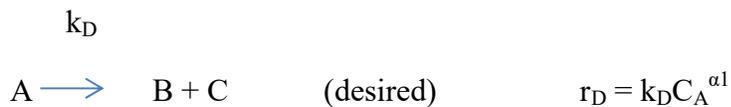


UNIT-I & II

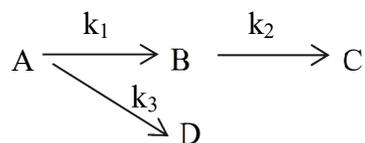
(1) Discuss the algorithms for multiple reactions where at least one species is involved in only one reaction.

(2) For parallel reactions



Consider all possible combinations to select the reaction scheme that will maximize $S_{D/U}$.

(3) For the elementary reaction

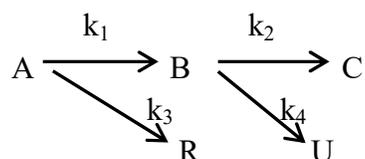


Find $C_{R,\max}$ for

a) Plug flow reactor

b) CSTR

(4) For the elementary reaction

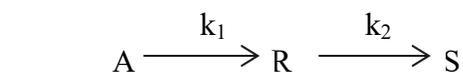


Find $C_{R,\max}$ for

a) Plug flow reactor

b) CSTR

(5) Derive the expression for $C_{R,\max}$, if the reaction

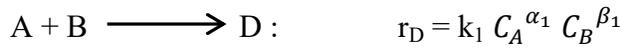


is carried out in

a) PFR

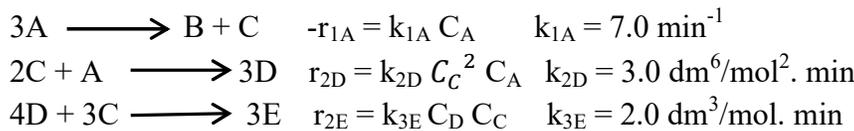
b) CSTR

(6) For parallel reactions



consider all possible combinations of reaction orders and select the reaction scheme that will maximize $S_{D/U}$.

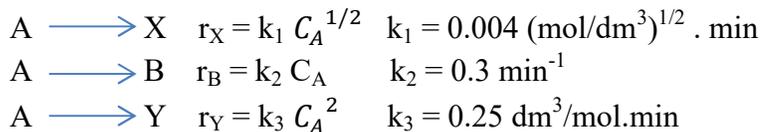
(7) The following liquid-phase reactions were carried out in a CSTR at 325 K.



The concentrations measured inside the reactor were $C_A = 0.10$, $C_B = 0.93$, $C_C = 0.51$, and $C_D = 0.049$ all in mol/dm^3 .

- i) What are r_{1A} , r_{2A} and r_{3A} ?
- ii) What are r_{1B} , r_{2B} and r_{3B} ?
- iii) What are r_{1C} , r_{2C} and r_{3C} ?
- iv) What are r_{1D} , r_{2D} and r_{3D} ?
- v) What are r_{1E} , r_{2E} and r_{3E} ?
- vi) What are the net rates of formation of A, B, C, D, and E?
- vii) The entering volumetric flow rate is $100 \text{ dm}^3/\text{min}$ and, the entering concentration of A is $3M$. What is the CSTR reactor volume?

(8) Consider the following system of gas-phase reactions:



B is the desired product, and X and Y are foul pollutants that are expensive to get rid of. The specific reaction rates are at 27°C . The reaction system is to be operated at 27°C and 4 atm. Pure A enters the system at a volumetric flow rate of $10 \text{ dm}^3/\text{min}$. Consider a series reactor. What would be the volume of the first reactor?

(9) What reaction schemes and conditions would you use to maximize the selectivity parameters S for the following parallel reactions:





where D is the desired product and U_1 is the undesired product?

(ii) State how your answer to part (i) would change if C were to react with D to form another undesired product.



At what temperature should the reactor be operated **if** the concentrations of A and D in the reactor were each 1 mol/dm³?

(10) What reaction schemes and conditions would you use to maximize the selectivity parameters S for the following parallel reactions:



where D is the desired product and U is the undesired product?

