

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular/Backlog), April-May 2018

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.

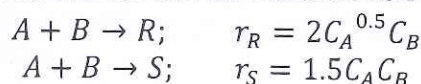
Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

10

i. A batch reactor is suitable for:

- a) large scale gaseous phase reaction
- b) achieving cent percent conversion of reactants into products
- c) liquid phase reactions
- d) obtaining uniform polymerization products in highly exothermic reactions

ii. 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 |

iii. 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) $-r_A = \frac{1}{3}r_B = -\frac{1}{5}r_C = -\frac{1}{7}r_D$ |

iv. The first order reaction requires two equal sized CSTR. The conversion is:

- a) less when they are connected in series
- b) more when they are connected in series
- c) more when they are connected in parallel
- d) same whether they are connected in series or parallel

v. Which of the following is the most suitable for very high pressure gas phase reaction?

- | | |
|----------------------------|----------------------------|
| (i) Batch Reactor | (ii) Tubular flow reactor |
| (iii) Stirred tank reactor | (iv) Fluidized bed reactor |

vi. A chemical reaction $A + \frac{b}{a}B \rightarrow \frac{c}{a}C + \frac{d}{a}D$ is carried out at constant pressure and under isothermal conditions. The correct equations for a batch process under variable volume, is

a) $V = V_0(1 + \epsilon X)$

b) $C_A = \frac{N_{A0}(1-X)}{V_0(1+\epsilon X)}$

c) $C_A = \frac{C_{A0}(1-X)}{(1+\epsilon X)}$

d) all of these

vii. 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) $-\frac{dC_A}{dt}$

viii. 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

ix. Define space time and space velocity.

x. Distinguished yield from selectivity

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

10

(i) Write the name of different methods used for analyzing the concentration-time data collected in a reactor.

(ii) What is the difference between pulse and step tracer input.

(iii) The half-life period of a first order reaction is 240 seconds. Calculate its rate constant.

(iv) For an elementary reaction, $A + B \rightarrow \text{Products}$, the reaction rate at 500K is ten times that at 400K. Calculate the activation energy of this reaction.

Q.3A Derive a design equation for constant volume batch reactor for irreversible first order reaction in terms of conversion.

05

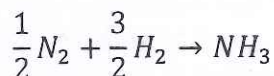


Q.3B Write the name of different methods used for analyzing the concentration-time data collected in a reactor. Discuss at least one method in detail to determine the reaction order in a constant volume batch reactor for irreversible first order reaction?

05

Q.4A The gas phase reaction

05



is to be carried out isothermally in CSTR. The molar feed is 50% H_2 and 50% N_2 , at a pressure of 16.4 atm and 227°C.

(a) Construct a complete stoichiometric table.

(b) What are C_{A0} , δ , ϵ ? Calculate the concentrations of ammonia and hydrogen when the conversion of H_2 is 60%.

Q.4B Give the classification of multiple reactions with suitable examples. How do you maximize the desired product for one reactant in parallel reaction system?

05

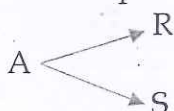
Q.5A Show that the reaction time needed to achieve a conversion X for a second order reaction in a batch reactor is given by:

05

$$t = \frac{1}{kC_{A0}} \left(\frac{X}{1-X} \right)$$

Q.5B 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.6 Substance A in a liquid phase reacts to produce R and S as follows: 05



With $r_R = k_1 C_A^2$ and $r_S = k_2 C_A$

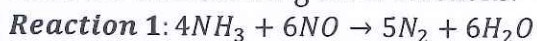
A feed ($C_{A0}=1$, $C_{R0}=C_{S0}=0.3$ mol/lit) enters a battery of two mixed flow reactors in series. The space time of the two reactors are 2.5 min and 10 min respectively. The composition of the three species in the first reactor is $C_{A1}=0.4$, $C_{R1}=0.2$ and $C_{S1}=0.7$ mol/lit. Find the composition leaving the second reactor.

OR

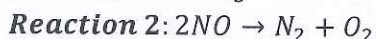
Q.6 From the data given below, determine the reaction order and specific reaction rate using least square analysis method for the dissolution of MnO_2 in HBr. 05

C_{A0} (mol HBr/dm ³)	0.1	0.5	1.0	2.0	4.0
$-r''_{A0}$ (mol HBr/m ² .hr) $\times 10^2$	0.073	0.7	1.84	4.86	12.84

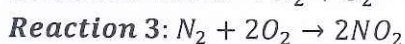
Q.7A Consider the following set of reactions: 10



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



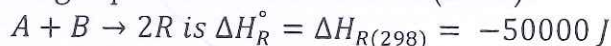
$$r_{2N_2} = k_{2N_2} C_{NO}^2$$



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

Write the rate law for each species in each reaction and then write the net rates of formation of NO, O₂ and N₂.

Q.7B The standard heat of gas phase reaction at 25°C (298K) 05



Indicating that the reaction is strongly exothermic. It is planned to run this reaction at 1000°C. What is the value of heat of reaction at this temperature? Is the reaction still exothermic at 1000°C?

Data: The average C_p values between 25°C and 1000°C for various reaction components are:

$$C_{PA} = 35 \text{ J/mol.K} ; C_{PB} = 45 \text{ J/mol.K} ; C_{PR} = 70 \text{ J/mol.K}$$

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 adiabatic process? Derive the energy balance equation relating conversion and temperature for the adiabatic system 10

Q.9A Calculate the reactor size and temperature of the irreversible isomerization reaction that is to be carried out in the liquid phase in a mixed flow reactor. The reactor is operated adiabatically. 10



Given data:

Rate constant (k) at 165°C = 0.7 (h)⁻¹

Activation Energy = 120000 J/mol
 Heat of reaction = -350 KJ/kg
 Heat capacity of reactants and products = 1.95 kJ/(kg.K)
 Volumetric flowrate = 0.33 m³/h
 Feed temperature = 20°C
 Conversion expected = 95%

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

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

OR

- Q.9B A homogenous liquid phase reaction $A \rightarrow R$ takes place with 50% conversion in a mixed flow reactor. Its rate reaction is $-r_A = \frac{dC_A}{dt} = kC_A^2$ 10
- (a) What will be the conversion if this reactor is replaced by the one, 6 times larger reactor and all else remaining unchanged?
- (b) What will be the conversion if the original reactor is replaced by a plug flow reactor of equal size and all else remaining unchanged?

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