Name: Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, March 2023

Programme Name: M Tech (Chemical Engineering) **Semester : II**

Course Name : Scale-Up Methods **Time : 03 hrs.**

Course Code : CHPD7025P **Max. Marks: 100**

Nos. of page(s) : 2

Instructions: Go through the questions carefully.
For the numerical, the Scaling ratio has been provided.
During derivations number the equations appropriately
For the numerical and derivations highlight the results/final expressions

SECTION A
(5Qx4M=20Marks)

S. No.	Questions	Marks	CO
Q1	Explain Scaling up in Chemical Processes with Examples?	**4**	**CO1**
Q2.	What is the difference between a true model and a distorted model? Explain with an example?	**4**	**CO2**
Q3	Describe SIMILARITY in chemical processes with special relevance of Scale-Up? Describe the different types of similarities in Scaling with examples.	**4**	**CO3**
Q4	Provide the expressions for the dimensionless number - Reynold’s Number and Froude’s Number?	**4**	**CO2**
Q5	Explain Damkohler Number, with special relevance to scaling heat transfer processes?	**4**	**CO2**

SECTION B
(4Qx10M=40Marks)

S. No.	Questions	Marks	CO
Q6	Explain Control regime? Provide the expressions for Control regime of heat transfer for a Gas-Liquid semi batch process.	**10**	**CO2**
Q7	Explain Scaling in Chemical Reactors, with special relevance to a) First Order Homogenous Batch reaction b) First Order Homogenous Batch reaction with agitation and c) First Order Homogenous reaction in a Plug flow reactor	**10**	**CO3**
Q8	A pipe of diameter 1.5 m is required to transport an oil of specific gravity 0.9 and viscosity 3×10^{-2} poise at the rate of 3000 litre/sec. Tests were conducted on a 15 cm diameter pipe using water at 20°C. Find the velocity and rate of flow in the model? Scaling ratio are provided below	**10**	**CO3**

	Velocity Ratio: $V_r = \frac{V_P}{V_m} = \frac{L_m}{L_P}\frac{\upsilon_P}{\upsilon_m} = \frac{\upsilon_r}{L_r}$ Time Ratio: $Tr = \frac{T_P}{T_m} = \frac{L_P/V_P}{L_m/V_m} = \frac{L_r}{V_r}$ Acceleration Ratio: $a_r = \frac{a_P}{a_m} = \frac{V_P/T_P}{V_m/T_m} = \frac{Vr}{Tr}$ Discharge Ratio: $Q_r = \frac{A_P V_P}{A_m V_m} = L_r^2 V_r$ Force Ratio: $F_r = m_r a_r = \rho_r Q_r V_r = \rho_r L_r^2 V_r V_r = \rho_r L_r^2 V_r^2$ Power Ratio: $P_r = F_r . V_r = \rho_r L_r^2 V_r^2 V_r = \rho_r L_r^2 V_r^3$		
Q9	The discharge through a weir is 1.5 m^3/s. Find the discharge through the model of weir if the horizontal dimensions of the model=1/50 the horizontal dimension of prototype and vertical dimension of model =1/10 the vertical dimension of prototype. Scale ratio for horizontal direction: $(L_r)_H = \frac{L_P}{L_m} = \frac{B_P}{B_m}$ Scale ratio for vertical direction: $(L_r)_V = \frac{h_P}{h_m}$ Scale Ratio for Velocity: $Vr = V_P / V_m = \frac{\sqrt{2gh_P}}{\sqrt{2gh_m}} = \sqrt{(L_r)_V}$ Scale Ratio for area of flow: $Ar = A_P / A_m = \frac{B_P h_P}{B_m h_m} = (L_r)_H (L_r)_V$ Scale Ratio for discharge: $Qr = Q_P / Q_m = \frac{A_P V_P}{A_m V_m} = (L_r)_H (L_r)_V \sqrt{(L_r)_V} = (L_r)_H (L_r)_V^{3/2}$	**10**	**CO3**
SECTION C **(2Qx20M=40Marks)**			
Q10	Flow components are critical to Industrial processes. Considering the flow for an incompressible viscous fluid in a pilot plant and in a commercial plant. Assuming as simple geometry – rectangular coordinates with flow in the x direction only. Derive the dimensionless form of Navier-Stokes for the model and the prototype. $$\frac{\partial v}{\partial t} + v\frac{\partial v}{\partial x} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + g + \frac{\mu}{\rho}\left(\frac{\partial^2 v}{\partial x^2}\right)$$	**20**	**CO4**
Q11	Describe the usage and application of various scale up techniques for developing an industrial process? Take a specific case of your choice on an industrial process (production & refining), build the process formulation, process flow diagram, flow sheet, and indicate how scaling is achieved for commercialization of the chemical process. Highlight the scaling features, improvements in production efficiency and profitability?	**20**	**CO5**