(11) Reactant A decomposes by three simultaneous reactions to form three products: one that is desired, D, and two that are undesired, T and U. These gas phase reactions, together with their corresponding rate laws, are:

Desired product:



$$r_D = \left\{ 0.0012 \exp \left[26,000 \left(\frac{1}{300} - \frac{1}{T} \right) \right] \right\} C_A$$

Unwanted product U:



$$r_U = \left\{ 0.0018 \exp \left[25,500 \left(\frac{1}{300} - \frac{1}{T} \right) \right] \right\} C_A^{1.5}$$

Unwanted product T:



$$r_T = \left\{ 0.00452 \exp \left[5,000 \left(\frac{1}{300} - \frac{1}{T} \right) \right] \right\} C_A^{0.5}$$

How and under what conditions (e.g., reactor type, pressure, temperature, etc.) should the reactions above be carried out to minimize the concentrations of the unwanted products U and T?

(12) A mixture of 50% A, 50% B is charged to a constant volume batch reactor in which equilibrium is rapidly achieved. The initial total concentration is 3.0 mol/dm^3 .

Calculate the equilibrium concentrations and conversion of A at 330 K for the reaction sequence

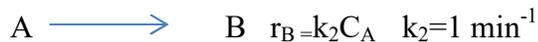


Additional Information:

$$\Delta H_{R1} = -20,000 \text{ J/mole A}, \quad \Delta H_{R2} = +20,000 \text{ J/mol B},$$

$$\Delta H_{R3} = -40,000 \text{ J/mole A}$$

(13) Consider the following system of gas-phase reactions:



B is the desired product, and X and Y are foul pollutants that are expensive to get rid of. What kind of reactor system would you recommend for this reaction scheme?

(14) The elementary liquid-phase series reaction



is carried out in a 500-dm^3 batch reactor. The initial concentration of A is

1.6 mol/dm^3 . The desired product is B, and separation of the undesired product C is very difficult and costly. Because the reaction is carried out at a relatively high temperature, the reaction is easily quenched.

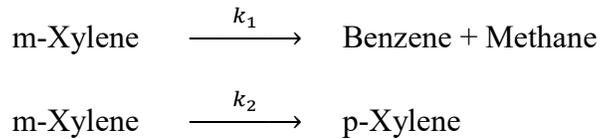
$$k_1 = 0.4 \text{ h}^{-1}$$

$$k_2 = 0.01 \text{ h}^{-1} \text{ at } 100^\circ \text{C}$$

- a) Assuming that each reaction is irreversible, plot the concentrations of A, B, and C as a function of time.

- b) For a CSTR space time of 0.5 h, what temperature would you recommend to maximize B? ($E_1 = 10,000$ cal/mol, $E_2 = 20,000$ cal/mol)
- c) Assume that the first reaction is reversible with $k_{-1} = 0.3$ h⁻¹, Plot the concentrations of A, B, and C as a function of time.
- d) Plot the concentrations of A, B, and C as a function of time for the case where both reactions are reversible with $k_{-2} = 0.005$ h⁻¹.

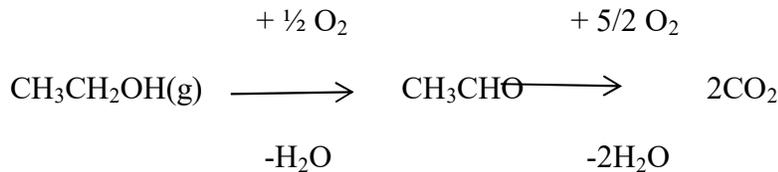
(15) m-Xylene is reacted over a ZSM-5 zeolite catalyst. The following parallel elementary reactions were found to occur



(i) Calculate the space time and volume for PFR to achieve 90% conversion of m-Xylene in a packed-bed reactor. Plot the overall selectivity and yields as a function of τ . The specific reaction rates are $k_1 = 0.22$ s⁻¹ and $k_2 = 0.71$ s⁻¹ at 673°C. A mixture of 75% m-Xylene and 25% inert is fed to a tubular reactor at volumetric flow rate of 2000 dm³/min and a total concentration of 0.05 mol/dm³. As a first approximation, neglect any other reactions such as the reverse reactions and isomerization to o-Xylene.

