Reg. No.

B.E / B.TECH. DEGREE EXAMINATION, MAY 2023

Sixth Semester

BT18601 – CHEMICAL REACTION ENGINEERING

(Biotechnology)

(Regulation 2018/2018A)

TIME: 3 HOURS **MAX. MARKS: 100**

COURSE OUTCOMES	STATEMENT	RBT LEVEL
CO 1	Organize an experimental investigation in order to determine rate equations.	2
CO 2	Solve material and energy balances in order to analyse the performance of a reactor.	3
CO 3	Demonstrate the residence time distribution in ideal and non-ideal flow reactor.	3
CO 4	Build a reactor for bio based products to achieve production and yield specifications.	4
CO 5	Demonstrate an experimental data using standard statistical methods to establish quantitative results.	3

PART- A (10 x 2 = 20 Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	On doubling the concentration of reactant, the rate of reaction doubles. Find the reaction order for any unimolecular reaction.	1	2
2.	How will you differentiate elementary and non-elementary reactions based on order and stoichiometry?	1	2
3.	Compare single and multiple plug-flow reactors in terms of conversion.	2	2
4.	Comment on holding time and space time for ideal flow reactors.	2	2
5.	List out any four characteristics of tracer used in RTD measurement.	3	2
6.	Brief about earliness and lateness of mixing of fluid with a suitable diagram.	3	2
7.	State Whitman's two film theory of mass transfer in a heterogeneous system.	4	2
8.	Point out the role of Hatta number in liquid-liquid and gas-liquid reactions.	4	2
9.	Distinguish between Shrinking-Core Model and Progressive-Conversion Model in case of fluid-particle reactions.	5	2
10.	Experiments are conducted on the decomposition of A with a particular catalyst. Is the reaction influenced by pore diffusion? Data: For cube of 2 cm pellet: Effective mass diffusivity = $5x10^{-5}$ $m^3/(m\ cat.h)$; Observed reaction rate = 10^5 $mol/(h.m^3\ cat)$; C_{Ag}= 20 mol/m^3 (at 1 atm and 336°C).	5	2

PART- B (5 x 14 = 70 Marks)

			Marks	CO	RBT LEVEL
11.	(a)	A reactant, called the substrate is converted to product by the action of enzyme, a high molecular weight (mw > 10000) protein-like substance. An enzyme is highly specific, catalyzing one particular reaction, or one group of reactions. Thus, $A \xrightarrow{enzyme} R$. Many of these reactions exhibit the following behavior: A rate proportional to the concentration of enzyme introduced into the mixture $[E_0]$; At low reactant concentration the rate is proportional to the reactant concentration, [A]; At high reactant concentration the rate levels off and becomes independent of reactant concentration. Propose a mechanism to account for this behavior.	(14)	1	3
		(OR)			
	(b)	α-Amylase from malt is used to hydrolyse starch. The dependence of initial reaction rate on temperature is determined experimentally. At 40ºC, the rate of glucose production is four times the rate at 20ºC. Find the activation energy for this reaction using Arrhenius law and collision theory. What is the percentage difference in rate of glucose production at 60ºC predicted by these methods?	(14)	1	3
12.	(a)	Consider a reactor where lateral mixing of fluid exists but no mixing along the flow path. Derive the performance equation of the above reactor. Assume constant-density system.	(14)	2	3
		(OR)			
	(b)	Consider a system of N equal-sized mixed flow reactors connected in series. Derive an expression for space time of the above system by assuming first order reaction.	(14)	2	3
13.	(a)	The concentration readings given below represent a continuous response to pulse input into a closed vessel. This vessel is to be used as a reactor for decomposition of liquid A, A→products with rate $-r_A=kC_A$, k=0.1 min^{-1}.	(14)	3	4

t, min	0	1	2	3	4	5	6	7	8	9	10	12	14
C_{pulse}, g/m^3	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

Estimate the fraction of the reactant unconverted in the real reactor and compare this with the fraction unconverted in a plug flow reactor of same size.

