

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular/ Backlog), April-May 2016

B. Tech in Chemical Engineering, Semester IV

Roll No.....

CHE404: Chemical reaction Engineering-I

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

10

i. The half-life period of a first order reaction is given by:

- (a) 1.5K (b) 2.5K (c) 0.693/K (d) 6.96K

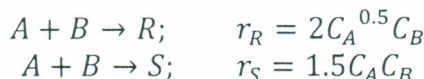
ii. For a mixed flow reactor operating at steady state, the rate of reaction is given by:

- (a) $\frac{F_{A0}}{V} - \frac{dC_A}{dt}$ (b) $\frac{F_{A0}}{V} + \frac{dC_A}{dt}$
(c) $\frac{F_{A0} X_A}{V}$ (d) $-\frac{dC_A}{dt}$

iii. A chemical reaction $A + \frac{b}{a}B \rightarrow \frac{c}{a}C + \frac{d}{a}D$ in which N_{A0}, N_{B0}, N_{C0} and N_{D0} , the initial number of moles of A, B, C and D respectively are present, At any time t, the $N_{A0}X$ moles of molecule A are consumed. Value of the concentration of B at time t, i.e. C_B in terms of moles per unit volume is:

- (a) $\frac{N_B}{V}$ (b) $\frac{N_{B0} - (\frac{b}{a})N_{A0}X}{V}$
(c) $\frac{N_{B0} + \delta N_{A0}X}{V}$ (d) none of these

iv. To maximize the formation of R in the simultaneous reaction,



We should have

- (a) low C_A , low C_B (b) low C_A , high C_B
(c) high C_A , low C_B (d) high C_A , high C_B

v. For a reaction, $A + 3B \rightarrow 5C + 7D$ which one of the following is correct?

- (a) $-r_A = -\frac{1}{3}r_B = \frac{1}{5}r_C = \frac{1}{7}r_D$ (b) $-r_A = -3r_B = 5r_C = 7r_D$
(c) $-r_A = -\frac{1}{3}r_B = -5r_C = -7r_D$ (d) $-r_A = \frac{1}{3}r_B = -\frac{1}{5}r_C = -\frac{1}{7}r_D$

vi. If the concentration is expressed in mol/l and time in sec., the units of rate constant for a first order reaction is:



- (a) $\text{mol L}^{-1} \text{sec}^{-1}$
(c) mol L^{-1}

- (b) sec^{-1}
(d) mol^{-1}

vii. If $\text{Da} > 10$ then $X > \underline{\hspace{2cm}}$.

viii. In a continuous flow stirred tank reactor the composition of the exit stream

- a) is same as that in the reactor
b) is different than that in the reactor
c) depends upon the flow rate of inlet stream
d) none of these

ix. A batch reactor is

- a) suitable for gas-phase reactions on commercial scale
b) suitable for liquid phase reaction involving small production rate
c) least expensive to operate for a given rate
d) most suitable for very large production rate.

x. Define space time and space velocity.

Q.2 Short answer type questions (4 questions @ 2.5 marks)

10

- (i) What is the difference between pulse and step tracer input.
(ii) The half-life period for a certain first order reaction is 2.5×10^3 s. How long will it take for $\frac{1}{4}$ of the reactant to be left behind?
(iii) Give the classification of multiple reactions with suitable examples.
(iv) Distinguished yield from selectivity.

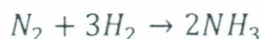
Q.3A For the two CSTRs in series, 40% conversion is achieved in the first reactor. What is the volume of each of the two reactors necessary to achieve 80% overall conversion of the entering species A?

05

X	0	0.1	0.2	0.4	0.6	0.7	0.8
$[\text{F}_{\text{A0}} / -r_{\text{A}}] \text{ m}^3$	0.89	1.09	1.33	2.05	3.54	5.06	8.0

Q.3B Calculate the heat of reaction for the synthesis of ammonia from hydrogen and nitrogen at 150°C in kcal/mol of N_2 reacted and also in KJ/mol of H_2 reacted

05



Given Data:

$$\Delta H_{\text{Rx}}^\circ (298\text{K}) = -22.04 \frac{\text{kcal}}{\text{mol N}_2 \text{ reacted}}$$

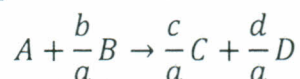
$$C_{P_{\text{H}_2}} = 6.992 \frac{\text{cal}}{\text{mol H}_2} \text{K}$$

$$C_{P_{\text{N}_2}} = 6.984 \frac{\text{cal}}{\text{mol N}_2} \text{K}$$

$$C_{P_{\text{NH}_3}} = 8.92 \frac{\text{cal}}{\text{mol NH}_3} \text{K}$$

Q.4A For a given chemical reaction

05



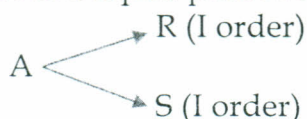
Set up a stoichiometric table for the constant volume batch reaction system.

