Registration No. : | | | | | | | | | | |

Total number of printed pages – 3

B. Tech.
PCML 4301

Sixth Semester Examination – 2013

TRANSPORT PHENOMENA

BRANCH : CHEMICAL

QUESTION CODE : A 264

Full Marks – 70

Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*
The figures in the right-hand margin indicate marks.
Assume suitable notations wherever necessary.
Assume any missing data suitably.

1. Answer the following questions : 2×10

   (a) Specify the interface boundary condition in a system for solving momentum transport problems.

   (b) Estimate the viscosity of liquid benzene at 20°C. (T_b = 80.1°C and specific molar volume = 89.0 cm^3/gmol)

   (c) Define convective momentum transport.

   (d) Define equation of motion.

   (e) What are the boundary conditions used for solving shell heat balance equation ?

   (f) What are the modes of heat transfer process in a double pipe heat exchanger ?

   (g) Write the generalized heat conduction equation for a plane wall with heat generation under unsteady state heat transfer.

   (h) State Eucken formula for thermal conductivity.

   (i) Define Schmidt and Lewis numbers.

   (j) How diffusivity varies with temperature in case of gas and liquid ?

P.T.O.

2. (a) Derive an expression for velocity profile, when non-Newtonian (Power law) fluid flows between two vertical walls, separated by a distance 2B, taking origin at midpoint of 2B distance. 5

(b) One method for determining the radius of a capillary tube is by measuring the rate of flow of a Newtonian liquid through the tube. Find the radius of a capillary from the following flow data : 5

Length of capillary tube	:	50.02 cm
Kinematic viscosity of liquid	:	$4.03 \times 10^{-5}\ m^2/s$
Density of liquid	:	$955.2\ kg/m^3$
Pressure drop in the horizontal tube	:	$4.829 \times 10^5\ Pa$
Mass rate of flow through tube	:	2.997×10^{-3} kg/sec

3. (a) In a pipe flow, if $v_{av} = (P_0 - P_L)R^2/8\mu L$, show the head loss is $32\mu v_{av}L/\rho g d^2$. 5

(b) Derive an expression for shear stress profile, when a Newtonian fluid is flowing in an annulus. 5

4. Consider a long cylindrical nuclear fuel rod, surrounded by an annular layer of aluminum cladding. Within the fuel rod heat is produced by fission; this heat source depends on position approximately as : $S_n = S_{n0}\left[1 + b\left(\frac{r}{R_F}\right)^2\right]$. Here S_{n0} and b are known constants, and r is the radial coordinate measured from the axis of the cylindrical fuel rod. R_F and R_C are the radii of fission and cladding materials. Derive an expression for temperature profile in the cladding material if the temperature at the outer surface of cladding is T_0. 10

5. (a) A viscous fluid with temperature independent physical properties is in fully developed laminar flow through a vertical tube of radius R. At $z = 0$, the fully developed flow is achieved. For $z < 0$ the fluid temperature is uniform at $T = T_1$. For $z > 0$, heat is added radially at a constant, uniform flux q_0, at the tube surface. Make a shell energy balance to obtain the differential equation for $T(r,z)$ in the zone $z > 0$. 5

(b) Develop the non-dimensional differential equation of "part a" in terms of the following variables : 5

$\Theta = (T - T_1)/(q_0 R/K)$, $\xi = r/R$, $\Phi = Kz/(\rho C_p v_{max} R^2)$

6. (a) Diffusion of A through a stagnant gas film. Derive a differential expression for mass flux in z-direction. 5

(b) Derive the mass flux profile as : $N_{AZ} = \frac{CD_{AB}}{z_2 - z_1}(x_{A1} - x_{A2})$ by neglecting $x_A(N_A + N_B)$. 5

7. (a) A hollow solid sphere has its inner ($r = R_1$) and outer ($r = R_2$) surfaces maintained at concentrations C_{A1} and C_{A2} respectively. Obtain the expression for concentration profile in the solid at steady-state condition. 5

(b) Chloropicrin (CCl_3NO_2) is evaporating at 25°C into air inside a cylinder. Make the customary assumption that air is a pure substance. What is the evaporation rate in gm/hr ? 5

Total pressure: 760 mmHg

Diffusivity (CCl_3NO_2- air): 0.088 cm^2/sec

Vapor pressure of CCl_3NO_2 : 23.81 mmHg

Distance from liquid level to top of tube: 12 cm

Density of CCl_3NO_2 : 1.65 gm/cm^3

Surface area of liquid exposed for evaporation: 2.8 cm^2

8. Write short notes on any **two** : 5 × 2

(a) Classify types of fluids

(b) Creeping flow around the sphere

(c) Conduction and Convection

(d) Steady state equimolar counter diffusion.