(ii) Suppose that $E_1 = 20,000$ cal/mol and $E_2 = 10,000$ cal/mol, what temperature would be recommend to maximize the formation of p-xylene in a 2000-dm³ CSTR?

(16) The oxidation of ethanol to form acetaldehyde is carried out on a catalyst of 4 wt. % Cu – 2 wt % Cr on Al₂O₃. Unfortunately, acetaldehyde is also oxidized on this catalyst to form carbon dioxide. The reaction is carried out in a threefold excess of oxygen and it dilute concentrations (ca. 0.1% ethanol, 1% O₂, and 98.9% N₂). Consequently, the volume change with the reaction can be neglected. Determine the optimum concentration of acetaldehyde ,



The reactions are irreversible and first order in ethanol and acetaldehyde, respectively.

(17) A liquid feed to well-mixed reactor consists of 0.4 gmol/dm³ of A and the same molar concentration of F. The product C is formed from A by two different reactions mechanisms: either by direct transformation or through intermediate B. The intermediate is also formed from F. Together with C, which remains in solution, an insoluble gas D is formed, which separates in the reactor.

All reaction steps are irreversible and the first-order, except for the formation of B from F, which is second-order in F. The liquid carrier for reactants and product is an inert solvent, and no volume change results from the reactions:

$$k_1 = 0.01 \text{ min}^{-1} \quad ; \quad k_2 = 0.02 \text{ min}^{-1} \quad ; \quad k_3 = 0.07 \text{ min}^{-1} \quad ; \quad k_4 = 0.50 \text{ dm}^3/\text{g mol. min}$$

Reactor volume = 120 liters

- (i) What is the maximum possible molar concentration of C in the product?
- (ii) If the feed rate is $2.0 \text{ dm}^3/\text{min}$, what is the yield of C (expressed as a percentage of the maximum), and what is the mole fraction of C in the product on a solvent-free basis?

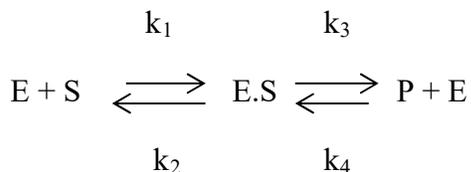
UNIT-III

- (1) Discuss the rules of thumb for development of mechanism.
- (2) Give the informative account of the following
 - (i) Active intermediates
 - (ii) PSSH
- (3) Ozone is reactive gas that has been associated with respiratory illness and decreased lung function. For the decomposition of ozone in an inert gas M, the rate expression is

$$-r_{O_3} = \frac{k(O_3)^2(M)}{(O_2)(M) + k'(O_3)}$$

Suggest a mechanism.

- (4) Derive a rate law for the enzyme-catalyzed reaction sequence



in terms of the substrate concentration, the total enzyme concentration, and the specific reaction rates k_1, k_2, k_3 and k_4 .

- (5) Consider the application of the PSSH to epidemiology. We shall treat each of the following steps as elementary in that the rate will be proportional to the number of people in a particular state of health. A healthy person, H, can become ill, I, spontaneously, such as by contracting smallpox spores:



Or he may become ill through contact with another ill person:



The ill person may become healthy:



Or he may expire:

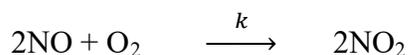


The reaction given in equation (4) is normally considered completely irreversible, although the reverse reaction has been reported to occur.

i) Derive an equation for the death rate.

ii) At what concentration of healthy people does the death rate become critical?

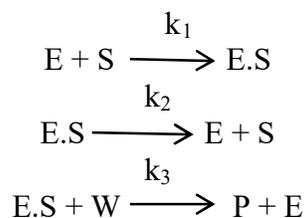
(6) The gas-phase homogeneous oxidation of nitrogen monoxide (NO) to dioxide (NO₂)



is known to have a form of third-order kinetics that suggests the reaction is elementary as written, at least for low partial pressures of the nitrogen oxides. However, the rate constant k actually decreases with increasing absolute temperature, indicating an apparently negative activation energy. Because the activation energy of any elementary reaction must be positive, some explanation is in order.

