Code No: 07A70801 **R07** **Set No. 2**

IV B.Tech I Semester Examinations November 2010

TRANSPORT PHENOMENA
Chemical Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Compare Newton's law of viscosity and Hooke's law of elasticity.
   (b) Compute the steady state momentum flux, when the lower plate velocity is 1 ft/sec in the positive x direction, the plate separation is 0.001 ft, and the fluid viscosity is 0.7 cp.
   (c) How does the viscosity vary with temperature and pressure for
      i. dilute gases
      ii. liquids. [6+6+4]

2. Component A disappears according to first order irreversible reaction in a long solid slab of uniform height 'H' and width 'W'. The upper and lower surfaces of the slab are maintained at concentrations C_{AH} and zero respectively. Use equation of continuity for component A to derive concentration profile. Find the rate of molar flux of A at both surfaces. [16]

3. (a) Define different types of expressing concentrations and velocities in multi component systems.
   (b) Show that for a binary mixture $JA^* + JB^* = 0$.
   [8+8]

4. (a) Define substantial time derivative and total time derivative and write their mathematical equations.
   (b) Equation of motion is a statement of Newton's second law. Prove the statement by deriving the equation from the first principles of momentum balance on a parallelepiped. [6+10]

5. Consider a Newtonian liquid of variable viscosity $\mu = \mu_0 e^{-\alpha x/\delta}$ (and density δ) in laminar flow down an inclined flat plate of length L and width W. The liquid flows as a falling film with negligible rippling under the influence of gravity. End effects may be neglected because L and W are large compared to the film thickness δ.
   (a) Determine the steady-state velocity distribution.
   (b) Obtain the mass rate of flow and average velocity in the falling film.
   (c) What is the force exerted by the liquid on the plate in the flow direction [16]

6. Develop the equation for temperature distribution using shell balance approach, in a fin of width 'w' , length 'L' and thickness '2B' attached to a wall having temperature T_w. Ambient temperature is T_a. [16]

7. (a) Compare the orders of magnitude of the thermal conductivities of gases, liquids, and solids.

   (b) Estimate the thermal conductivity of molecular oxygen at 300K and low pressure.
   Data: M = 32, σ= 3.433A^o and Ω_μ =1.074, C$_p$=7.019 cal/gmole.K [8+8]

8. Obtain expression for effectiveness factor for the case of diffusion and chemical reaction inside a porous catalyst. [16]

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Code No: 07A70801 **R07** **Set No. 4**

IV B.Tech I Semester Examinations November 2010

TRANSPORT PHENOMENA
Chemical Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) What is diffusion? What factors may cause diffusion to occur?
   (b) Explain about molecular mass transport?
   (c) Show that $j_A = -\rho D_{AB} \nabla w_A$ [4+6+6]

2. In studying the rate of leaching of a substance A from solid particles by a solvent B, it is postulated that the rate controlling step in diffusion of A from the particle surface through a liquid film out in to the main liquid stream. The solubility of A in B is C_{A0} and concentration in main stream beyond the liquid film of thickness δ is $C_{A\delta}$.
   (a) Obtain a differential equation for C_A as a function of z by making mass balance of A over a thin slab of thickness Δz. Assume that D_{AB} is constant and A is only slightly soluble in B. Neglect the curvature of the particle.
   (b) Show that in the absence of chemical reaction in the liquid phase the concentration profile is linear.
   (c) Show that the rate of leaching is given by
   $N_A = \frac{D_{AB}(C_{A\delta} - C_{A0})}{\delta}$ [16]

3. Derive expressions (using shell balances) for shear stress and velocity distributions of a laminar flow of a Newtonian fluid flowing through an annulus. Find the average velocity [16]

4. Derive an expression for the temperature distribution T(x) in a viscous fluid in steady laminar flow between large flat parallel plates. Both plates are maintained at constant temperature. Take in to account explicitly heat generated by viscous dissipation. Neglect temperature dependence of thermal conductivity and viscosity. [16]

5. (a) Define and give the dimensions of Thermal conductivity k, Thermal diffusivity α , Heat capacity CP, Heat flux q, and combined energy flux e.
   (b) A plastic panel of area 1 ft^2 and thickness 0.252 in. was found to conduct heat at a rate of 3.0 W at steady state with temperature 24^oC and 26^oC imposed on the two main surfaces. What is the thermal conductivity of the plastic in cal/cm.s.k at 25^oC?
   [8+8]

6. (a) Modify the equation of motion for free convection problems.

(b) What is transpiration cooling and give application of transpiration cooling? [8+8]

7. The lower plate is being pulled at a relative velocity of 0.40 m/sec. greater than the top plate. The fluid used is water at 24^oC.

   (a) How far apart should the two plates be placed so that the shear stress is 0.30 N/m^2. Also calculate the shear rate.

