Q. Code:530408

Reg. No. | | | | | | | | | | | | | |

B. E / B. TECH.DEGREE EXAMINATIONS, MAY 2024

Sixth Semester

BT18601– CHEMICAL REACTION ENGINEERING

(Biotechnology)

(Regulation2018/2018A)

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.	4

PART- A(10x2=20Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	Differentiate elementary and non-elementary reactions.	1	2
2.	Comment on holding time and space time for ideal flow reactors.	2	2
3.	Compare single and multiple plug-flow reactors in terms of conversion.	2	2
4.	List out the factors that make up the flow pattern in real reactors.	3	2
5.	How will you relate F and E curve in RTD determination?	3	2
6.	State Whitman's two film theory of mass transfer in a heterogeneous system.	4	2
7.	Why heterogeneous reactions involving solid-phase catalysts are important in bioprocessing? Justify your answer with examples.	4	3
8.	Distinguish between Shrinking-Core Model and Progressive-Conversion Model in case of fluid-particle reactions.	5	3
9.	The Thiele modulus for a first order isothermal reaction for a flat plate geometry catalyst is found to be 2. Calculate the catalyst effectiveness factor.	5	3
10.	The rate constant of a zero order reaction is 0.2 mol/(l.h). What will be the initial concentration of the reactant if, after an hour, its concentration is 0.025 mol/l?	1	2

PART- B (5x 14=70Marks)

		Marks	CO	RBT LEVEL
11. (a)	At 500 K the rate of a bimolecular reaction is ten times the rate at 400 K. Find the activation energy for this reaction using Arrhenius law and Collision theory. What is the percentage difference in rate of reaction at 600 K predicted by these	**(14)**	1	2

methods?

(OR)

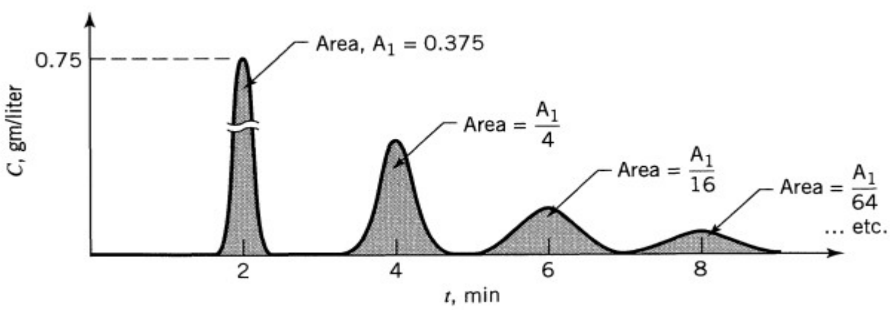
(b) Consider an enzyme-substrate reaction, $A \xrightarrow{enzyme} R$. Explain the kinetics of the given enzyme-substrate reaction using an equilibrium assumption as proposed by Michaelis and Menten (1913). What final rate form $-r_A$ in terms of [A], [E_0], k_1, k_2 and k_3 does the Michaelis-Menten mechanism give? **(14)** 1 2

12. (a) Given a series arrangement of N identical mixed flow reactors, derive an equation for the space time of this system under the assumption of a first-order reaction. **(14)** 2 3

(OR)

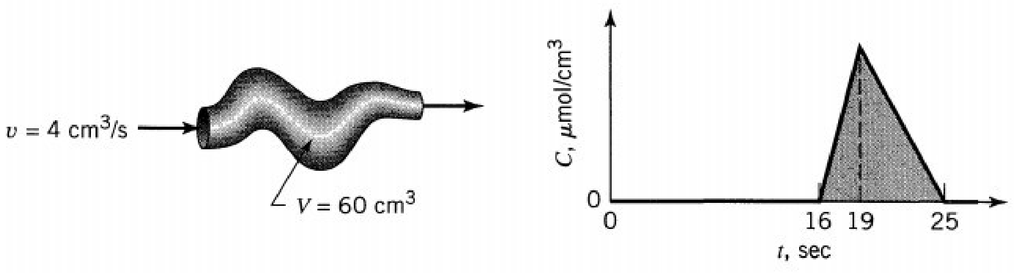
(b) Imagine a reactor characterized by lateral fluid mixing but no mixing along the flow path. Derive the performance equation for this reactor, considering it to be a constant-density system. **(14)** 2 3

13. (a) A large tank (860 liters) is used as a gas-liquid contactor. Gas bubbles up through the vessel and out the top, liquid flows in at one part and out the other at 5 liters/s. To get an idea of the flow pattern of liquid in this tank a pulse of tracer (M = 150 gm) is injected at the liquid inlet and measured at the outlet, as shown in figure. Determine the E curve for the liquid. Also calculate mean residence time. **(14)** 3 4



(OR)

(b) A pulse input of tracer (M=13.5 μmol/s) into a vessel of volume 60 cm^3 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. **(14)** 3 4



14. (a) Gaseous A absorbs and reacts with Bin 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=100m^2/m^3 reactor

f_l=0.01m3 liquid/m3 of reactor

$D_{Al}=D_{Bl}$=10-6m2/hr

k=10-2m3liquid/mol.hr; HA=1 Pa.m3 of liquid/mol.

At a point in the reactor where p_A=100pa 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.m^{3}of reactor. Locate the reaction zone and the resistance to reaction. Also determine the behaviour in the liquid film.

(OR)

(b) 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_{Aga}=0.01 mol/hr.m^2.Pa

k_{Ala}=20 hr^{-1}

a= 20 m^2/m^3 reactor

f_l =0.98

$D_{Al}=D_{Bl}$=10^{-6} m^2/hr

H_A=10^5 Pa.m^3/mol, very low solubility

k=10^6 m^6/mol^2.hr

For a point in the absorber-reactor where p_A=5x10^3 Pa and C_B=100 mol/m^3, Find the location of the reaction zone and resistance to reaction. Also calculate the rate of reaction and determine the behavior in the liquid film.

15. (a)	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 $C_{AS} = 2x10^{-4}mol/cm^3$. Determine the true rate constant and effective diffusivity for the data given below.	**(14)**	**5**	**4**

d_p,cm	$-r_{A,Obs,}$ mol/(h.cm^3.cat)
0.20	0.12
0.02	1.03

(OR)

(b)	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**

PART- C (1x 10=10Marks)

(Q.No.16 is compulsory)

		Marks	CO	RBT LEVEL
16.	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.	**(10)**	**3**	**3**

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

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