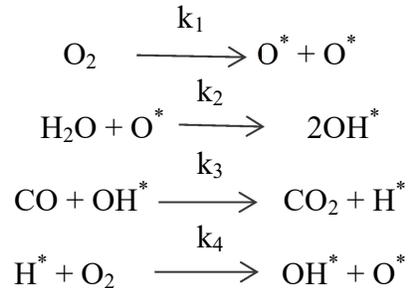
Provide an explanation, starting from the fact that an active intermediate species, NO₃, is a participant in some other known reactions that involve oxides of nitrogen.

(7) For the reaction mechanism

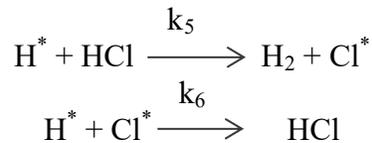


Develop Michaelis – Menten equation

(8) Flame Retardants, Hydrogen radicals are important to sustaining combustion reactions. Consequently, if chemical compounds are introduced that can scavenge the hydrogen radicals then the flames can be extinguished. While many reactions occur during the combustion process, we shall choose CO flames as a model system to illustrate the process. In the absence of inhibitors

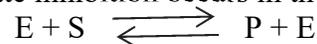


The last two reactions are rapid compared to the first two. When HCl is introduced to the flame, the following additional reactions occur:



Assume all reactions are elementary derive a rate law for the consumption of CO when retardant is present.

(9) It has been observed that substrate inhibition occurs in the following enzymatic reactions:



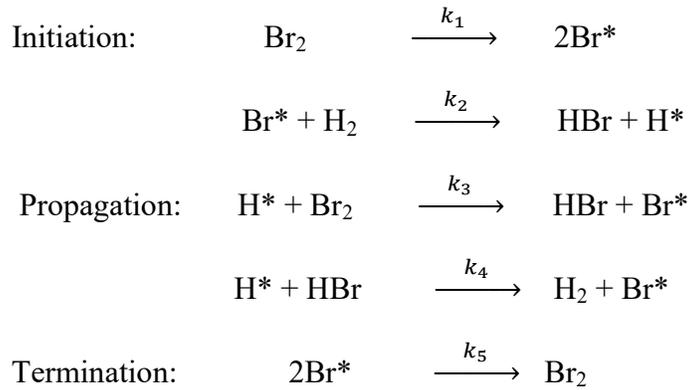
If this reaction is carried out in a CSTR that has a volume of 1000 dm^3 , to which the volumetric flow rate is $3.2 \text{ dm}^3/\text{min}$, determine the three possible steady states, noting, if possible, which are stable. The entrance concentration of the substrate is $50 \text{ mol}/\text{dm}^3$. What is the highest conversion?

(10) Beef catalase has been used to accelerate the decomposition of hydrogen peroxide to yield water and oxygen. The concentration of hydrogen of hydrogen peroxide is given as a function of time for a reaction mixture with a pH of 6.76 maintained at 30°C .

t (min)	0	10	20	50	100
$C_{\text{H}_2\text{O}_2}$ (mol/L)	0.02	0.01775	0.0158	0.0106	0.005

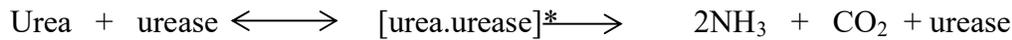
- Derive the relation required to determine the Michaelis – Menten parameters and determine them by the integral method of analysis
- If the total enzyme concentration is tripled, what will the substrate concentration be after 20 minutes?

(11) Using the PSSH, develop a rate law for the formation of HBr for the mechanism below.



The specific reaction rates k_1 and k_5 are defined with respect to Br_2 .

