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RM-7025

B. E. - III (Sem. VI) (Chemical) Examination

May / June – 2010

Chemical Reaction Engg. - I

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :

☛ **B. E. - 3 (Sem. 6) (Chemical)**

Name of the Subject :

☛ **Chemical Reaction Engg. - I**

☛ Subject Code No. : **7 0 2 5** ☛ Section No. (1, 2,.....) : **1&2**

Seat No. :

Student's Signature

(2) Answer each section in the **separate** answer books.

(3) Figures indicated at right side of the question is full marks.

(4) Assume appropriate data and give sketches wherever necessary.

SECTION - I

1 (a) Answer the following : **10**

(i) Write down the reaction rate in terms of surface of solid occupied and with respect to the volume of the reactor used. **2**

(ii) Write down true or false : **5**

(a) The order of a reaction is always an integer value.

(b) Reactions with low activation energies are very temperature sensitive, while reactions with high activation energies are relatively temperature insensitive.

(c) The frequency factor K_o does not affect the temperature sensitivity of a reaction.

(d) Reactions with order $n > 1$ can always go to completion in finite time.

(e) The slope of the plot ln $t_{1/2}$ Vs. ln C_{AO} is negative for n > 1.

(iii) Draw a typical concentration Vs. time curve for a consecutive first order reactions. **2**

(iv) Define order of the reaction. **1**

(b) The thermal decomposition of ethane to ethylene, methane, butane and hydrogen is believed to proceed in the following sequences : **10**

Initiation :

(i) $C_2H_6 \xrightarrow{KC_2H_6} 2CH_3^*$

Propogation :

(ii) $CH_3^* + C_2H_6 \xrightarrow{k_2} CH_4 + C_2H_5^*$

(iii) $C_2H_5^* \xrightarrow{k_3} C_2H_4 + H^*$

(iv) $H^* + C_2H_6 \xrightarrow{k_4} C_2H_5^* + H_2$

Termination :

(v) $2\,C_2H_5^* \xrightarrow{k_4} C_4H_{10}$

Derive a rate law for the rate of formation of ethylene and also derive rate of disappearance of ethane.

2 Answer any **two** : **2×8=16**

(a) Derive the reaction kinetics for a homogenous catalyzed system.

(b) Find a rate equation using integral method of analysis for the following reaction,

$A \rightarrow P$

where A decomposes in a batch reactor. The composition of A in the reactor is measured at various times with results shown below. Find the rate equation to represent the data :

time, s	0	20	40	60	120	180	300
C_A, mol/liter	10	8	6	5	3	2	1

(c) Derive the relationship between conversion and concentration for isothermal varying density system.

3 Answer any **two** : **2×7=14**

(a) For the reaction $A \rightarrow R$, 2^{nd} order kinetics and C_{AO} = 1 mol/liter, we get 50% conversion after 1 hr in a batch reactor. What will be the conversion and concentration of A after 1 hour if C_{AO} = 10 mol/liter?

(b) For the decomposition $A \rightarrow R$, C_{AO} = 1 mol/liter, in a batch reactor conversion is 75% after 1 hour, and is just complete after 2 hours. Find a rate equation to represent these kinetics.

(c) Consider a feed C_{AO} = 100, C_{BO} = 200, C_{20} = 100 to a steady flow reactor. The isothermal gas phase reaction is $A + 3B \rightarrow 6R$

If C_A=40 at the reactor exit, what is C_B, X_A and X_B there?

SECTION - II

4 (a) Answer the following : **10**

(i) Define mean residence time. **1**

(ii) The thermodynamic equilibrium constant is unaffected by the pressure of the system - State True or False. **1**

(iii) If K>>1, it indicates that practically conversion is impossible and the reaction can be considered reversible - State True or False. **1**

(iv) Give the graphical representation of energy balance equation for adiabatic operation. **2**

(v) State two methods to control product distribution for the reactions of the type : **2**

$A \xrightarrow{k_1} R$ (desired)

$A \xrightarrow{k_2} S$ (unwanted)

(vi) Draw contacting patterns for various combinations of high and low concentration of reactants in non continuous operations. **2**

(vii) Define space velocity. **1**

(b) Define optimum temperature progression. Discuss the effects of temperature on irreversible reactions, endothermic and exothermic reactions. Draw operating lines for minimum reactor size. **10**

5 Answer the following : (any **two**) **16**

(i) 100 lt/hr of radioactive fluid having half-life period 20 hr is to be treated by passing it through two ideal steel tank mixed reactions in series of volume 40,000 lt. each. In passing through the system, how much has the activity decayed? **8**

(ii) Discuss quantitative treatment in plug flow or Batch reactor for the reactions : **8**

$$A \xrightarrow{K_1} R \xrightarrow{K_2} S$$

(iii) Equimolar quantities of A, B and D are fed continuously to a MFR where they combine by the elementary reaction : **8**

$$A + D \xrightarrow{k_1} R$$

$$B + D \xrightarrow{k_2} S \qquad \frac{k_2}{k_1} = 0.2$$

(a) 50% of incoming A is consumed, find out what fraction of product formed is R.

(b) If 50% of incoming B is consumed, find out which fraction of product formed is S.

6 Answer the following : (any **two**) **14**

(i) Derive a relation for overall fractional yield lin PFR for following reaction in parallel : **7**

$$A \xrightarrow{k_1} R \quad \text{(desired)}$$

$$A \xrightarrow{k_2} S \quad \text{(undesired)}$$

(ii) A first order reaction is to be treated in a series of 2 mix reactors. Show that the total volume of two reactors is minimum when reactors are of equal size. **7**

(iii) Discuss the effect of temperature and pressure on equilibrium conversion as predicted by thermodynamics. **7**
