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Exam. Code: 0909
Sub. Code: 6710

1128

B.E.(Bio-Technology) 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

Q.1a). Give the three dimensional form of the Fourier's law of heat conduction.

b). What do you understand by the term 'diffusion controlled reactions'.

c). At the interface between gas and liquid shear stress for a Newtonian fluid is ____________

d). Write the Navier-Stokes equation for a fluid of constant density and viscosity

e). Which dimensionless number in mass transfer is equivalent to Prandtl number?

f). Flow behavior index (n) for Newtonian fluids is ____________.

g). Give the Hagen Poiseuille equation.

h). Give the Fick's law of diffusion.

i). The value $\frac{C_p \mu}{k}$ is known as ____________

j). Define 'combined energy flux vector'. (10)

SECTION-A

Q.2. Consider the steady state laminar flow of a fluid of constant density and viscosity in a vertical tube of length L and radius R. The fluid flows downwards under the influence of pressure difference and gravity. Set up a momentum balance over a shell of thickness Δr to find the momentum flux distribution and the velocity distribution in the circular tube. Also obtain an expression for calculating the maximum velocity, average velocity and the mass flow rate of the fluid. (10)

Q.3.a). Toluene is contained between two identical and parallel plates each of area 5 m2. The top plate is pulled in the minus x direction by a force of 0.083 N at a velocity of 0.3 m/s. The bottom plate is pulled in the opposite direction by a force of 0.027 N at a velocity of 0.1 m/s. The plates are 10 mm apart. Calculate the viscosity of toluene.

b). Discuss the temperature and pressure dependence of viscosity for liquids and gases. (5,5)

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Q.4 A Newtonian fluid is in laminar flow in a narrow slit formed by two parallel walls a distance 2B apart as shown in the figure. The wall at x = B is moving in the positive z direction at a steady speed of V_o. Make a differential momentum balance to obtain expressions for the shear-stress distribution and the velocity distribution. (Assume B<<W<<L). (10)

SECTION-B

Q.5. A heated sphere of radius R is suspended in a large motionless body of fluid. It is desired to study the heat conduction in the fluid surrounding the sphere in the absence of convection. Using shell energy balance obtain expressions (i) describing temperature as a function of r, the distance from the center of the sphere and (ii) heat flux at the surface. Given at r=R, T= T_R and at r=∞, T=T_∞. Use Newton's law of cooling to show that a dimensionless heat transfer coefficient Nusset Number, Nu=2. The thermal conductivity k of the fluid may be considered constant and free convection effects be neglected. (10)

Q.6 a) A cylindrical shaped cell is placed in an isotonic saline solution, where it begins to slowly sink. The terminal velocity V is thought to depend on the following variables. Cell density ρ_c, cell radius R_c, cell length L, saline density ρ_s, saline viscosity μ_s and acceleration due to gravity g. Determine appropriate dimensionless parameters that can relate terminal velocity using the Buckingham Pi theorem.

b) A hollow solid sphere has its inner surface at r = a and outer surface at r = b maintained at concentrations C_{A_a} and C_{A_b} respectively. Using shell mass balance obtain an expression for concentration profile in the solid at steady state conditions. Determine the flux at the outer surface. (5,5)

Q.7. Liquid A is evaporating into vapor B in a tube of infinite length. The liquid level is maintained at a fixed position at all times. The entire system is maintained at a constant temperature and pressure and the vapors A and B are assumed to form an ideal gas mixture. 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 liquid gas interface is x_{A_2}. Using shell balance approach obtain (a) an expression for the concentration profile (b) rate of evaporation. (10)

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