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

Total number of printed pages – 3

B. Tech.

PCML 4301(New)

Sixth Semester (Back) Examination – 2013

TRANSPORT PHENOMENA

BRANCH : CHEMICAL

QUESTION CODE : B 323

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 boundary conditions used in solving momentum transport problems.

   (b) Define equation of continuity.

   (c) Define control volume.

   (d) Write combined energy flux.

   (e) Write the generalized heat conduction equation for a plane wall without heat generation under unidirectional steady state heat transfer.

   (f) How thermal conductivity depends on temperature in liquid and low density gas ?

   (g) Define Brinkman and Lewis numbers.

   (h) How diffusivity depends on temperature in liquid and low density gas ?

   (i) Define combined mass flux.

   (j) State Fick's Law of Diffusion.

2. (a) Derive an expression for velocity profile, when Bingham fluid flows in a pipe of inner radius R vertically downward. 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 :	49.03 cm
Kinematic viscosity of liquid :	$4.02 \times 10^{-5}\ m^2/s$
Density of liquid :	$955.6\ kg/m^3$
Pressure drop in the horizontal tube :	$4.829 \times 10^5\ Pa$
Mass rate of flow through tube :	$2.998 \times 10^{-3}\ kg/sec$

3. (a) Derive an expression for shear stress profile, when a Newtonian fluid is flowing in an annulus which is existing in R_1 and R_2 radii and length L. 5

(b) 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

4. A heated sphere of radius R suspended in a large motionless body of fluid. Show that, $Nu = \frac{hD}{K} = 2$, where h is heat transfer coefficient, D is the diameter of sphere, and k is the thermal conductivity. 10

5. (a) Explain Fourier's law of heat conduction. 5

(b) Derive an expression for temperature profile in heat conduction with electrical heat source when thermal conductivity is linearly varying with temperature. 5

6. (a) 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 ?

Total pressure: 770 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 : 13 cm

Density of CCl_3NO_2 : $1.65\ gm/cm^3$

Surface area of liquid exposed for evaporation: $3.2\ cm^2$ 5

(b) Explain diffusion controlled chemical reaction. 5

7. (a) In studying the rate of leaching of a substance A from solid particles by a solvent B, the rate controlling step is diffusion of A from the particle surface through a stagnant liquid film thickness δ out into the main stream. The molar solubility of A in B is C_{A0} and the main stream is $C_{A\bar{O}}$.

Show that, Rate of leaching is $N_{AZ} = D_{AB}\left(C_{AO} - C_{A\delta}\right)\Big/\delta$. 5

(b) A droplet of liquid A of radius r_1, is suspended in a stagnant film of gas of radius r_2. Boundary conditions are $r = r_1$, $x_A = x_{A1}$ and $r = r_2$, $x_A = x_{A2}$. Taking the value of constant as $r_1^2 N_{Ar1}$, show that 5

$$N_{Ar1} = \frac{CD_{AB}}{r_2 - r_1}\left(\frac{r_2}{r_1}\right)\ln\left(\frac{x_{B2}}{x_{B1}}\right).$$

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

(a) Non-Newtonian fluids

(b) Creeping flow around the sphere.

(c) Convection heat transfer

(d) Momentum, heat, and mass transfer analogy.