25-Nov-2019 1T00525 - T.E.(Chemical Engineering)(SEM-V)(Choice Base) / 31704 - Chemical Reaction Engineering - I (CRE-I) 78096

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

N.B.:

(i) Question No.1. is compulsory.
(ii) Attempt any three questions out of remaining five questions.
(iii) Assume suitable data and justify the same.
(iv) Figures to the right indicate full marks

Q 1 (a) Explain Differential method of analysis of kinetic data **05**

(b) Explain molecularity and order of reaction **05**

(c) Derive performance equation of Batch reactor **05**

(d) Compute K_y at 10 atm if K_p at this pressure is 0.00381 atm^{-2} for the ammonia synthesis reaction from hydrogen and nitrogen at 500 ^{0}C. (Assume that ideal gas law is applicable) **05**

Q 2 (a) For the gas phase decomposition of azomethane $(CH_3)_2N_2 \rightarrow C_2H_6 + N_2$ with a rate expression $-r_{N_2} = \frac{K_1[C_{AZO}{}^2]}{1+K'C_{AZO}}$ where AZO = azomethane. Devise a mechanism to explain this rate **10**

(b) The gaseous reaction 2A → R + 2S is second order with respect to A. If pure A is introduced at 1atm into a constant volume batch reactor, the pressure rises by 40 % in 3 minutes. In case of a constant pressure batch reactor find i) the time required to achieve the same conversion and ii) the fractional increase in volume at that time. **10**

Q 3 (a) A specific enzyme E acts as a catalyst in the fermentation of substrate A (the reactant). At a given enzyme concentration in the aqueous feed stream of 25 l/min. Find the volume of plug flow reactor required to achieve 95 % conversion of reactant A (C_{A0} = 2 mol/l).The kinetics and stoichiometry of the fermentation reaction are given by **10**

$$A \xrightarrow{enzyme} R \qquad -r_A = \frac{0.10C_A}{1+0.5C_A}\ mol/(l.min)$$

(b) A kinetic study of decomposition of acetaldehyde at 518^{0}C and 1 atm pressure is made in a flow reactor. The decomposition proceeds as per the reaction **10**

$CH_3CHO \rightarrow CH_4 + CO$

Acetaldehyde is boiled in a flask and passed through a reaction tube maintained at 518^{0}C by a surrounding furnace. The reaction tube has a inside diameter of 33 mm and length 800 mm. The flow rate through the tube is varied by changing the boiling rate. Analysis of the product stream leaving the tube is given below. Find a rate equation which will satisfactorily fit the data

Rate of flow of acetaldehyde, g/h	130	50	21	10.8
Fraction of acetaldehyde decomposed	0.06	0.13	0.24	0.35

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 C_{A0} = 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**

(b) Nitrous oxide decomposes according to the second order rate equation **10**
$2N_2O \rightarrow 2N_2 + O_2$ The reaction rate constant is 977 cm^3 /mol.sec at 895 ^0C . Calculate the fraction decomposed at 1 sec, 10 sec and at 10 min in a constant volume batch reactor. The initial pressure (all N2O) is 1 atm.

Q 5 (a) Reactant A decomposes as follows **15**

$$A \rightarrow R$$

$$A \rightarrow S$$

$$A \rightarrow T$$

The rate equations are $r_R = 1$, $r_S = 2\,C_A$ and $r_T = C_A^2$

Determine the maximum concentration of desired product that can be obtained i) in a mixed flow reactor and ii) in a plug flow reactor for R is the desired product and $C_{A0} = 2$

(b) A common rule of temperature is that the rate of a reaction doubles for each 10^0C rise in temperature. What activation energy would this suggest at a temperature of 25^0C. **05**

Q 6 (a) The elementary irreversible liquid phase reaction $A+B \rightarrow C$ is carried out in a mixed flow reactor. An equimolar feed in A and B enters the reactor at 200 K(27^0C) and the volumetric flow rate is 2 lit/s. Calculate the volume of reactor to achieve 85 % conversion when the reaction is carried out adiabatically. **12**

Data : ΔH^0_f for A = -20 kcal/mol, ΔH^0_f for B = -15 kcal/mol and ΔH^0_f for C = -41 kcal/mol

C_{A0} = 0.10 kmol/m^3, $C_{P_A} = C_{P_B}$ = 15 cal/(mol.K), C_{P_C} = 30 cal/(mol.K)

k= 0.01 (lit/mol.sec) at 300 K, E = 10000 cal/mol

(b) The standard heat of gas phase reaction at 25^0C (298K) **08**
$A + B \rightarrow 2R$ is $\Delta H^0_{R(298K)}$ = -50000 J indicating that the reaction is strongly exothermic. It is planned to run this reaction at 1000 ^0C . What is the value of heat of reaction at this temperature ? Is this reaction is exothermic at 1000^0C?
Data : The mean /average C_P values between 25^0C and 1000^0C for the various reaction components/participants are

$\bar{C}_{P_A} = 35\ J/molK$

$$\bar{C}_{P_B} = 45\ J/molK$$

$$\bar{C}_{P_R} = 70\ J/molK$$