(OR)

			Marks	CO	RBT LEVEL
	(b)	A first order liquid phase reaction (k=0.25 min^{-1}) is carried out in a reactor for which the results of (pulse) tracer test are given below. Calculate conversion using Tank-in-series model.	(14)	3	4

t, min	0	1	2	3	4	5	6	7	8	9	10	12	14
C_{pulse}, g/m^3	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

14. (a) Air with gaseous A bubbles through a tank containing aqueous B. Reaction occurs as follows A (g→l) + 2B(l)→R(l), $-r_A=kC_AC_B$. For this system, **(14)** 4 4

$k_{Ag}a$=0.01 mol/hr.m².Pa

$k_{Al}a$=20 hr⁻¹

a= 20 m²/m³ reactor

f_l =0.98

$D_{Al}=D_{Bl}=10^{-6}$ m²/hr

$H_A=10^5$ Pa.m³/mol, very low solubility

$k=10^6$ m⁶/mol².hr

For a point in the absorber-reactor where $p_A=5\times10^3$ Pa and C_B=100 mol/m³, Find the location of the reaction zone and resistance to reaction. Also calculate the rate of reaction and determine the behaviour in the liquid film.

(OR)

(b) Gaseous A absorbs and reacts with B in liquid according to the equation A(g→l) +B(l)→R(l), $-r_A=kC_AC_B$ in a packed bed under conditions where **(14)** 4 4

$k_{Ag}a$=0.1 mol/hr.m³ of reactor.Pa

$k_{Al}a$=100 m³ liquid /m³ of reactor.hr

a= 100 m²/m³ reactor

f_l =0.01 m³ liquid/m³ of reactor

$D_{Al}=D_{Bl}=10^{-6}$ m²/hr

$k=10^{-2}$ m³ liquid/mol.hr; H_A=1 Pa.m³ of liquid/mol.

At a point in the reactor where p_A=100 pa and C_B=100mol/m³ liquid and for the given values of reaction rate and Henry's law constant, calculate the rate of reaction in mol/hr. m³ of reactor. Locate the reaction zone and the resistance to reaction. Also determine the behaviour in the liquid film.

15. (a) Two small samples of solids are kept in a constant environment oven for period of 1 h. Under the conditions prevailing in the oven, the 4 mm particles are 57.8% converted, the 2mm particles are 87.5% converted into a firm non-flaking product. Find the rate controlling mechanism for the conversion of solids. Also calculate the time required for complete conversion of 1mm particle in this oven. **(14)** 5 4

(OR)

(b) Experiments are carried out on different sizes to determine the effect of pore diffusion of crushed catalyst (spherical particles) for first order irreversible reaction. The surface concentration of reactant A was $C_{AS} = 2\times10^{-4}$ mol/cm³. Determine the true rate constant and effective diffusivity. **(14)** 5 4

Data:

d_p,cm	$-r_{A,Obs,}$ mol/(h.cm³.cat)
0.20	0.12
0.02	1.03

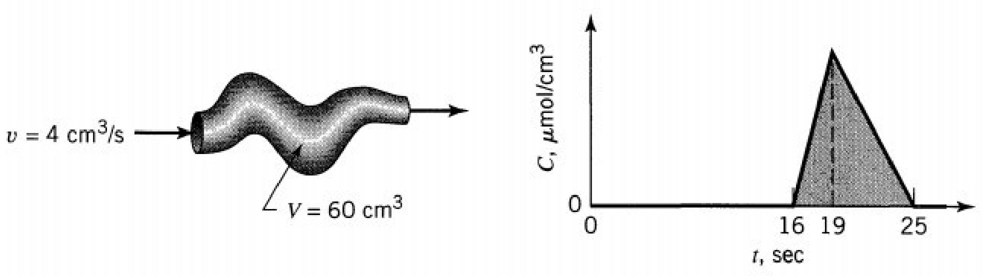
Q. Code: 350326

PART- C (1 x 10 = 10 Marks)

(Q.No.16 is compulsory)

Marks CO RBT LEVEL

16. A pulse input of tracer (M=13.5 μmol/s) into a vessel of volume 60 cm³ gives the results as shown below. The results are found to be consistent by checking the material balance with the tracer curve. Construct E curve. Also calculate mean residence time. **(10)** 3 5



****