Reg. No: 23BCM0050

S/K/TY

Final Assessment Test – November 2025

VIT
Vellore Institute of Technology

Course: BCHE303L - Chemical Reaction Engineering I

Class NBR(s): 1240 Slot: B1+TB1

Time: Three Hours Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

COs	CO Statements
CO1	Classify various reaction types and their applications
CO2	Apply the principles of reaction kinetics, formulate rate equations and analyse the batch reactor data
CO3	Compare and analyse ideal reactor designs (Batch, CSTR, PFR, recycle and autocatalytic) for simple chemical reaction schemes
CO4	Evaluate the choice of right reactor among single, multiple, recycle reactor, etc. with or without multiple reactions
CO5	Design non-isothermal reactors and explore steady-state multiplicity

BL – Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)

Answer ALL Questions
(10 X 10 = 100 Marks)

1. Explain in detail about the temperature dependency term of rate equation from transition state theory for the transformation of reactants into products. CO1 BL1

2. At 500 K the rate of a bimolecular reaction is ten times the rate at 400 K. Find the activation energy for this reaction (a) from Arrhenius law, (b) from collision theory, (c) what is the percentage difference in rate of reaction at 600 K predicted by these two methods? CO1 BL3

3. In studying the kinetics of decomposition reaction, the concentration of reactants were determined analytically at different time. The following results were obtained. CO2 BL3

Time,min	0	10	20	40	100	125
Conc., mol/l	0.10	0.0714	0.0556	0.0385	0.02	0.0167

Determine the order and rate constant for the reaction.

4. In an isothermal batch reactor, the conversion of a liquid reactant A achieved in 13 min is 70%. Find the space time and space velocity to effect this conversion in a plug flow reactor and in a mixed flow reactor. Consider first order kinetics. CO3 BL3

5. In an industry, the technical team is planning to operate a mixed flow reactor to convert A into R. This is a liquid phase reaction with the stoichiometry $A \rightarrow R$. The rate of reaction as a function of concentration is given below. What size of mixed flow reactor is required to achieve 75% conversion of feed stream of 1000 mol A/l with C_{A0}=1.20 mol/l? CO3 BL3

C_A, mol/l	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.3	2.0
$-r_A$, mol/(l.min)	0.1	0.3	0.5	0.6	0.5	0.25	0.1	0.06	0.05	0.045	0.042

Presently 90% of reactant A is converted into product by a second order reaction in a single mixed flow reactor. It is proposed to use a second reactor similar to the one being used in series with it. For the same treatment rate as that used presently, find the effect of this addition of reactor on the conversion of reactant. CO4 BL3

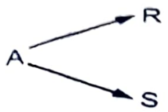
7. A gas mixture containing 50 mole% A and 50 mole% inerts at 10 atm enters a reactor system with a flow rate of 6 l/s at 144°C. The laboratory measurements of the rate as a function of conversion at 144°C and 10 atm are: CO4 BL3

X_A	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85
$-r_A \frac{mol}{l.s}$	0.0053	0.0052	0.005	0.0045	0.004	0.0033	0.0025	0.0018	0.00125	0.001

If the reaction is carried out in two reactors in series with 40% conversion in the first reactor and 85% overall conversion, estimate the total volume of the two reactors when (i) the reactors are both mixed flow and (ii) the reactors are both plug flow.

8. Elucidate the recycle reactors and also derive its performance equation. CO4 BL2

9.a) Substance A in a liquid reacts to form R and S according to the following reaction scheme. CO4 BL3



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

A feed with $C_{A0}=1$, $C_{R0}=0$ and $C_{S0}=0.30$ enters in two mixed flow reactors in series (τ_1=2.5 min; τ_2=10 min). The composition of the exit stream from the first reactor is $C_{A1}=0.40$, $C_{R1}=0.20$ and $C_{S1}=0.70$. Find the composition of the exit stream from the second reactor.

OR

9.b) Liquid reactant A produces R and S by the following reactions in parallel: CO4 BL3

$$A \rightarrow R, \qquad r_R = k_1 C_A^2, \qquad k_1 = 0.4\ m^3/(mol.min)$$

$$A \rightarrow S, \qquad r_S = k_2 C_A, \qquad k_2 = 2\ (min)^{-1}$$

A feed of aqueous A with C_{A0}=40 mol/m³ enters a reactor, reacts to produce R and S, and a mixture of A, R and S leaves the reactor. Find C_R, C_S and τ for 90% conversion of A in a mixed flow reactor.

10.a) Determine the equilibrium conversion for the following elementary reaction between 0°C and 100°C. CO5 BL3

$$A \rightleftharpoons R$$

At 298 K: $\Delta G^o = -14130 \frac{J}{mol}, \Delta H_R^o = -75300\, J/mol\,, C_{P_A} = C_{P_R} = Constant$

(i) Construct a plot of temperature vs conversion.

(ii) What restrictions should be placed on the reactor operating isothermally if conversion of 75% or highest is desired?

OR

10.b) For reversible first order aqueous reaction CO5 BL3

$$A \rightleftharpoons R$$

starting with pure A, kinetic experiments in a batch reactor give 58.1% conversion in 1 min at 65°C and 60% conversion in 10.1 min at 25°C. Find the rate expression for this reaction.

Data: Equilibrium conversion at 65°C = 0.89

Equilibrium conversion at 25°C = 0.993

At 298 K; $\Delta G^o = -14130 \frac{J}{mol}; \Delta H_R^o = -75300 \frac{J}{mol}; C_{P_A} = C_{P_R} = Constant$

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