Code No: M0821/R07

Set No. 1

IV B.Tech I Semester Supplementary Examinations, Feb/Mar 2011
TRANSPORT PHENOMENA
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. Estimate the viscosity of the following gas mixture at 1 atm and 293 K from the given data on the pure components at the same pressure and temperature: [16]

S.No.	Species	Mole fraction	Molecular weight	viscosity$\times 10^7$(gm/cm.sec)
1	CO_2	0.133	44.01	1462
2	O_2	0.039	32.0	2031
3	N_2	0.828	28.02	1754

2. Calculate the thermal conductivity of a mixture containing 20 mole% CO_2 and 80mole% H_2 at 1 atm and 300K. [16]
Data:

Species	α	Mole fractionx_α	M_α	$\mu_\alpha \times 10^5 (pas.s)$	$K_\alpha (w/m.k)$
CO_2	1	0.2	44.01	1.506	0.01661
H_2	2	0.8	2.016	0.8944	0.1789

3. (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]

4. Consider a liquid (of density ρ) in laminar flow down an inclined flat plate of length L and width W. The fluid 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 for a non-Newtonian fluid that obeys the power law model. Reduce the result to the Newtonian case.
   (b) Obtain the mass flow rate for a power law fluid. Simplify for a Newtonian fluid.
   (c) What is the force exerted by the fluid on the plate in the flow direction? [16]

5. Derive an expression for temperature distribution T(x) in a viscous fluid in steady laminar flow between two large vertical flat parallel plates separated by distance 2B. Both the plates are maintained at a constant temperature T_0. Take in to account explicitly the heat generated by viscous dissipation. Neglect temperature dependence of viscosity and thermal conductivity. Velocity distribution is given by $v_z = \frac{(P_0 - P_L)B^2}{2\mu L}\left(1 - \left[\frac{x}{B}\right]^2\right)$ [16]

6. Component A is disappearing in accordance with a 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 a concentration of C_{AH} and zero respectively. Use shell mass balance method, determine the steady state concentration profile in the slab and determine mass flux at two surfaces. [16]

7. (a) Arrive at the substantial time derivative from the following equation of motion.
$$\frac{\partial \rho v_x}{\partial t} = -\left(\frac{\partial \rho v_x v_x}{\partial x} + \frac{\partial \rho v_x v_y}{\partial y} + \frac{\partial \rho v_x v_z}{\partial z}\right) - \left(\frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z}\right) - \frac{\partial p}{\partial x} + \rho g_x$$
   (b) Consider an isothermal, incompressible Newtonian fluid flowing radially between two porous spherical shells. Assume steady state laminar flow and neglect end effects. Arrive at the differential equations for pressure distributions by modifying the equations of change. [6+10]

8. Give detailed account of special form of equations of motion for the free convection problem in which the system has temperature inequalities as well as concentration inequalities. [16]

⋆ ⋆ ⋆ ⋆ ⋆

Code No: M0821/R07

Set No. 2

IV B.Tech I Semester Supplementary Examinations, Feb/Mar 2011
TRANSPORT PHENOMENA
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
⋆ ⋆ ⋆ ⋆ ⋆

1. (a) Explain the concept of molecular theory of the viscosity of liquids.
   (b) Estimate the viscosity of liquid benzene at 20^{o}C.
   Data: At 20^{o}C , $\bar{V} = 89.0\, cm^3/gm - mole$, $T_b = 80.1^oC$

2. (a) Compute the thermal conductivity of Ne at 1 atm and 373.2K
   Data: Ne molecular weight = 20.183, σ = 2.789Ao and $\Omega_\mu = 0.821$
   (b) In what way are Newton's law of viscosity and fourier's law of heat conduction are similar. [8+8]

3. (a) Show that $v_A - v_B = -D_{AB}\nabla \ln \frac{x_A}{x_B}$
   (b) Show that $\frac{j_A}{\rho\, w_A\, w_B} = \frac{J_A^*}{c\, x_A\, x_B}$. [8+8]

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. A viscous fluid with constant physical properties is in steady laminar flow in a circular tube of radius 'R'. For z < 0, (z is longitudinal axis) the fluid temperature is uniform at T_0. For z < 0, there is a constant wall heat flux 'Q'. Arrive at the partial differential equation for steady state temperature distribution using shell balance approach. Indicate clearly all the applicable boundary conditions. [16]

6. A droplet of substance A is suspended in a stream of gas B. The droplet radius is r_1. Assuming that there is a spherical stagnant gas film of outer radius r_2 surrounding the droplet. Obtain an expression by shell balance method for the flux of component A in the gas phase when its concentrations are x_{A1} and x_{A2} at radii r_1 and r_2 respectively. Also show that when r_2 tends to infinity, the Sherwood number is 2. [16]

7. 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]

