aR on the outside surface of the tube. Set up a momentum balance over a shell of thickness Δr in the thin film and derive an expression for the velocity distribution in the falling film. (10)

4a). Consider a solid cone of circular cross-section with diameters at x = 0 and x= L are 25 cm and 5 cm respectively. Under steady-state conditions, the heat flux at x=0 is 45 W/m^2. Determine the heat transfer rate and heat flux at x=L. Assume the lateral surface is insulated.

b). The mass flow rate of a viscous fluid flowing through a capillary tube is measured to be 3.6×10^{-3} kg/s. The length of the capillary is 450 mm. The pressure drop across the tube is 485 kN/m^2. If the density and kinematic viscosity of the fluid is 960 kg/m^3 and 3.6×10^{-4} m^2/s respectively. Determine the radius of the capillary. (5,5)

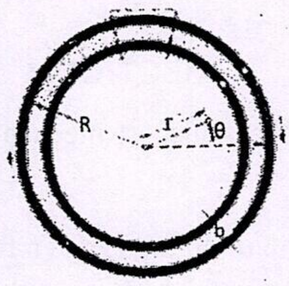
P.T.O.

SECTION-B

5. Apply the Buckingham π theorem to establish a correlation between the bubble size and the properties of the liquid when gas bubbles are formed by gas issuing from a small orifice below the liquid surface. Let D be bubble diameter, d is the orifice diameter, ρ is the liquid density, μ is liquid viscosity, σ is surface tension in N/m and g is the acceleration due to gravity. (10)

6. An incompressible Newtonian fluid flows between two coaxial cylinders. The surfaces of the inner and outer cylinders are maintained at T_o and T_b, respectively. The outer cylinder rotates with an angular velocity Ω. This friction between adjacent layers of the fluid produces heat; the volume heat source resulting from this "viscous dissipation," is designated by S_v. Using shell energy balance approach obtain an expression for the temperature profile between the cylinders. (10)

Outer cylinder rotating with angular velocity Ω



7. Liquid A is evaporating into vapor B in a tube of infinite length. The vapors A and B are assumed to form an ideal gas mixture. The level of liquid A is maintained at a fixed position at all times. The solubility of B in A is negligible. The gas phase concentration of A at the liquid-gas interface expressed as mole fraction is x_{A_1} while the concentration of A in the gas mixture away from the lliquid-gas interface is x_{A_2}. Using shell balance approach obtain an expression for (a) concentration profile (b) rate of evaporation. (10)

x-x-x