BE-5th Sem

Exam. Code: 0909
Sub. Code: 33371

2124

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). How does an increase in temperature affect the viscosity of fluids? Explain the reason.

b). State and explain the Fick's law of diffusion.

c). Suppose the flow rate of blood in a coronary artery has been reduced to half its normal value by plaque deposits. By what factor has the radius of the artery been reduced, assuming no turbulence occurs?

d). Define combined energy flux vector.

e). Verify that Reynolds number is a dimensionless quantity. (10)

SECTION-A

Q.2a). Consider a Newtonian fluid flowing down an inclined plate of length L and width W. The plate is inclined at an angle β with the horizontal. The fluid forms a thin film of thickness δ on the surface of the inclined plate. Using shell momentum balance obtain an expression for i) velocity distribution in the thin film ii) maximum velocity iii) average velocity. Assume steady state conditions and density and viscosity of the fluid to be constant.

b). An oil has a kinematic viscosity of 1×10^{-2} m²/s and a density of 1×10^{3} kg/m³. If we want to have a falling film of thickness 3 mm on a vertical wall that is 1 m wide, what should be the mass rate of film flow? (7,3)

Q.3. Consider a steady-state laminar flow of a fluid with constant density and viscosity within a vertical cylindrical tube of length L and radius R. The fluid flows downwards due to the combined effect of a pressure gradient and gravitational force. Using a differential shell momentum balance, derive the expressions for (i) shear stress distribution (ii) velocity distribution (iii) maximum velocity (iv) average velocity and (v) mass flow rate of the fluid through the tube. (10)

P.T.O.

Q.4.a) A copper rod of length 0.5 m and a cross-sectional area of 0.01 m^2 has one end maintained at a temperature of 150°C, while the other end is at 50°C. The thermal conductivity of copper is 385 W/m K. Assuming steady-state conditions, calculate (i) heat transfer rate through the rod (ii) temperature at a point 0.3 m from the hotter end. Assume linear temperature distribution.

b). Compare and analyze the similarities between the transport mechanisms and governing equations for momentum, heat and mass transfer processes. (5,5)

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 at a distance far away from the sphere is T_∞. Using shell balance approach derive an expression describing the temperature T in the surrounding fluid as a function of radius of the sphere r. Using Newton's law of cooling obtain an expression for the heat flux at the surface of the sphere and find 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. Use the Buckingham Pi theorem to determine the dimensionless parameters that relate the power consumption P of an impeller to the following variables: the diameter D of the impeller, the rotational speed N, the fluid density ρ, the fluid viscosity μ, and the acceleration due to gravity g. (10)

Q.7. In the leaching process of a substance A from solid particles into a solvent B, the rate-limiting step is the diffusion of A across a stagnant film of liquid B surrounding each particle, with a thickness δ. The molar solubility of A in B is c_{A0} and in the main stream is $c_{A\delta}$. Assume that D_{AB} is constant and that A is only slightly soluble in B. Neglect the curvature of the particles.

(a) Derive a differential equation for the concentration c_A as a function of distance z by making a mass balance on A over a thin slab of thickness Δz.

(b) Find the rate of leaching. (10)

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