

C.C.

B 2259

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2007.

Fifth Semester

Industrial Biotechnology

IB 332 — CHEMICAL REACTION ENGINEERING

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. The half life of a I order irreversible reaction $A \rightarrow B$ is 10 min. What percent of A remains after 80 min?
2. The rate constant of a zero order reaction is 0.2 mol/(l.hr). What would have been the initial concentration of the reactant if after half an hour its concentration is 0.05 mol/l?
3. What are the advantages of a batch reactor?
4. In an isothermal batch reactor 70% of reactant A is converted in 13 minutes by a I order reaction. Find the space time needed to effect this conversion in a mixed flow reactor.
5. For the series reaction $A \rightarrow R \rightarrow S$ with the rate constants k_1 and k_2 in which $k_1 > k_2$ sketch concentration versus time of the three species.
6. For the I order reversible aqueous reaction $A \rightleftharpoons R$ if $\Delta G^\circ = -14130 \text{ J/mol}$ and $\Delta H_R^\circ = -75300 \text{ J/mol}$ determine the value of the equilibrium constant K at 298 K.
7. What are the causes for the deviation from ideal flow patterns?
8. What is the residence time distribution function E for an ideal plug flow reactor and an ideal CSTR?
9. For an enzyme --- substrate reaction, the rate of disappearance of the substrate is given by the expression $-r_A = 1760 C_A E_0 / (6 + C_A) \text{ mol/m}^3 \cdot \text{s}$ where C_A is the concentration of the substrate in mol/m^3 and E_0 is the enzyme concentration in mol/m^3 . What are the units of the two constants in the above expression?
10. What is the main distinction between Enzyme fermentation and microbial fermentation?

PART B — (5 × 16 = 80 marks)

11. (a) In studying the kinetics of decomposition, the concentration of the reactant was determined analytically at different times and the following results were obtained.

Time (min)	0	10	20	40	100	125
Con (mol/l)	0.1	0.0714	0.0556	0.0385	0.02	0.0167

Determine

- (i) the order of the reaction. (12)
 (ii) the value of the specific reaction rate. (4)

Or

- (b) The I order homogeneous gaseous reaction $A \rightarrow 2.5 R$ is carried out in an isothermal batch reactor at 2 atm pressure with 20 mole% inert present and the volume increases by 60% in 20 minutes. If the same reaction takes place in a constant volume reactor determine the time required for the pressure to reach 8 atm if the initial pressure is 5 atm, 2 atm of which consists of inerts.
12. (a) Butadiene is to be dimerised in a tubular reactor at 1 atm and 911 K as per the reaction $2C_4H_6 \rightleftharpoons C_8H_{12}$. The reactor feed is a mixture of butadiene and steam in the mole ratio of 2 : 1 and the steam is used to preheat the butadiene to the desired temperature. The forward reaction is II order and the reverse reaction is I order. At 911 K the specific reaction rate of the forward reaction is 114.6 gmol/lit.hr.atm² and the equilibrium constant is 1.27 atm⁻¹. Estimate the volume of the reactor required to achieve 95% of equilibrium conversion for a molar feed rate of 50 kmol/hr of butadiene to the reactor.

Or

- (b) The flow through a plug flow reactor effecting a I order irreversible reaction is increased by 20% and in order to maintain the same fractional conversion it is decided to increase the operating temperature of the reactor. If the reaction has an activation energy of 4 kcal/gmol and the initial temperature is 150°C find the new operating temperature of the reactor.
13. (a) Consider the elementary reaction $A \xrightarrow{K_1} R \xrightarrow{K_2} S$ taking place in a plug flow reactor.

Derive an expression for the maximum concentration of R that can be achieved in terms of the rate constants if $k_2 = k_3$.

Or

(b) A irreversible isomerisation first order reaction $A \rightarrow R$ is carried out in liquid phase in a mixed flow reactor. The rate constant at 165°C is $0.7(\text{hr})^{-1}$. The activation energy of the reaction is 120 kJ/gmol . And the heat of reaction is -350 kJ/kg . The heat capacity of the reactants and the products can be assumed to be constant at 1.95 kJ/kg.K . If the volumetric flow rate is $0.33\text{ m}^3/\text{hr}$, feed temperature is 20°C and the conversion is 95% calculate the reactor volume if it is operated adiabatically.

14. (a) The concentration readings given below represent a continuous response to a pulse input into a closed vessel.

t (minute)	0	5	10	15	20	25	30	35
$C_{\text{tracer}}(\text{g/l})$	0	3	5	5	4	2	1	0

This vessel is to be used as a reactor for decomposition of a liquid A as per the irreversible reaction $A \rightarrow B + C$. With a rate $-r_A = k C_A$ where $k = 0.307\text{ min}^{-1}$. Estimate the fraction of the reactant unconverted in the vessel and compare this with the fraction unconverted in an ideal plug flow reactor of the same size.

Or

(b) The following results were obtained for a pulse test on a reaction equipment. The output concentration rose linearly from 0 to $0.5\ \mu\text{mol/dm}^3$ in 5 minutes and then fell linearly to zero in 10 minutes after reaching the maximum value. Calculate

(i) The mean residence time. (12)

(ii) The reactor volume if the flow rate is 570 lit/min . (4)

15. (a) Determine the Michaelis Menten parameters V_{max} and K_m for an Enzyme catalysed reaction from the following data

Concentration of the substrate (kmol/m^3)	0.2	0.02	0.01	0.005	0.002
Rate of dissociation of Substrate ($\text{kmol/m}^3.\text{s}$)	1.08	0.55	0.38	0.20	0.09

Or

(b) At room temperature, Sucrose is hydrolyzed by the enzyme sucrase. Starting with a sucrose concentration of $C_{A0} = 1\text{ mol/m}^3$ and sucrase concentration of $C_{E0} = 0.01\text{ mol/m}^3$ the following data are obtained in a batch reactor.

$C_A(\text{mol/m}^3)$	0.68	0.16	0.006
t, hr	2	6	10

Find a rate equation to represent the kinetics of this reaction.