Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

Course: Chemical Reaction Engineering I **Semester: V**
Program: B. Tech Chemical Engineering spl. Refining and Petrochemicals **Time : 3 hrs.**
Course Code: CHCE 3004 **Max. Marks: 100**

Instructions: <u>The Exam is "OPEN BOOK, OPEN NOTES". You will be REQUIRING THE LAPTOP to solve some of the problems</u>. The MS Excel sheet must be saved by name EndSem_Rollnumber. Please email the excel sheet to nbanerjee@ddn.upes.ac.in. You will be needing graph paper for some of the questions. Please read all the questions carefully before answering

SECTION A

S. No.		Marks	CO

You work as the Lead engineer for Colgate-Palmolive Ltd soap making division. The liquid phase saponification reaction is as follows

$$3NaOH + (C_{17}H_{35}COO)_3C_3H_5 \rightarrow 3C_{17}H_{35}COONa + C_3H_5(OH)_3$$
$$3A + B \rightarrow C + D$$

The company wishes to start a new soap factory and you have been given the charge of identifying the kinetics and designing the reactor for the process. On experimentation, you have generated the rate data as given in the table below.

Time (mins)	C_A (NaOH) (kmol/m^3)	C_B (kmol/m^3)	C_C (kmol/m^3)
$0.001*T_o$	$0.998*C_{Ao}$	300	0
$0.50*T_o$	$0.848* C_{Ao}$	298	1.5
$1.00*T_o$	$0.715* C_{Ao}$	248	4.8
$1.50*T_o$	$0.610* C_{Ao}$	211	9.12
$2.00*T_o$	$0.467* C_{Ao}$	189	11.3
$3.00*T_o$	$0.376* C_{Ao}$	161	18.67
$4.00*T_o$	$0.270* C_{Ao}$	132	25.72
$6.00*T_o$	$0.145* C_{Ao}$	105	39.21
$10.0*T_o$	$0.003* C_{Ao}$	93	62.1

Here, **T_o = LAST THREE NUMBERS OF YOUR SAP ID**

C_{Ao} = LAST THREE NUMBERS OF YOUR ROLL NUMBER

Based on the above information, please answer the following questions.

Q1.	Identify the possible **"*Theoretical rate laws*"** for the above process. *Mention all the necessary assumptions made.*	**15**	**CO1**
Q2.	Using the experimental data provided in the table above, identify the **"*Experimental rate law*".** *Please mention all the necessary assumptions taken.* Choose the method of your choice to identify the rate equation. Give necessary justification for the choice. ***Use MS-Excel to develop the equation***.	**25**	**CO2**
Q3.	Analyze the "Theoretical rate law" and the "Experimental rate law" derived and comment on your observations.	**5**	**CO1**
Q4.	Colgate-Palmolive wishes to run this process in a Batch reactor for a 75% conversion of A. ***For how long a single batch should run so that the required conversion is achieved***? *All necessary assumptions should be mentioned.* *Hint: Use graphical methodology*	**15**	**CO3**
Q5.	However due to heavy requirement of labour and loss of time, Colgate-Palmolive wishes to convert their batch processes into a continuous system. They have a choice between. a) Single CSTR (75% conversion) b) Single PFR (75% conversion) c) CSTR followed by PFR (50% conversion in first reactor and 75% conversion in second reactor) d) PFR followed by CSTR (50% conversion in first reactor and 75% conversion in second reactor) ***Which one of the above do you think is the best possible reactor or combination of reactors to choose from***, if the volumetric flow rate is 1.5 m^3/min and the molar flowrates of reactants A and B are 50 kmol/min and 85 kmol/min. Give all reasons for the choice. *Mention all the necessary assumptions.*	**20**	**CO3**
Q6.	The reaction as mentioned above 3A + B → C + D, for soap saponification was running well in your reactor and the process was working fine. However, you suddenly observe that due to come contaminations there are additional reactions occurring in the process. On investigation, you found out that the new reactions occurring in your reactors are as follows 3A + B → C + D (Desired reaction) 3A + B → E (Undesired reaction) The rate law for the undesired reaction follows $-r_{A2} = 0.02C_AC_B$ ***Suggest a reactor type that should be used to ensure that the desired reaction and products are being maximized***.	**20**	**CO4**