8. A natural gas containing Helium gas in a pyrex tube with inner and outer radii R_1 and R_2 respectively. Obtain an expression for the rate at which Helium will leak through the tube using equation of continuity for Helium. The interfacial concentrations C_{He1} and C_{He2} respectively at R_1 and R_2 respectively. [16]

⋆⋆⋆⋆⋆

Code No: M0821/R07

Set No. 3

IV B.Tech I Semester Supplementary Examinations, Feb/Mar 2011
TRANSPORT PHENOMENA
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
⋆ ⋆ ⋆ ⋆ ⋆

1. (a) Explain three parameter models for non-Newtonian fluids.
   (b) What are the physical meanings of the lennard - jones parameters and how can they determined from viscosity data? [8+8]

2. (a) Compute the thermal conductivity of argon at 100^0C 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]

3. (a) Discuss the dependence of mass diffusivity on temperature and pressure.
   (b) Show that for a binary mixture $jA^*+jB^*=\rho(v-v^*)$..
   (c) Show that for a binary mixture $jA + jB = 0$.
   [8+8]

4. Consider a fluid (of constant density ρ) in incompressible, laminar flow in a tube of circular cross section, inclined at an angle β to the vertical. End effects may be neglected because the tube length L is relatively very large compared to the tube radius R. The fluid flows under the influence of both a pressure difference Δp and gravity.
   (a) Using a differential shell momentum balance, determine expressions for the steady-state shear stress distribution and the velocity profile for a Newtonian fluid of variable viscosity μ .
   (b) Obtain expressions for the maximum velocity, average velocity and the mass flow rate for pipe flow. [8+8]

5. Obtain the radial temperature distribution with in an electrical wire with the rate of heat production given by $S_e = \frac{I^2}{k_e}$, where I is current density in amp/cm^2 and k_e is electrical conductivity in $ohm^{-1}cm^{-1}$. The wire surface is maintained at temperature T_0. Use shell balance approach. [16]

6. An air conditioning room has an atmosphere of air with a 30mole% CO_2 concentration. Outside the room, the concentration of CO_2 is very small. However there is a hole in the wall. The pressure is 1 atm and temperature is 25 ^{0}C. Under these conditions the diffusivity of CO_2 in air is $0.164 \times 10^{-4} m^2/s$. The hole is 10 cm in diameter and wall is 30 cm thick.

(a) The amount of CO_2 that exits the room

(b) The amount of air that enters the room. [16]

7. (a) Distinguish between substantial derivative and total time derivative with the help of an example.

   (b) Apply Navier-Stokes equation to find an expression for velocity distribution for laminar flow of Newtonian fluid in thin film along an inclined flat plate. [6+10]

8. There are two concentric spherical shells of radii aR and R in which the inner surface of the outer one is at temperature T_1 and outer surface of the inner one is maintained at T_a. Dry air at temperature T_a is blown radially from the inner shell in to the intervening space and out through outer shell. Develop an expression for the required rate of heat removable from the inner sphere as a function of mass flow rate of gas. Assume steady laminar flow and low gas velocity.

   $\rho C_p v_r \frac{dT}{dr} = k \frac{1}{r^2} \frac{d}{dr}\left(r^2 \frac{dT}{dr}\right)$ [16]

⋆⋆⋆⋆⋆

Code No: M0821/R07

Set No. 4

IV B.Tech I Semester Supplementary Examinations, Feb/Mar 2011
TRANSPORT PHENOMENA
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

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. (a) Compute the thermal conductivity of Ne at 1 atm and 373.2K
   Data: Ne molecular weight = 20.183, $\sigma = 2.789$Ao and $\Omega_\mu = 0.821$
   (b) In what way are Newton's law of viscosity and fourier's law of heat conduction are similar.
   [8+8]

3. (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^{0}K 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

4. 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]

5. (a) Give analogy between laminar flow of fluid in a pipe and heat conduction in a wire with electrical heat source.
   (b) A power law fluid is rotated in between two coaxial cylinders with the inner cylinder stationary and the outer cylinder moving with constant velocity 'V'. The heat generated due to viscous dissipation per unit volume is given by $S_V = K\left(\frac{V}{b}\right)^{n+1}$, where b is the space between the cylinders. Obtain the temperature distribution of the fluid by shell energy balances. State the assumptions made clearly. [6+10]

6. 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]

7. Determine velocity distribution and torque for the tangential laminar flow of an incompressible fluid between two coaxial cylinders, the outer one of which is rotating with an angular velocity ω_0 and the inner one is stationary using equations of change. [16]

8. A hollow solid sphere has its inner (r=b) and outer (r=a) surfaces maintained at temperatures T_b and T_a respectively. Obtain the relation for temperature distribution in the solid at steady state conditions using thermal energy equation. Determine the heat flux at both surfaces and comment on the results. [16]

⋆ ⋆ ⋆ ⋆ ⋆