Code No: RR320802 **Set No. 1**

III B.Tech II Semester Supplimentary Examinations, Apr/May 2008
CHEMICAL REACTION ENGINEERING-I
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) What are the variables affecting the reaction rate. List out the different forms of definition of reaction rate. [8]
   (b) The following rate equation is reported for vapor- phase reaction $-dP_A$/dt =3.66PA_2,atm/hr
      i. What are the units of the rate constant?
      ii. What is the value of the rate constant if the rate equation is written interms of molar concentration of A? [8]

2. The gas reaction 2A → R + 2S is approximately second order with respect to A. When pure A is introduced at 1 atm. into a constant volume batch reactor, the pressure rises 40% in 3 minutes. For a constant pressure batch reactor find
   (a) the time required for the same conversion [8]
   (b) the fractional increase in volume at that time. [8]

3. For the non elementary reaction A + 2B → R + S if the mechanism suggested is

   $A + B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} R + X$

   $B + X \xrightarrow{K_3} S$

   where X is the unstable intermediate compound,
   (a) Derive an expression for rate of disappearance of A
   (b) Explain how the rate constants can be evaluated using the rate law. [8+8]

4. The decomposition of gaseous A proceeds as follows

   A → R $(-r_A) = kC_A{}^2$

   A tubular reactor of 2 liters volume is fed at 2 m^3/hr of pure A at 300^0C and 20 atm. Conversion of reactant is 65%. In a commercial plant, it is desired to treat $100m^3/hr$ of feed gases at 40 atm and 300^0C containing 60%A and 40% diluents to obtain 85% conversion of A. Find the volume of reactor required. [16]

5. The kinetics of the aqueous-phase decomposition of A is investigated in two mixed reactors in series, the second having twice the volume of the first reactor. At steady state with a feed concentration of 1 mol A/liter and mean residence time of 96 sec in the first reactor, the concentration in the first reactor is 0.5 mol A/liter and in the second is 0.25 mol A/liter. Find the kinetic equation for the decomposition? [16]

6. (a) Define a catalyst and describe its properties.
   (b) Compare physical adsorption and chemisorption.
   (c) What is an adsorption isotherm? Define. [6+6+4]

7. For the first order reactions $A \xrightarrow{k_1} R \xrightarrow{k_2} S$ taking place in a plug flow reactor derive the expression for $C_{R,max}$ and $\tau_{p,opt}$. [16]

8. Write detailed note on:
   (a) Enzyme - substrate reactions
   (b) Methods of analysis of kinetic data. [8+8]

⋆ ⋆ ⋆ ⋆ ⋆

Code No: RR320802 **Set No. 2**

III B.Tech II Semester Supplimentary Examinations, Apr/May 2008
CHEMICAL REACTION ENGINEERING-I
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) Derive the Arrhenius law from thermodynamic principles. [8]
   (b) For a given activation energy the rate doubles for 10^oC rise in temperature. It is a thumb rule and valid at a specific temperature. Show that the relationship between activation energy and temperature for which the rule holds is T = $\left[\frac{(10^oK)\,E}{R\,\ln\,2}\right]^{1/2}$ [8]

2. The kinetic data for the reaction of sulphuric acid with diethyl sulphate
   $H_2SO_4 + (C_2H_5)_2SO_4 \leftrightarrow 2C_2H_5SO_4H$ is given in table

Time, min	0	41	48	75	127	162	180	212	318	368	410	∞
$C_2H_5SO_4H$ $mole/litre$	0	1.18	1.38	2.24	3.31	3.381	4.11	4.45	5.515	5.32	5.4 2	5.8

   Initial concentration of H_2SO_4 and $(C_2H_5)_2SO_4$ are each 5.5 $mole/litre$. Find a rate equation for this reaction. [16]

3. Experiment shows that the homogeneous decomposition of ozone proceed with a rate $-r_{03} = K[O_3]^2[O_2]^{-1}$. Suggest a two step mechanism to explain this rate and explain how would you further test this mechanism? [16]

4. The decomposition of gaseous A proceeds as follows
   A $\rightarrow$ R $(-r_A) = kC_A{}^2$
   A tubular reactor of 2 liters volume is fed at 2 m^3/hr of pure A at 300^0C and 20 atm. Conversion of reactant is 65%. In a commercial plant, it is desired to treat $100m^3/hr$ of feed gases at 40 atm and 300^0C containing 60%A and 40% diluents to obtain 85% conversion of A. Find the volume of reactor required. [16]

5. Acetic anhydride is to be hydrolyzed in three stirred tank reactors operated in series. The reaction is first order with k = $0.0806min^{-1}$. Each reactor has a volume of 1.8 $liters$ and the feed rate to the first is 35 $liters/hr$. Compute the percent of hydrolysis accomplished in the three reactors. [16]

6. (a) Define a catalyst and describe its properties.
   (b) Compare physical adsorption and chemisorption.
   (c) What is an adsorption isotherm? Define. [6+6+4]

