Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Mid Semester Examination, December 2018

Programme Name: M. Tech PDE/PLE **Semester : I**
Course Name : Transport Phenomena **Time : 03 hrs**
Course Code : CHPD-7001/ CHPL-7002 **Max. Marks : 100**
Nos. of page(s) : 3

Instructions:

1. Put your Roll No. immediately on the question paper.
2. Mark question number clearly in the left margin.
3. Assume data if necessary, and justify your assumptions.
4. Explain all answers with suitable drawings/figures/graphs/illustrations as needed.
5. No student is allowed to leave exam hall in the first hour of exam.
6. Use of unfair means will lead to immediate disqualification

S. No.	Section A: Attempt All 4 (4 Q x 5 marks =20)	Marks	CO
Q1	Three materials of different substance are in contact with each other. They are in turn in contact with fluids at T_a and T_b. Derive an expression for the heat flux in terms of T_a, T_b, and conductivity.	5	CO2
Q2	What is creeping flow. Explain important transport phenomena implications.	5	CO1
Q3	What is Prandtl number and explain its importance.	5	CO2
Q4	Helium diffusion through pyrex glass, enormously higher Diffusivity. Some helium in natural gas, can flow through pyrex tubes to separate, 2mm OD 1mm ID. Generally diffusion limited. calculate the production rate.	5	CO3

S. No.	Section B: Attempt All 4 (4 Q x 10 marks =40)	Marks	CO
Q5	The flow in closed conduit like pipe differs from open channel where the flow in pipe is at a pressure and does not have a free surface. The flow in pipe can be demonstrated such as Laminar, Transitional or Turbulent flow. Re=f (V, ρ, υ or μ, D). Describe the Reynolds Experiment and explain its implications for flow through a circular conduit and for flow over a flat plate.	10	CO4
Q6	a. For the steady, fully developed, laminar flow in a circular tube of radius R we know that the velocity distribution and the average velocity are given by [3] $\frac{v_z}{v_{z,\max}} = 1 - \left(\frac{r}{R}\right)^2$ and $\frac{\langle v_z \rangle}{v_{z,\max}} = \frac{1}{2}$ (Re < 2100) For a pipe of ID of 6 inch, with $\langle v_z \rangle = 2$ m/s, plot $v_z(r)$ as a function of radius from r = -R	10	CO1

	to r = R on the graph sheet. b. In case of turbulent flow, the velocity distribution is given by power law, as per following equation: [3] $$\frac{\bar{v}_z}{v_{z,\max}} \approx \left(1 - \frac{r}{R}\right)^{1/7} \quad \text{and} \quad \frac{\langle \bar{v}_z \rangle}{v_{z,\max}} \approx \frac{4}{5} \qquad (10^4 < Re < 10^5)$$ Presuming that $v_{z,\ max,\ laminar} = v_{z,\ max,\ turbulent}$, plot the $v_z(r)$ for turbulent flow on the same graph. c. What are the implications of evolution of laminar flow to turbulent which can be observed from this example. [4]		
Q7	Write the transport equation for binary system and prove that $D_{AB} = D_{BA.}$	10	CO3
Q8	What is the instantaneous velocity in case of turbulent flow. What is Reynolds stress Tensor. Explain the contribution of eddy diffusivity in turbulence.	10	CO4

S. No.	Section C: Attempt All 2 (2 Q x 20 marks =40)	**Marks**	**CO**
Q9	As fluid flows through a packed bed it experiences a pressure loss due to friction. This problem is about the use of the Carman-Kozeny and Ergun equations for the calculation of pressure drop through a randomly packed bed of spheres. Imagine a packed bed with following parameters: f∗ = packed bed friction factor g = Gravitational constant (g = 9.81 m/s) H = Height of the packed bed (m) ΔP = Fluidization pressure drop (Pa) −ΔP = Pressure drop through the packed bed (Pa) U = Superficial fluid velocity (m/s) x = Spherical equivalent particle diameter (m) ϵ = Bed voidage ρ_f = Density of the fluid flowing through the packed bed (kg/m^3) ρ_p = Density of particles in the packed bed (kg/m^3) μ =Viscosity of the fluid flowing through the packed bed (Pa.s) Sabri Ergun used a extensive set of experimental data covering a wide range of particle size and shapes, and presented a general equation to calculate the pressure drop across a packed bed for all flow conditions (laminar to turbulent). This equation is commonly referred to as the Ergun equation for flow through a randomly packed bed of spheres and takes the following form: $$-\Delta P/H = 150\mu U(1-\varepsilon)^2/x^2\varepsilon^3 + 1.75\ \rho_f U^2(1-\varepsilon)/x\varepsilon^3$$ a. Derive Kozeny-Carman equation for pressure drop for low particle Reynolds number of less than 20. b. Derive Burke-Plummer equation for pressure drop for high particle Reynolds	20	CO1

	number of more than 1000. c. What are the flow regimes in a, and b and why? d. Illustrate with a plot the Pressure Drop and the Reynolds number and show the limiting cases. e. Comment on the practical applications of Ergun Equations in Refining Engineering		
Q10	a. Explain the usual ranges of diffusivities of solids, liquids, and gases. Also elaborate on the pressure and temperature dependence of diffusivity for gases. [10] b. Diffusivity of a component in a mixture of components can be calculated using the Wilke's relation: $D_{1-mixture} = \dfrac{1}{\dfrac{y_2'}{D_{1-2}} + \dfrac{y_3'}{D_{1-3}} + \ldots\ldots\ldots\ldots + \dfrac{y_n'}{D_{1-n}}}$ Calculate the diffusivity of CO_2 [1], O_2 [2], and N_2 [3] in a gas mixture having the composition CO_2 = 28.5 %, O_2 = 15%, N_2 = 56.5%, The mixture is at 273 K and at 1 atm. pressure. The binary diffusivities at 273 K are given as $D_{12}P$ = 1.874 m^2Pa/sec, $D_{13}P$ = 1.945 m^2Pa/sec, and $D_{23}P$ = 1.834 m^2Pa/sec. [10]	20	CO3