(12) Determine the Michaelis Menten parameters V_{\max} and K_m for the reaction



The rate of reaction is given as a function of urea concentration in the following table

C_{urea} (kmol/m^3)	0.2	0.02	0.01	0.005	0.002
$-\text{r}_{\text{urea}}$ ($\text{kmol}/\text{m}^3 \cdot \text{s}$)	1.08	0.55	0.38	0.2	0.09

UNIT-IV

- (1) Discuss the steps in modeling chemical systems with diffusion and reaction.
- (2) Doing mole balance on shrinking core show the time necessary to complete regeneration of the catalyst pellet is

$$t_c = \frac{\rho_c R_0^2 \phi}{\sigma D_e C_{A0}}$$

- (3) Discuss different types of boundary conditions used for diffusion in heterogeneous reactions.
- (4) Discuss mass transfer limited reaction in following two catalytic reactors.

- (i) Catalyst monolith
- (ii) Wire gauge

(5) Discuss in brief about the following

- (i) Mass transfer only by convection.
- (ii) Mass transfer by diffusion & convection.

(6) Discuss diffusion through a stagnant gas and show that $W_A = cD_{AB} \nabla \ln y_B$

(7) For the dissolution of monodispersed solid particles show that the time to complete dissolution of the solid particle is

$$t_c = \frac{1}{\alpha} \left[D_i + \frac{D_i^2}{2D^*} \right]$$

(8) Hydrazine has been studied extensively for use in monopropellant thrusters for space flights of long duration. Thrusters are used for altitude control of communication satellites. Here the decomposition of hydrazine over a packed bed of alumina-supported iridium catalyst is of interest. In a proposed study, a 2% hydrazine in 98% helium mixture is to be passed over a packed bed of cylindrical particles 0.25 cm in diameter and 0.5 cm in length at a gas – phase velocity of 15 m/s and a temperature of 750 K. The kinematic viscosity of helium at this temperature is $4.5 \times 10^{-4} \text{ m}^2/\text{s}$. The hydrazine decomposition reaction is believed to be externally mass transfer-limited under these conditions. If the packed bed is 0.05 m in length, what conversion can be expected? Assume isothermal operation.

Additional information:

$$D_{AB} = 0.69 \times 10^{-4} \text{ m}^2/\text{s} \text{ at } 298 \text{ K}$$

Bed porosity: 30%

Bed fluidicity: 95.7%

(9) For mass transfer limited reactions in packed bed show that

$$\frac{C_A}{C_{A0}} = \exp\left[- \frac{k_c a}{U} z \right]$$

(10) Discuss the steps in modeling chemical systems with diffusion and reaction.

(11) Species A is diffusing at steady state through a liquid film of thickness δ . The concentrations of A at the left and right boundaries are C_{A0} and $C_{A\delta}$, respectively, with $C_{A0} > C_{A\delta}$. Determine the concentration gradient and the flux of A.

(12) Species A, which is present in dilute concentrations, is diffusing at steady state from the bulk fluid through a stagnant film of B of thickness δ to the external surface of the catalyst. The concentration of A at the external boundary is C_{Ab} and at the external catalyst surface is C_{As} , with $C_{Ab} > C_{As}$. Because the thickness of the “hypothetical stagnant film” next to the surface is small

with respect to the diameter of the particle (i.e., $\delta \ll d_p$), we can neglect curvature and represent the diffusion in rectilinear coordinates.

Determine the concentration profile and the flux of A to the surface using (a) shell balances and (b) the general balance equations.

Additional information:

$$D_{AB} = 0.01 \text{ cm}^2/\text{s} = 10^{-6} \text{ m}^2/\text{s} \quad C_{T0} = 0.1 \text{ kmol/m}^3$$

$$y_{Ab} = 0.9 \quad y_{As} = 0.2$$

(13) The reaction



is carried out on a metallic surface and follows Langmuir-Hinshelwood kinetics at room temperature with corresponding rate laws:

$$-r_A'' = \frac{10^{-8} C_A}{1 + 0.5 C_A + 0.2 C_B} \frac{\text{g mol}}{\text{m}^2 \cdot \text{s}}$$

However, at higher temperatures the reaction is mass transfer-limited. The reaction currently takes place on a monolith catalyst where 45% conversion is achieved. It is proposed to double the number of plates for the same width and to halve the length of the reactor. What conversion can be expected for

- i) Monoliths operated at low Reynolds numbers?
- ii) Monoliths operated at high Reynolds numbers?