7. Derive the energy balance equation for an adiabatically operated CSTR. [16]

8. Write a brief note on:
   (a) Recycle reactors
   (b) enzyme - substrate reactions. [8+8]

⋆ ⋆ ⋆ ⋆ ⋆

Code No: RR320802 **Set No. 3**

III B.Tech II Semester Supplimentary Examinations, Apr/May 2008
CHEMICAL REACTION ENGINEERING-I
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) What are the variables affecting the reaction rate. List out the different forms of definition of reaction rate. [8]
   (b) The following rate equation is reported for vapor- phase reaction $-dP_A/dt = 3.66 P A_2$,atm/hr
      i. What are the units of the rate constant?
      ii. What is the value of the rate constant if the rate equation is written interms of molar concentration of A? [8]

2. (a) Calculate the expansion factor for the reaction A→4R with 30% inert present in the feed. Derive the equation you use for calculating expansion factor. [4]
   (b) Sketch the energies involved in the transformation of reactants to products in an elementary reaction. [4]
   (c) An elementary vapour phase homogeneous reaction 2A → R is carried out under isothermal and isobaric conditions. The reaction mixture initially contains 80% of A and 20% of inerts. Calculate the % volume charge of reaction mixture for 50% conversion of A. [8]

3. Consider the reaction A + 3B → R + 3S for which the mechanism suggested is

   $A + B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} S + X$

   $B + X \underset{k_2}{\overset{k_1}{\rightleftharpoons}} S + Y$

   $B + Y \overset{k_5}{\rightarrow} R + S$

   (a) Derive the rate law.
   (b) Show how the rate law transforms when each of the mechanism steps controls the rate. [16]

4. The reaction A + B → R is first order with respect to each of the reactants when conducted in liquid phase in a $1.5m^3$ plug flow reactor using a mole ratio

   $M = C_{Bo}/C_{Ao} = 2$, a 90% conversion is obtained. What mole ratio M will provide the same amount of product, if the reaction is conducted in a 7.5 m^3 backmix reactor. [16]

5. (a) Define recycle ratio. What is the effect of varying the recycle ratio from zero to infinity on the performance of the recycle reactor?

(b) Develop the performance equation for a recycle reactor. Write the performance equation for the two extremes of the recycle ratio. [4+12]

6. For the solid catalyzed reaction A $\leftrightarrows$ R derive the expression for the rate of reaction if adsorption of A is rate controlling. [16]

7. We have a mixture consisting of 90 mole % A (45 mol/liter) and 10 mole % impurity B (5 mol/liter). To be of satisfactory quality the mole ratio of A to B in the mixture must be 100 to 1 or higher. D reacts with both A and B as follows:
   A + D $\rightarrow$ R, $-r_A = 21\ C_A C_D$
   B + D $\rightarrow$ S, $-r_B = 147\ C_B C_D$
   Assuming that the reactions go to completion, how much D need be added to a batch of mixture to bring about the desired quality? [16]

8. Write a short note on:

   (a) Half life period method

   (b) Excess reactant and stoichimetric proportions methods. [8+8]

⋆ ⋆ ⋆ ⋆ ⋆

Code No: RR320802 **Set No. 4**

III B.Tech II Semester Supplimentary Examinations, Apr/May 2008
CHEMICAL REACTION ENGINEERING-I
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. For the general reaction scheme aA + bB → rR + sS explain and derive expressions for the following. [4×4=16]
   (a) General mole relation (Stoichiometric equation)
   (b) Fractional conversion
   (c) Rate of reaction
   (d) Law of mass action

   Show what form they take when the reaction under consideration is a constant volume reaction.

2. The gas reaction 2A → R + 2S is approximately second order with respect to A. When pure A is introduced at 1 atm. into a constant volume batch reactor, the pressure rises 40% in 3 minutes. For a constant pressure batch reactor find
   (a) the time required for the same conversion [8]
   (b) the fractional increase in volume at that time. [8]

3. The primary reaction occurring in the homogeneous decomposition of nitrous oxide is found to be

   $N_2O \rightarrow N_2 + \frac{1}{2}\ O_2$

   With rate $-r_{N_2O} = \frac{K_1[N_2O]^2}{1+K_1[N_2O]}$

   Devise a mechanism that is consistent with and can explain the observed rate law. [16]

4. The reaction A + B → R is first order with respect to each of the reactants when conducted in liquid phase in a $1.5m^3$ plug flow reactor using a mole ratio

   $M = C_{Bo}/C_{Ao} = 2$, a 90% conversion is obtained. What mole ratio M will provide the same amount of product, if the reaction is conducted in a 7.5 m^3 backmix reactor. [16]

5. The kinetics of the aqueous-phase decomposition of A is investigated in two mixed reactors in series, the second having twice the volume of the first reactor. At steady state with a feed concentration of 1 mol A/liter and mean residence time of 96 sec in the first reactor, the concentration in the first reactor is 0.5 mol A/liter and in the second is 0.25 mol A/liter. Find the kinetic equation for the decomposition? [16]

6. For the solid catalyzed reaction A $\leftrightarrows$ R derive the expression for the rate of reaction if adsorption of A is rate controlling. [16]
7. Derive the energy balance equation for an adiabatically operated CSTR. [16]
8. Write detailed note on:
   (a) Enzyme - substrate reactions
   (b) Methods of analysis of kinetic data. [8+8]

⋆ ⋆ ⋆ ⋆ ⋆