Paper / Subject Code: 31723 / Chemical Reaction Engineering-I

1T00535 - T.E.(Chemical Engineering)(SEM-V)(Choice Base Credit Grading System) (R- 19) (C Scheme) / 31723 - Chemical Reaction Engineering-I QP CODE: 10029763 DATE: 29/05/2023

(3 Hours)   **Total Marks : 80**

N.B.   (1) Question No.1 is compulsory.
         (2) Attempt any three questions.
         (3) Assume suitable data wherever necessary with proper justification

Q1 a.   A 10 minute experimental run shows that 75% of liquid reactant is converted to product by a ½ order rate. What would be the fraction converted in a half hour run?   **(05)**

Q1 b.   Explain Integral method of analysis of kinetic data   **(05)**

Q1 c.   Write and explain each term of the performance equation for recycle reactor?   **(05)**

Q1 d.   Substance A in liquid reacts to produce R and S as follows.   **(05)**
$A \rightarrow R$ (first order)
$A \rightarrow S$ (first order)
A feed ($C_{A0}=1$, $C_{R0}=0$, $C_{S0}=0$) enters two mixed flow reactors in series ($\tau_1= 2.5$ min, $\tau_2= 5$ min) Knowing the composition in the first reactor ($C_{A1}=0.4$, $C_{R1}=0.4$, $C_{s1}=0.2$). Find the composition leaving the second reactor.

Q2 a.   The thermal decomposition of ethane to ethylene is believed to have following mechanism.   **(10)**
$C_2H_6 \rightarrow 2CH_3*$
$CH_3*+C_2H_6 \rightarrow CH_4+C_2H_5 *$
$C_2H_5 * \rightarrow C_2H_4 +H*$
$H*+C_2H_6 \rightarrow H_2+ C_2H_5{}^*$
$2C_2H_5* \rightarrow C_4H_{10}$
Derive a rate equation for the formation of ethylene (C_2H_4)

Q2 b.   For the irreversible first order series reaction $A \rightarrow R \rightarrow S$ the values of rate constants k_1 and k_2 are $0.17 min^{-1}$ and 0.11 min^{-1} respectively for reaction 1 and 2. i) Calculate the time at which the concentration of R is maximum and ii) maximum concentration of R   **(10)**

Q3 a.   The elementary irreversible liquid phase reaction $A +B \rightarrow R + S$ takes place in a plug flow reactor using equimolar amounts of A and B ($C_{A0} = C_{B0}= 1$ mol/l and results in 96 % conversion of A . If a mixed flow reactor ten times as large as the plug flow reactor were placed in series with the existing reactor, which reactor should come first and by what fraction could the production rate be increased for that set up   **(10)**

Q3 b   Explain procedure of differential and integral method of analysis of experimental data   **(10)**

Q4 a.   The Kinetics of the liquid phase decomposition of A is studied in two mixed flow reactors in series, the second unit having twice the volume of the first one. At steady state with a feed with $CA0 = 1$ mol/l and mean residence time of 96 sec in the first reactor, the concentration of A in the first unit (reactor) is 0.5 mol/lit and in the second is 0.25 mol/lit. Find the rate equation for the decomposition of A.   **(10)**

1DBE795DEFDE72D41A42706B1241A4C8

Q4 b. The first order homogeneous gaseous reaction A → 2.5 R is carried out in **(10)** isothermal variable volume batch reactor at 2 atm pressure with 20 mole % inerts present and the volume increases by 60 % in 20 minutes. In case of 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

Q5 a. From the steady-state kinetic runs in a mixed flow reactor, we obtained the **(14)** following data on the reaction

A → R
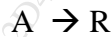
Find the space time needed to treat a feed with initial concentration of 100 mol/m^3 to 80% conversion in,
   (i)   Plug flow reactor
   (ii)   Mixed flow reactor

Space time, min	Initial Concentration of A, mol/m^3	Concentration of A in exit stream of reactor, mol/m^3
60	50	20
35	100	40
11	100	60
20	200	80
11	200	100

Q5 b. Explain Optimum Temperature Progression and its significance in design of **(06)** reactor

Q6 For the elementary liquid phase reaction, **(20)**

$$A \rightleftharpoons B$$
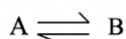
Construct a plot of equilibrium conversion as a function of temperature and from this plot determine the adiabatic equilibrium temperature and conversion when pure A at a temperature of 27 ^{0}C (300 K) is fed to reactor.

$\Delta H_f^{\circ} = -40000 \, cal/mol$ ….. For A

$\Delta H_f^{\circ} = -60000 \, cal/mol$ …….For B

C_{pA} = 50 cal/mol

C_{pR} = 50 cal/mol

K=100000 at 298 K

_____