- Q.4B Derive a design equation for constant volume Continuous stirred tank reactor for irreversible first order liquid phase reaction in terms of conversion. Also define the conversion in terms of Damkohler number. 05



- Q.5A Write the name of different methods used for analyzing the concentration-time data collected in a reactor. How could you determine the reaction order by using integral method in a constant volume batch reactor for irreversible first order reaction? 01+04 = 05

- Q.5B Substance A in a liquid phase reacts to produce R and S as follows: 05

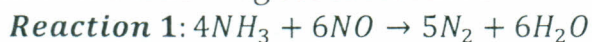


A feed ($C_{A0}=1$, $C_{R0}=C_{S0}=0$ mol/lit) enters a battery of two mixed flow reactors in series. The space time of the two reactors are 2min and 5 min respectively. The composition of the three species in the first reactor is $C_{A1}=0.4$, $C_{R1}=0.4$ and $C_{S1}=0.2$ mol/lit. Find the composition leaving the second reactor.

- Q.6A Write about: 05

- (a) Residence-time distribution function
(b) Cumulative distribution function

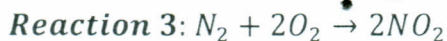
- Q.6B Consider the following set of reactions: 05



$$-r_{1NO} = k_{1NO} C_{NH_3} C_{NO}^{1.5}$$



$$r_{2N_2} = k_{2N_2} C_{NO}^2$$



$$-r_{3O_2} = k_{3O_2} C_{N_2} C_{O_2}^2$$

Write the mole balances on a PFR in terms of molar flow rates for each species.

OR

- Q.6B Discuss the concept of multiple steady state in CSTR. 05

- Q.7A Liquid A decomposes in a batch reactor by second order kinetics. If 50% of A is converted in a five minutes run, how long would it take to reach 75% conversion? 05

- Q.7B A homogenous liquid phase reaction $A \rightarrow R$; $-r_A = kC_A^2$; takes place with 50% conversion in a well mixed reactor operating isothermally. What will be the conversion if the reactor is replaced by a plug flow type of equal size-all else remaining the same? 05

OR

- Q.7B For the first order reaction taking place in the batch reactor, 80% of the liquid reactant is converted to product in 15 minutes. Calculate the space velocity required to achieve same conversion in the plug flow reactor and CSTR? 05

- Q.8A What do you understand by recycle reactors? Where it is used? Derive the performance equation for recycle reactors applicable for any kinetics. 10



Q.9A The elementary irreversible liquid phase reaction 10



is carried out in a mixed flow reactor. An equimolar feed in A and B enters the reactor at 200K (27°C) and the volumetric flowrate is 2 L/s. Calculate the volume of reactor to achieve 85% conversion when the reaction is carried out adiabatically.

Given Data:

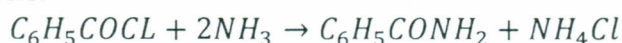
$$\Delta H_f^\circ \text{ for } A = -20 \frac{\text{kcal}}{\text{mol}}, \text{ for } B = -15 \frac{\text{kcal}}{\text{mol}} \text{ and for } C = -41 \frac{\text{kcal}}{\text{mol}}$$

$$C_{A0} = 0.10 \text{ kmol/m}^3$$

$$C_{PA} = C_{PB} = 15 \frac{\text{cal}}{\text{mol.K}}, C_{PC} = 30 \frac{\text{cal}}{(\text{mol.K})}$$

$$k = 0.01 \text{ (l/mol.s) at } 300\text{K}; E = 10000 \text{ cal/mol}; R = 1.987 \text{ cal/(mol.K)}$$

Q.9B Benzylamide is the product obtained from the liquid phase reaction of ammonia 10
and benzoyl chloride:



- Taking benzoyl chloride as your basis of calculation, set up a stoichiometric table for a batch system
- If the initial mixture consisted solely of ammonia at a concentration of 6 gmol/liter and benzoyl chloride at a concentration of 2 gmol/liter, calculate the concentrations of ammonia and benzylamide when the conversion is 25%.
- Taking ammonia as a basis of your calculation, explain how your stoichiometric table would be different for a flow system.

OR

Q.9B Calculate the mean residence time and the variance for the vessel from the following 10
data:

t, min	0	1	2	3	4	5	6	7	8	9	10	12	14
E, min ⁻¹	0	0.02	0.1	0.16	0.2	0.16	0.12	0.08	0.06	0.044	0.03	0.012	0

***** GOOD LUCK *****