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Exam.Code:0909
Sub. Code: 6710

1078

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. 1 which is compulsory and selecting two questions from each Section.*

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Q.1a). What are the analogous terms for heat, mass and momentum transfer?

b). At the interface between gas and liquid, shear stress for a Newtonian fluid is ______

c). Give the dimensions of heat transfer coefficient, h.

d). Under steady state, rate of flow of heat through any cross section of slab is directly proportional to ____________

e). Write about non-Newtonian fluids.

f). Define porosity.

g). What is Nusselt number?

h). Discuss the effect of pressure on the diffusivity of gases.

i). 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.

j). Show that the 'Grashof number' is dimensionless. (10)

SECTION-A

Q.2a). Consider steady state evaporation of chloropicrin (CCl_3NO_2) liquid into air which may be considered to be a pure substance. The temperature is 25°C. The liquid chloropicrin is taken in a tube containing air. Calculate the rate of evaporation in gm/hr of chloropicrin into air. Data given: Total pressure: 770 mm Hg. diffusivity (CCl_3NO_2-air): 0.088 $cm^2 sec^{-1}$, vapor pressure: 23.81 mm Hg, distance from liquid level to the top of the tube: 11.14 cm, density of CCl_3NO_2: 1.65 g cm^{-3}, surface area of liquid exposed for evaporation: 2.29 cm^2

b). Consider the flow of a Newtonian fluid between two parallel plates. Compute the steady-state momentum flux τ. in lbf/ft^3 when the lower plate velocity V is 1ft/s . the plate separation is 0.001 ft. and the fluid viscosity μ is 0.7 cP. (5.5)

P.T.O.

Q.3. A horizontal circular pipe of radius R_1 is placed concentrically inside another pipe of radius R_2. If the flow in the annular space between the pipes is laminar, starting with a shell momentum balance show that the maximum velocity occurs at a radius r, given by $r = \sqrt{R_2^2 - R_1^2 / 2\log_e(R_2/R_1)}$. (10)

Q.4 A Newtonian fluid is in laminar flow in a narrow slit formed by two vertical parallel walls a distance 2B apart. The length of the walls is L. Make a differential momentum balance, and

(a) obtain the following expressions for the momentum-flux and velocity distributions.

$$\tau_{xz} = \left(\frac{P_0 - P_L}{L}\right)x$$

$$\vartheta_z = \frac{(P_0 - P_L)B^2}{2\mu L}\left[1 - \left(\frac{x}{B}\right)^2\right]$$

(b) What is the ratio of the average velocity to the maximum velocity.

(c) Obtain an expression for the mass flow rate. (10)

SECTION-B

Q.5. A solid catalyzed dimerization reaction 2A→B is carried out in a catalytic reactor. Each catalytic particle is assumed to be surrounded by a stagnant gas film through which A has to diffuse to reach the catalyst surface where the reaction takes place instantaneously. The product B then diffuses out through the gas film to the main stream composed of A and B. Assuming that the gas film is isothermal, derive an expression for the concentration profile of A in the gas film. The main stream concentration of A and B are given to be x_{A_0} and x_{B_0} respectively and the effective gas film thickness is δ. (10)

Q.6. Heat is flowing through an annular wall of inside radius r_0 and outside radius r_1 and length L. The thermal conductivity varies linearly with temperature from k_o at T_o to k_1 at T_1. Using shell energy balance develop an expression for the heat flow through the wall at $r = r_0$. (10)

Q.7. The velocity of flow through a flow measuring nozzle has been determined to be a function of diameter of the pipe (D), density (ρ), diameter of nozzle (d), viscosity (μ) and pressure drop (ΔP). Determine the dimensionless numbers using Buckingham method. (10)

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