(14) A mass transfer limited reaction is being carried out in two reactors of equal volume and packing, connected in series as shown in fig B. Currently 86.5% conversion is being achieved with this arrangement. A new engineer suggest that the rate of reaction could be increase by a factor of 2^{10} by increasing the reaction temperature from 400°C to 500°C , reasoning that the reaction rate doubles for every 10°C increase in temperature. Another engineer arrives on the scene and berates the new engineer with quotation concerning this rule of thumb. She points out that it is valid only for specific activation energy within a specific temperature range. She then suggests that he go ahead with the proposed temperature increase but should only expect an increase on the order of 2^3 or 2^4 . What do you think? Who is correct?

UNIT-V& VI

- (1) Give the brief account for zero parameter models.
- (2) Minimum time the fluid may spend in the laminar flow is $t = \frac{\tau}{2}$
- (3) Give the comparative study of internal age distribution and external age distribution.
- (4) Give the informative account of maximum mixedness model.
- (5) Give brief account of reactor modeling with RTD.
- (6) Give the comparative study of pulse input and step input.
- (7) Derive the equation of a first-order reaction using the segregation model when the RTD is equivalent to (a) an ideal PFR, (b) an ideal CSTR, and (c) a laminar flow reactor. Compare these conversions with those obtained from the design equation.
- (8) Discuss the different types of boundary conditions used for heterogeneous reaction.
- (9) Give the informative account of the moments of the RTD
- (10) Twice in the last 15 years, gasoline shortages in the United States have produced long lines of motorists at service stations. The table below shows a distribution of the times required to obtain gasoline at 23 Centre County service stations. What is the average time required? If you were to ask randomly among those people waiting in line, "How long have you been waiting?" what would be the average of their answers?

Total Waiting Time (min)	0	3	6	9	12	15	18	21
No. of Stations Having That Total Waiting Time	0	4	3	5	8	2	1	0

- (11) An RTD analysis was carried out on a liquid-phase reactor. Analyze the following data:

t (s)	0	150	175	200	225	240	250	260	275	300	325	350	375	400	450
C x 10 ³ (g/dm ³)	0.0	0.0	1.0	3.0	7.4	9.4	9.7	9.4	8.2	5.0	2.5	1.2	0.5	0.2	0.0

- i) Plot the E (t) curve for these data.
- ii) What fraction of the material spends between 230 and 270 s in the reactor?
- iii) What is the mean residence time?

iv) What is the standard deviation?

v) What is the skewness?

(12) A second-order irreversible reaction takes place in a nonideal yet isothermal CSTR. The volume of the reactor is 1000 dm^3 , and the flow rate of the reactant stream is $1 \text{ dm}^3/\text{s}$. At the temperature in the reactor, $k = 0.005 \text{ dm}^3/\text{mol}\cdot\text{s}$. The concentration of A in the feedstream is $10 \text{ mol}/\text{dm}^3$. The RTD is obtained from a tracer test on this reactor at the desired feed rate and reaction temperature. From the given RTD:

Estimate the maximum segregation conversions that can be obtained from this reactor because of the different micromixing conditions that are possible.

t(s)	E(t) (s^{-1})
0	3.250×10^{-3}
5	3.187×10^{-3}
10	3.124×10^{-3}
25	2.945×10^{-3}
40	2.776×10^{-3}
70	2.468×10^{-3}
100	2.194×10^{-3}
175	1.637×10^{-3}
250	1.224×10^{-3}
325	9.184×10^{-4}
400	6.913×10^{-4}
700	2.366×10^{-4}
1000	9.755×10^{-5}
2500	2.691×10^{-5}
4000	1.839×10^{-5}
7000	8.689×10^{-6}
10000	4.104×10^{-6}
15000	1.176×10^{-6}
20000	3.369×10^{-7}

(13) The concentration readings in table represent a continuous response to a delta function input into a closed vessel which is to be used as a chemical reactor.

Time t, min	0	5	10	15	20	25	30	35
Tracer output conc. gm/lit fluid	0	3	5	5	4	2	1	0

On the assumption that the closed vessel of above is well represented by the dispersion model, calculate the vessel dispersion number.

