University of Mumbai

May-June 2022 Examinations

Program: **Chemical Engineering**

Curriculum Scheme: Rev2019 C Scheme

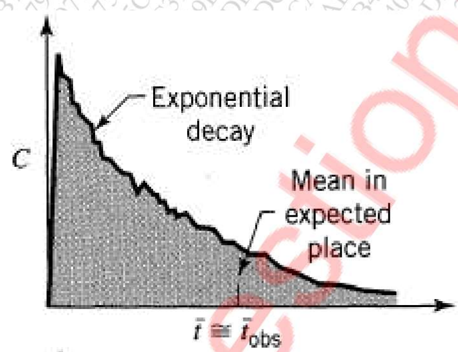
Examination: TE, Semester VI

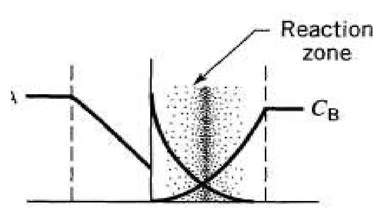
Programme No: 1T53006 Course Code: 89242

Subject:Chemical Reaction Engineering II

Time:Max. Marks: 80

DATE: 21/5/2022 QP CODE: 93295

Q1.	**Choose the correct option for following questions. All the Questions are compulsory and carry equal marks**
1.	What is the dispersion number for a plug flow reactor?
Option A:	0
Option B:	3
Option C:	1
Option D:	10
2.	The single parameter model proposed for describing non ideal flow is the ________________ model
Option A:	Tank in series
Option B:	Dispersion
Option C:	Both A & B
Option D:	PFR
3.	Following figure represents a tracer output curve for the step input to the reactor. Identify the possible type of reactor from the following options, 
Option A:	Ideal Plug flow reactor
Option B:	Non ideal packed bed reactor
Option C:	Mixed flow reactor
Option D:	Any reactor
4.	The exit age distribution of fluid leaving a vessel is used.
Option A:	to study the reaction mechanism
Option B:	to study the extent of non-ideal flow in the vessel
Option C:	to know the reaction rate constants
Option D:	to know the activation energies of a reaction
5.	A fluidised bed is charged with particles of single size at a rate of 2 kg/min.The bed

	contains 60 kg of solids. Find the mean residence time of solid for no carry over of particles
Option A:	30 min
Option B:	60 min
Option C:	40 min
Option D:	20 min
6.	Solid particle consumption dynamics as a function of conversion for different controlling regimes of Shrinking Core Model are given below A) $\frac{t}{\tau} = 1 - (1 - X_B)^{\frac{1}{3}}$ B) $\frac{t}{\tau} = X_B$ C) $\frac{t}{\tau} = 1 - 3(1 - X_B)^{\frac{2}{3}} + 2(1 - X_B)$ Identify the controlling regime for each of these
Option A:	A-Gas film controlling, B-Ash layer controlling, C-Reaction controlling
Option B:	B-Gas film controlling, A-Ash layer controlling, C-Reaction controlling
Option C:	B-Gas film controlling, A-Ash layer controlling, C-Reaction controlling
Option D:	C-Gas film controlling, B-Ash layer controlling, A-Reaction controlling
7.	For a first order chemical reaction in a porous catalyst, the thielemodulas is 10. The effectiveness factor is approximately equal to
Option A:	1
Option B:	0.5
Option C:	0.1
Option D:	0
8.	Effectiveness factor of a catalyst pellet is measure of the __________ resistance.,
Option A:	Pore diffusion
Option B:	Gas film
Option C:	Chemical reaction
Option D:	None of these
9.	When a high liquid hold up is required in a reactor for gas liquid reaction, use __________ column.
Option A:	Packed column
Option B:	Spray tower
Option C:	Tray column
Option D:	Bubble column
10.	Using following diagram, identify the case of reaction. 
Option A:	Instantaneous reaction with high concentration of B
Option B:	Fast reaction with high concentration of B
Option C:	Slow reaction in liquid phase
Option D:	Slow reaction without film resistances

Q2	**Solve any Four out of Six5 marks each**
A	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.
B	Calculate the time required to burn to completion spherical particles of graphite (*radius 12 mm, bulk density 2.4 g/cc*) in a 12% oxygen stream at 900°C and 1 atm. Assume gas film resistance to be negligible. Surface reaction rate constant = k" = 25 cm/s
C	Determine pore volume, particle porosity of the sample of a catalyst from the following information. Mass of sample: 120 gm V_H displaced =50 cc V_M displaced =96 cc
D	Explain the significance of Hatta number in case of Fluid fluid reaction.
E	A closed vessel with dispersion number =0.2 is planned to represent by Tank in Series Model.Determine the number of tanks required. Calculate conversion if tm = 2.5 min and k=0.025 $min^{-1.}$
F	Explain pulse input experiment for RTD measurement.

Q3	**Solve any Two Questions out of Three 10 marks each**
A	Develop the conversion time relationship for spherical particles of unchanging size using Shrinking Core Model for the case when chemical reaction is controlling.
B	Gaseous A absorbs and reacts with B in liquid according to A (g → l) + B(l) → R(l), $-r_A = kC_AC_B$ in a packed bed. (i) Calculate the rate of reaction in mol/(h·m² of reactor). (ii) Locate the resistance to reaction (what % is in gas film, in the liquid film, in the main body of liquid). Use the following data: p_A= 100Pa and C_B= 100 mol / m^3 liquid. k_{Ag} a=0.10 mol/ (h-m³ of reactor. Pa) k_{Al} a = 100m^3 liquid/(m³ reactor . h) a = 100 m^2 / m^3 reactor f_l = 0.01 m^3 liquid/m^3 reactor D_{Al} = D_{Bl} =10^{-6} m^2/ h k = $10^8 m^3$liquid/ (mol. h) H_A = 1.0 (Pa. m^3 liquid) / mol

C	Develop Langmuir –Hinshelwood type of rate equation for A + B→ R + S When the adsorption of A is rate controlling step.

Q4 **Solve ANY TWO10 Marks each**

A The RTD analysis was carried out in a liquid phase reactor as follows –

Time, min	0	2.5	2.9	3.3	3.75	4	4.6	4.33	4.58	5	5.41	6.25
Conc., (gm/cm^3)	0	0	1	3	7.4	9.4	9.7	9.4	8.2	5	2.5	0.5

1. Find mean residence time
2. Calculate conversion using segregation model for the reaction carried out in the reactor with rate constant of 0.7 min^{-1}

B Determine the weight and volume of catalyst necessary to achieve 89% conversion of Toluene in Packed Bed Reactor with a bulk density of 2.3 g/cc with an entering volumetric flow rate of 400 litre/ min.

$$C_6H_5CH_3 + H_2 \rightarrow C_6H_6 + CH_4$$

Rate law is –

$$-r_T = \frac{1.4 \times 10^{-8} p_{H2}.p_T}{1 + 1.26 p_B + 1.01 p_T}, \frac{mol\ Toluene}{gm\ catalyst.sec}$$

Pressure is in atm, T – toluene, B – Benzene. The feed consists of 20% Toluene, 40% H2 and 40% inert at 600C and 10 atm.

C A moving grate is continuously fed with a feed consisting of 30% of 50 µm radius particles, 40% of 100 µm radius particles and 30% of 200 µm radius particles. The feed is fed in the form of thin layer and moves on the grate in a crosscurrent fashion to the flow of reactant gas. The time required for complete conversion is
5 min for 50 µm particles
10 min for 100 µm particles
and 20 min for 200 µm particles.
Calculate the conversion of solids for a residence time of 8 min over the moving grate.