   (b) If oil with a viscosity of 2.0×10^{-2} pa.s is used instead at the same plate spacing and velocity as in part(a), what is the shear stress and the shear rate? [8+8]

8. Derive equation of continuity for isothermal fluid in cylindrical coordinates by means of mass balance over a stationary volume element $r\Delta r\ \Delta\theta\ \Delta z$. [16]

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Code No: 07A70801 **R07** **Set No. 1**

IV B.Tech I Semester Examinations November 2010

TRANSPORT PHENOMENA
Chemical Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Compare and contrast the molecular and convective mechanisms for momentum transport.
   (b) Estimate the viscosity of saturated liquid water at 100^{o}C.
   Data: At 100^{o}C , $\bar{V} = 18.80\, cm^3/gm - mole$ [8+8]

2. Derive an expression for equation of continuity for binary mixture in rectangular coordinates and simplify it for the following situations:
   (a) Constant density and diffusivity
   (b) Non-reacting mixture with zero velocity. Explain the application of Fick's second law of diffusion. [6+10]

3. (a) Compute the thermal conductivity of Argon at 100^{0}C and 1 atm
   Data: Argon molecular weight = 39.948, $\sigma = 3.432A^0$ and Ω_μ=1.0344
   (b) Compute the thermal conductivities of NO at 300K and 1 atm by Eucken's formula by using the data: M = 30.01, $\mu = 1929 \times 10^{-7}$ gm/cm.sec, C_p=7.15 cal/gmole.k.
   [16]

4. A common channel for fluid is annulus, the space between the two concentric circular pipes. The inside of the annulus has a radius 'r_1' and the out side 'r_2'.
   (a) Derive an expression for the velocity of flow 'V' at any radius 'r' in the annulus.
   (b) Derive an expression for the radius at which the maximum velocity occurs, in terms of r_1 and r_2. [16]

5. What is the average velocity of the downward moving stream in the system for air under the following conditions.
   Pressure - 1 atm
   Temperature of the heated wall - 200 ^{0}C
   Temperature of the cooled wall - 30 ^{0}C
   Spacing between wall - 0.8 cm
   The density of air at 200 ^{0}C and 30 ^{0}C may be taken as 9.615×10^{-4} g/cc and 0.0012 g/cc respectively. The viscosity at mean temperature is 1.9847×10^{-4} Poise. [16]

6. (a) Show that $J_A^* = -\left(\frac{\rho^2}{c\, M_A\, M_B}\right) D_{AB}\, \nabla w_A$

(b) Estimate D_{AB} for the system CO - CO_2 at 296.1^0K and 1 atm total pressure. [8+8]

Data:

label	Compound	M	T_c	P_c
A	CO	28.01	133	34.5
B	CO_2	44.01	304.2	72.9

7. Derive an expression for momentum flux and velocity distribution of Bingham plastic flow on an inclined plane making an angle θ with the horizontal. [16]

8. Consider a cylindrical jar in which gas A dissolves in liquid B and diffuses into the liquid phase. As it diffuses, A undergoes an irreversible first order chemical reaction A + B → AB. Arrive at steady state concentration distribution of A in liquid B. [16]

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Code No: 07A70801 | R07 | Set No. 3

IV B.Tech I Semester Examinations November 2010

TRANSPORT PHENOMENA

Chemical Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions

All Questions carry equal marks

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1. An incompressible isothermal Newtonian fluid is in steady laminar flow under a pressure gradient in a slot formed by two horizontal parallel walls a distance 2B apart and of infinite width. Let the length of the walls is L and assume the flow is fully established. Develop the relations for shear stress and velocity distributions by solving equations of change. [16]

2. (a) Show that only one diffusivity is needed to describe the diffusional behaviour of a binary mixture
   (b) Show that for a binary mixture $W_A = x_A M_A/(x_A M_A + x_B M_B)$. [8+8]

3. Let the thermal conductivity of a certain solid be expressed as laminar function of temperature:
   (a) Find expression for the heat flow if the geometry is a slab
   (b) Find the expression for heat flow if solid is in the shape of a pipe and heat flow is in radial direction only. [8+8]

4. Predict the thermal conductivity of the following gas mixture at 1atm and 293K from the given data on the pure components at the same pressure and temperature. [16]

Species	α	Mole fraction x_α	M_α	$\mu_\alpha \times 10^7\ (g/cm.s)$	$K_\alpha \times 10^7 (cal/cm.s.k)$
CO_2	1	0.133	44.01	1462	383
O_2	2	0.039	32.0	2031	612
N_2	3	0.828	28.016	1754	627

5. (a) The distance between the plates is 0.5 cm and velocity is 10 cm/sec, and the fluid is ethyl alcohol at 273K having a viscosity of 1.77 cp. Calculate the shear stress and shear rate.
   (b) Explain two parameter models for non-Newtonian fluids. [8+8]

6. Derive the equations for velocity profile and average velocity for flow of two immiscible fluids between a pair of horizontal plates under the influence of a pressure gradient. [16]

7. Liquid B is flowing under steady state conditions as a film along a flat vertical wall. The thickness of the film is δ and the flow is laminar. Gas A which is slightly soluble in B is in contact with the liquid. At the liquid gas interface the concentration of A is C_{A0}. Since then solubility of A in B is small, A will not penetrate very far

into B. For this situation develop the differential equation to describe the concentration distribution of A in liquid B. Indicate boundary conditions. The velocity distribution may be taken as [16]

$v_z = v_{z\,\max}(1 - \left[\frac{x}{\delta}\right]^2)$.

8. An incompressible Newtonian fluid is in steady laminar flow through a vertical circular tube of radius 'R'. The flow is in the direction of gravity (z direction). For z<0, the fluid is at uniform temperature T_0. For z>0, there is a constant wall heat flux q_1. The physical properties of the fluid may be assumed constant. The steady state fully established velocity distribution is given as $v_z = v_{z\,\max}(1 - \left[\frac{r}{R}\right]^2)$. Using equation of energy develop the partial differential equation for the temperature of liquid as function of r and z. Indicate boundary conditions. Use thermal energy equation. [16]

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