Exam. Code: 0909
Sub. Code: 6710

2031

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. Clearly state all assumptions.*

x-x-x

Q.1a). A liquid with kinematic viscosity 2×10^{-3} m^2/s is flowing over an inclined plane that is inclined at an angle of 45° with the vertical. Calculate the thickness of the film at a distance 0.05 m from the origin. The film travels at a velocity of 0.2 cm/s.

b). Show that only one diffusivity is needed to describe the diffusional behavior of a binary mixture.

c). A composite wall is made from three metal plates connected in series. The plates have same thickness and cross-sectional area. The thermal conductivity of the three metals are K, 3K and 5K respectively. Determine the ratio in which the temperature drop across the walls will be for same heat transfer.

d). Name the dimensionless number that governs the relationship between the thermal and hydrodynamic boundary layer thickness.

e). Give the energy equation for an incompressible fluid (constant K) without any energy source.

(2×5)

SECTION-A

Q.2a) Starting with the general equation of motion, $\frac{\partial}{\partial t}(\rho\bar{v}) = -[\bar{\nabla}.\rho\bar{v}\bar{v}] - \bar{\nabla}p - [\bar{\nabla}.\bar{\tau}] + \rho\bar{g}$ derive the Navier-Stokes equation. (Assume constant density and viscosity)

b) A fluid is contained between two identical and parallel plates each of area 5 m^2. The top plate is pulled in the minus x direction by a force of 0.085 N at a velocity of 0.4 m/s. The bottom plate is pulled in the opposite direction by a force of 0.03 N at a velocity of 0.12 m/s. The plates are 10 mm apart. Calculate the viscosity of the liquid. (6+4)

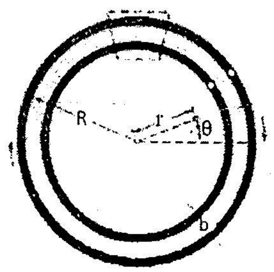
Q.3a). State the Newtons's law of viscosity. Compare the temperature dependence of the viscosity for gases and liquids.

b) A cylindrical tank is initially half full with water. The water is fed into the tank from the top and it leaves the tank from the bottom. The inlet and outlet volumetric flow rates are different from each other. The differential equation describing the time rate of change of water height is given by $\frac{dh}{dt} = 4 - 2\sqrt{h}$. Where h is height in m. calculate the height of water in the tank under steady state conditions.

(5+5)

P.T.O.

Q.4 For the flow of an incompressible Newtonian fluid between two coaxial cylinders, the inner surface of the cylinder is maintained at a temperature T_0 while at the outer surface the flux is zero. The volume heat source resulting from friction between adjacent layers of the fluid (viscous dissipation) can be designated as S_v. Make an energy balance over a shell of thickness Δx, width W and length L to derive an equation for temperature profile in the slit. Assume the slit width **b** is small with respect to the radius R of the outer cylinder. (10)



SECTION-B

Q.5. A heated sphere of radius R is suspended in a large, motionless body of fluid. The temperature of the fluid in contact with the surface of the sphere is T_R and that at a large distance away from the sphere is T_∞. Using shell balance approach derive an equation describing the temperature T in the surrounding fluid as a function of r, the distance from the center of the sphere. Also obtain an expression for the heat flux at the surface of the sphere and use "Newton's law of cooling" to obtain the value of the Nusselt number, $Nu = \frac{hD}{k}$, where D is the diameter of the sphere. Assume k, thermal conductivity to be constant. (10)

Q.6. A thin rectangular plate of width W and height H is located so that it is normal to a moving stream of fluid. Assume the drag, D, that the fluid exerts on the plate is a function of W and H, the fluid viscosity and density, μ and ρ, respectively, and the velocity V of the fluid approaching the plate. Determine a suitable set of dimensionless groups to study this problem experimentally. (10)

Q.7. Helium gas is contained in a pyrex tube of inner radius, R_1 and outer radius, R_2. The diffusivity of helium through pyrex, D_{He}, the concentration of helium at R_1, c_1 and that at R_2 being c_2. Obtain an expression for the rate at which helium will leak out of the tube at steady state. Use shell balance to obtain the differential equation governing the mass transport of helium and hence obtain an expression for the concentration distribution and the rate at which helium is lost over a length L of the tube. (10)

x-x-x