Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V • EXAMINATION – SUMMER 2013

Subject Code: 150403 Date: 21-05-2013

Subject Name: Chemical Reaction Engineering

Time: 10.30 am - 01.00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q-1 **(a)** A first order reaction is to be treated in a series of two CSTR. show that the total volume of the two reactors is minimum when the reactors are equal in size. **07**

(b) The hydrolysis of acetic anhydride is carried out with a large excess of water in a batch reactor. The reaction is **07**

$(CH_3CO)_2O + H_2O \rightarrow 2CH_3COOH$

The reaction is first order and irreversible w.r.t. the anhydride. The reactor is charged with a solution containing 0.4 gmmole/liter of acetic anhydride at 15^0C. From the following data, find the time required for 60 % conversion of the anhydride when the reactor is operated adiabatically. Data:-

1. The Cp of liquid reaction mixture is constant at 0.9 cal/gm ^{0}C
2. ρ of the reaction mixture is also constant at 1.07 gm/cc
3. The exothermic heat of the reaction is 50000 cal/mol of anhydride

Rate constant data

T^0 C	Kc min^{-1}
15	0.0806
20	0.113
25	0.158
30	0.211

Q-2 **(a)** The decomposition of NH_3 on a tungsten wire is carried out at 856^0 C at a constant volume condition and the data obtained are as follows: **07**

Time,sec	200	400	600	1000
Pressure atm	0.3	0.33	0.359	0.418

Check whether the reaction follows zero order kinetics. If so, find the rate constant.

(b) The non-elementary reaction, **07**

$2A + B \acute{z} A_2B$

Takes place by the following mechanism

$2A \underset{K_2}{\overset{K_1}{\acute{z}}} A_2^*$ and $A_2^* + B \underset{K_4}{\overset{K_3}{\acute{z}}} A_2B$

Find the rate equation of the reaction.

OR

(b) A first order irreversible reaction A $\rightarrow$B is carried out in mixed flow reactor followed by an equal size plug flow reactor in series. The concentration of A in the feed is 1 kgmole/m^3 and the residence time in each reactor is 3600 sec. The specific reaction rate constant is 1/3600 sec^{-1}. Find the conversion of A at the exit of the system. **07**

Q-3 **(a)** At 500^0 K, the rate of bimolecular reaction is 10 times the rate of 400^0 K. Find the activation energy of the reaction from **07**

1) Arrhenius Law
2) Collision theory

What is the percentage difference in the rate of reaction at 600^0 K calculated by these two methods?

(b) Prove that for autocatalytic reaction in the rate of reaction the rate is maximum when concentration of reactant is equal to concentration of product. **07**

OR

Q-3 **(a)** Assuming a stoichiometry A$\rightarrow$R for first order gas phase reaction, the volume of a plug flow reactor for 99% conversion of pure A is calculated to be 32 liters. in fact, however the stoichiometry of the reaction is A$\rightarrow$ 3R. For this corrected stoichiometry, find the required volume of a reactor. **07**

(b) What are the different ideal reactors? **07**
Derive the performance equation of ideal batch reactor.

Q-4 **(a)** Write a short notes on Optimum Temperature Progression. **07**

(b) For a system of N equal size mixed reactors in series, derive the equation for total space time equation negligible density change and first order reaction. **07**

OR

Q-4 **(a)** Explain the qualitative product distribution for irreversible first order reactions in series. **07**

(b) Find the first order rate constant for the disappearance of A in the gas phase reaction 2A $\rightarrow$ R. if on holding the pressure constant, the volume of the reaction mixture starting with 80 % of A decreases by 20% in 3 minutes. **07**

Q-5 **(a)** Find the overall order of the irreversible reaction, **07**

$2H_2 + 2NO \rightarrow N_2 + 2H_2O$

From the following constant volume data using equimolar amount of hydrogen and nitric oxide.

Total pressure,mm Hg	200	240	280	320	360
Half life, sec	265	186	115	104	67

(b) Zero order homogenous gas phase reaction,A$\rightarrow\gamma$R proceeds in a constant volume bomb with 20% inerts and pressure rises from 1 to 1.3 atms in two minutes .if the same reaction takes place in a constant pressure batch reactor, what is the fractional volume change in 4 minutes? the feed is at 3atms and consists 40 % inerts. **07**

OR

Q-5 **(a)** Enzyme E catalyses the fermentation of substance A (the reactant) to product R. Find the size of mixed flow reactor needed for 95 % conversion of reactant in a feed stream (25 litres /min) of reactant (2 moles/litre)and enzyme. The kinetics of fermentation at this enzyme concentration are given by A→R, **07**

$$(-r_A) = \frac{0.1c_A}{1+0.5c_A} \text{ mol/lit, min}$$

(b) The homogenous gas decomposition of phosphine $4PH_3 \rightarrow P_4 + 6H_2$ Proceeds at 649^0 C with 1st order rate, **07**

$-r_{PH3} = (10/hr).C_{PH3}$

What size of plug flow reactor operating at 649^0 C and 4.6 atms can produce 80% conversion of a feed which is 50 % PH_3 and 50 % inerts.

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