(14) Consider a second-order reaction being carried out in a real CSTR that can be modeled as two different reactor systems: In the first system a CSTR is followed by a PFR, in the second system the PFR precedes the CSTR. Let τ_s and τ_p each equal 1 min, let the reaction rate constant equal $1.0 \text{ m}^3/\text{kmol}\cdot\text{min}$, and let the initial concentration of liquid reactant, C_{A0} , equal $1 \text{ kmol}/\text{m}^3$. Find the conversion in each system.

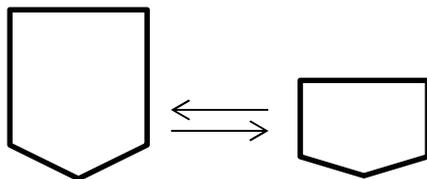
(15) The chemical Technology Division at Oak Ridge National Laboratory has developed the use of fluidized beds as bioreactors. Fluidized beds provide an effective means of promoting contact and hence mass transfer between the fluid and solid phases. The advantages of these features have been demonstrated in biological systems for ethanol production and wastewater treatment. For example, *Pseudomonas* bacteria adhering to coal particles in a fluidized bed successfully convert wastewater nitrates to nitrogen gas at 20 to 100 times the rate achieved in a stirred tank bioreactor. Although global reaction rates and operating conditions of fluidized bioreactors have been studied thoroughly, an understanding of their flow patterns is needed to allow modeling and scale-up.

From the exit concentration data of a typical run, $E(\theta)$ given below, fit the data with:

- (i) The axial dispersion model.
- (ii) The tanks-in-series model.

Θ	0.1	0.2	0.3	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3
	249	520	790	061	332	603	873	144	415	686	956
$E(\theta)$	0.0	0.0	0.0	0.2	0.9	1.3	1.3	1.2	0.9	0.7	0.4
	009	009	016	579	953	230	503	229	771	222	582
Θ	1.5	1.6	1.7	1.9	2.0	2.2	2.4	2.6	2.7	2.9	3.1
	227	498	769	251	946	640	334	029	723	418	112
$E(\theta)$	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	215	123	577	326	223	145	113	106	087	080	074

(16) You have non ideal batch tank reactor, and your predecessor (who was promoted for this brilliance at modeling reactors) modeled it as two well-mixed batch reactors, with transfer between them (as shown in figure). You wish to check this model. Your predecessor stated that V_1 was 30 ft^3 and V_{11} was 10 ft^3 . The transfer rate v was $0.1 \text{ ft}^3/\text{s}$. At time $t = 0$, you put 0.1 lb mol of tracer into the region near the agitator (Reactor I). If your predecessor was correct, what should be the concentration of tracer in Reactor I 100 s after you put in the tracer?



(17) A pulse test on a piece of reaction equipment gave the following results:

The output concentrations rose linearly from zero to $0.5 \mu\text{mol}/\text{dm}^3$ in 5 min, then fell linearly to zero in 10 min after reaching the maximum value.

- i) Calculate $E(t)$ and $F(t)$ at 1 min intervals. Sketch these functions.
- ii) What is the mean residence time? If the flow were 150 gal/min, what would be the total reactor volume? A second-order reaction with $kC_{A0} = 1.2 \text{ min}^{-1}$ is carried out in the system.
- iii) If the reactor were plug flow with the same flow and volume, what would be the conversion?

(18) A reactor has flow characteristics given by the non-normalized C-curve in table, and by the shape of this curve we feel that the dispersion or tanks-in-series models should satisfactorily represent flow in the reactor.

t, min	1	2	3	4	5	6	8	10	15	20	30	41	52	67
Tracer concen	9	57	81	90	90	86	77	67	47	32	15	7	3	1

- i) Find the conversion expected in this reactor, assuming that the dispersion model holds.
- ii) Find the number of tanks in series which will represent the reactor and the conversion expected, assuming that the tanks-in-series model holds.

Data: The elementary liquid-phase reaction taking place is $A + B \rightarrow \text{Products}$

With a large enough excess of B so that the reaction is essentially first order. In addition, if plug flow existed, conversion would be 99% in the reactor.

