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Total No. of Pages : 03

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B.Tech.(Petroleum Refinery Engineering) (2013 Batch) (Sem.-4)

CHEMICAL REACTION ENGINEERING-I

Subject Code : BTPC-406/BTCH-405

M.Code : 72429

Time : 3 Hrs.

Max. Marks : 60

INSTRUCTION TO CANDIDATES :

1. SECTION-A is COMPULSORY consisting of TEN questions carrying TWO marks each.
2. SECTION-B contains FIVE questions carrying FIVE marks each and students have to attempt any FOUR questions.
3. SECTION-C contains THREE questions carrying TEN marks each and students have to attempt any TWO questions.

SECTION A**Q1. Answer briefly :**

- a) Give the variables affecting the rate of reaction.
- b) Give the characteristics of plug flow reactor.
- c) Differentiate between space time and residence time.
- d) What will be the effect of increase in reaction order on the ratio of mixed flow reactor and plug flow reactor volumes?
- e) Define the terms "Selectivity" and "Yield".
- f) How does the concentration level of reactants affect the product distribution in parallel reactions?
- g) Give the applications of RTD.
- h) What is the effect of temperature on equilibrium conversion?
- i) The rate constants of a certain reaction are 1.6×10^{-3} and $1.625 \times 10^{-2} \text{ s}^{-1}$ at 10°C and 30°C , respectively. Calculate activation energy of this reaction.
- j) A 2nd order reaction is to be carried out in 3 CSTR's of Volume 100 liter, 150 liter and 200 liter. How these should be connected?



SECTION B

- Q2. The rate of homogeneous decomposition nitrous oxide, $N_2O \rightarrow N_2 + \frac{1}{2} O_2$ has been found to be represented by

$$-r_{N_2O} = \frac{k_1[N_2O]^2}{1 + k_2[N_2O]}$$

Suggest a reaction mechanism which is in consistent with this rate law.

- Q3. Derive the performance equation for a recycle reactor. Write the performance equation for the two extremes of the recycle ratio.
- Q4. An aqueous phase reaction $A \rightarrow 2R$ is carried out in a CSTR having volume of 5 liters and the following data is obtained.

Run	Feed rate (cm ³ /sec)	Temperature of the run (°C)	Concentration of R in the effluent (mol/liter)
1	2	13	1.8
2	15	13	1.5
3	15	84	1.5

Find the rate equation for this reaction and also evaluate the activation energy of the reaction, assuming the applicability of Arrhenius law.

- Q5. An aqueous feed of A and B (400 liter/min, 100 mmol A/liter, 200 mmol B/liter) is to be converted to product in a plug flow reactor. The kinetics of the reaction $A + B \rightarrow R$; is represented as

$$r_A = 200 C_A C_B \text{ mol/(liter-min)}$$

Find the volume of reactor needed for 90% conversion of A to product.

- Q6. Explain the stimulus response techniques for study of flow pattern in reaction vessels. Obtain the relation between E, F and C curves.

SECTION C

- Q7. A series reaction $A \xrightarrow{\text{1st order}} B \xrightarrow{\text{Zero order}} C$ is taking place in a CSTR. Derive the concentrations of A and B as functions of residence time τ , the rate constants (k_1 and k_2) and the initial concentration of A (C_{A0}). Assume that the concentrations of B and C in the reactor entrance stream are zero.

- Q8. An irreversible gaseous reaction $A \rightarrow B$ at 10 atm and 144°C has to be carried out in two reactor system. The volumetric feed (360 liter/min) contains 50 mole% A, and 50 mole% inerts is required to be processed. The laboratory measurement of rate of reaction ($-r_A$) as a function of conversion (X_A) at 10 atm and 144°C is as follows :

X_A	0	0.2	0.4	0.6	0.8	0.9
$-r_A$ (mol/liters)	0.0053	0.005	0.004	0.0025	0.00125	0.0006

If the reaction is carried out in two reactor system in series with $X_{A1} = 0.40$ as intermediate conversion (from 1st reactor) and $X_{A2} = 0.85$ as final conversion, estimate the total volume of two reactors when :

- i) The reactors are both mixed flow ii) The reactors are both plug flow.
- Q9. 75% conversion for a liquid phase reaction $A + B \rightarrow 2C$ has been achieved in a 300 liter CSTR. Equal mass flow rate of A and B (1.5 mol/s) at a temperature of 27°C and fed to the reactor. Specific heats (in J/mol-K) of A, B and C are 200, 180 and 190, respectively. The reactor is jacketed by water at a temperature of 20°C . The overall heat transfer coefficient has been estimated at $225 \text{ J/(m}^2 \cdot \text{s} \cdot \text{K)}$, and the heat transfer area is 1 m^2 . Mixing is ensured through an agitator, which contributes a work of 15 KW to the reactor. The heat of reaction is $-35,000 \text{ J/mole}$ of A. Calculate the steady state temperature in the reactor by assuming that the heat of reaction is independent of temperature.

NOTE : Disclosure of Identity by writing Mobile No. or Making of passing request on any page of Answer Sheet will lead to UMC against the Student.