(19) The flow through a reactor is $10 \text{ dm}^3/\text{min}$. A pulse test gave the following concentration measurement at the outlet:

If the reactor is modeled as tanks in series, how many tanks are needed to represent this reactor? What is the conversion ($k = 0.1 \text{ min}^{-1}$)?

If the reactor is modeled by a dispersion model, what is the Peclet number? What is the conversion ($k = 0.1 \text{ min}^{-1}$)?

t,min	0	1	2	4	6	8	10	20	30	50	60
$c \times 10^5$	0	62	81	78	65	52	41	13	44	5	1
		2	2	5	0	3	8	6			

(20) Distributions in a stirred tank Cholette and Cloutier studied the RTD in a tank for different stirring speeds. Their tank had a 30-in. diameter and a fluid depth of 30-in. inside the tank. The inlet and exit flow rates were 1.15 gal/min. Here are some of the tracer results, read from a figure appearing in their article:

Time (min)	Impeller Speed (rpm)	
	170	100
	Relative Concentration, C/C_0	
10	0.761	0.653
15	0.695	0.566
20	0.639	0.513
25	0.592	0.454
30	0.543	0.409
35	0.502	0.369
40	0.472	0.333
45	0.436	0.307
50	0.407	0.276
55	0.376	0.248
60	0.350	0.226
65	0.329	0.205

Calculate and plot the cumulative exit-age distribution, the intensity function, and the internal-age distributions as function of α for this stirred tank at the two impeller speeds. Can you tell anything about dead zones and bypassing at the different stirrer rates?

(21) The first – order reaction



is carried out in a 10-cm-diameter tubular reactor 6.36 m in length. The specific reaction rate is 0.25 min^{-1} . The results of a tracer test carried out on this reactor are shown in table.

Effluent Tracer Concentration as a Function of Time

t (min)	0	2	4	6	8	10	12	14	15	16	18	20
C (mg/L)	0	0	0.8	2	4.4	12.6	30	36	38	39	40	40

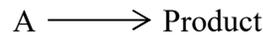
Calculate the conversion using (a) the closed vessel dispersion model

(b) PFR (c) tank-in-series model

(22) A sample of tracer hytane at 320 K was injected as a pulse to a reactor, and the effluent concentration was measured as a function of time, resulting in the data shown in table

t (min)	0	1	2	3	4	5	6	7	8	9	10	12	14
C (g/m ³)	0	1	5	8	10	8	6	4	3.0	2.2	1.5	0.6	0

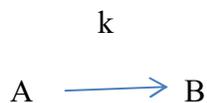
Calculate the mean conversion in the reactor characterized by RTD as shown above for first-order, liquid-phase, irreversible reaction in a completely segregated fluid:



The specific reaction rate is 0.1 min⁻¹

(23) Discuss tanks – in – series model versus dispersion model

(24) Show that $X_{T-I-S} = X_{MM}$ for a first-order reaction



(25) Discuss T-I-S model and show that RTD for n CSTRs in series, E(t)

$$E(t) = \frac{t^{n-1}}{(n-1)! \tau_1^n} e^{-t/\tau_1}$$

(26) The liquid phase elementary second order dimerization $2A \longrightarrow B$, for which $k = 0.01 \text{ dm}^3/\text{mol}\cdot\text{min}$ is carried out at a reaction temperature of 320 K. The feed is pure A with $C_{A0} = 8 \text{ mol}/\text{dm}^3$. The reactor is non-ideal and perhaps could be modeled as two CSTRs with interchange. The reactor volume is 1000 dm^3 and the feed rate for our dimerization is going to be $25 \text{ dm}^3/\text{min}$. Following table shows results for a tracer test on this reactor. Find the bounds on the conversion for the RTD of this reactor by using maximum mixedness model.

Tracer test on tank reactor: $N_0 = 100\text{g}$, $v = 25 \text{ dm}^3/\text{min}$.

T (min)	0	5	10	15	20	30	40	50	70	100	150	200
C (mg/dm ³)	112	95.8	82.2	70.6	60.9	45.6	34.5	26.3	15.7	7.7	2.5	0.9