Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(CHE-OLD)/SEM-5/CHE-504/2012-13

2012

CHEMICAL REACTION ENGINEERING

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) A reaction has the stoichiometric equation $A + B = 2R$. What is the order of reaction

   a) not known b) 1

   c) 2 d) 3

   ii) A 10 minute experimental run shows that 75% of liquid reactant is converted to product by half order rate order. What would be the amount converted in half an hour run ?

   a) 80% b) 100%

   c) 75% d) none of these.

iii) A reaction has the stoichiometric equation $\frac{1}{2}A + B = R + \frac{1}{2}S$ has the following rate expression $-r_A = 2C_A^{0.5}C_B$

What is rate expression, if the stoichiometric equation is written as

$A + 2B = 2R + S$

a) Same as above b) 3

c) 1 d) 2.

iv) A gas solid non catalytic reaction (combustion of low ash carbon particles having small size in air) A (fluid) + bB(solid) $\rightarrow$ Fluid and solid product is taking place at temperature of 1200°C. Which resistance will control the rate of reaction ? (give the answer with reason)

a) Chemical reaction

b) Ash layer diffusion

c) Gas film diffusion resistance

d) None of these.

v) For a first order of reaction, the rate constant depends upon

a) reaction temperature

b) initial concentration of reactants

c) reaction time

d) extent of reaction.

vi) A reaction which proceeds with evolution of heat is called

a) thermo-nuclear reaction

b) endothermic reaction

c) exothermic reaction

d) photochemical reaction.

vii) The rate of reaction between A and B increases by a factor of 50, when the concentration of A is increased 10 folds, the order of the with respect to A is

a) 5 b) 0

c) 1 d) 50.

viii) Which of the following explains the mechanism of catalysis ?

a) Activated complex theory

b) Collision theory

c) Thermodynamics

d) None of these.

ix) Unreacted core model represents the reaction involving

a) combustion of coal particles

b) roasting of sulphide ore

c) manufacture of carbon disulphide from elements

d) none of these.

x) Molecularity of a reaction

a) is always equal to the overall order of reaction

b) may not be equal to the order of reaction

c) cannot have a fractional value

d) both (b) and (c).

xi) An irreversible first order reaction is being carried out in a CSTR and PFR of same volume. The liquid flow rates are same. The relative conversion will

a) be more in CSTR than in PFR

b) be more in PFR than in CSTR

c) be same in both cases

d) depend on the temperature.

xii) n number of plug flow reactors in series with a total volume V gives the same conversion as one PFR of volume

a) V/n b) V

c) $V.n$ d) $1/V$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. The primary reaction for the homogeneous decomposition of nitrous oxide is

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

With rate $-r_{N_2O} = \frac{k_1[N_2O]^2}{1 + k_2[N_2O]}$. Devise a mechanism to explain the observed rate.

3. The aqueous reaction $A = R + S$ proceeds as follows :

Time (minute)	0	36	65	100	160	∞
C_A (mol/L)	0·1823	0·1453	0·1216	0·1025	0·0795	0·0494

With C_{A0} = 0·1823 mol/L, C_{R0} = C_{S0} = 55 mol/L; Find the rate equation for the reaction.

4. Two small sample of reacting solids are introduced into constant environment oven kept there for an hour. Under these conditions the 4 mm particles are 58% converted and the 2 mm particles are 87·5% converted :

   a) Find the rate controlling mechanism for conversion of solids

   b) Find the time needed for complete conversion of 1 mm particles in this oven. $2\frac{1}{2} + 2\frac{1}{2}$

5. Consider a fermentation reaction :

   a) *A* (Organic feed) $\xrightarrow{\text{Microorganism}}$ (Product Chemical) *R* + (more cell) *C*.

   b) A (Organic feed) $\xrightarrow{\text{Enzyme } E}$ (Product Chemical) *R*.

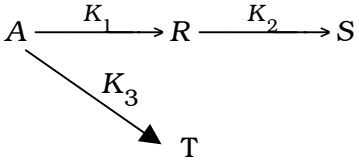
   In batch reactor condition (liquid phase) draw the concentration distribution curve with time for two case (a) and (b) and give proper explanation. $2\frac{1}{2} + 2\frac{1}{2}$

6. For any particular duty and for all positive reaction orders the mixed flow reactor is always larger than the plug flow reactor. 5

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. For the elementary reaction 

Where, $K_2 = K_1 + K_3$. Find $\frac{C_{R\max}}{C_{A0}}$ and τ_{opt} in a Plug flow reactor. 8 + 7

8. The solid catalyzed decomposition of gaseous *A* proceeds as follows :

$$A \rightarrow R, \quad -r_A = kC_A^{\,2}$$

A tubular Pilot Plant reactor packed with 2 liters of catalyst is fed 2 m^3/hr. of pure *A* oil 300°C and 20 atm. Conversion of *A* = 65%. In larger plant it is desired to treat 100 m^3/hr. of feed gases at 40 atm and 300°C containing 60% and 40% diluents to obtain 85% of *A*. Find the internal volume of the reactor required. 7 + 8

9. Every May 22, I plant one watermelon seed. I water it, I fight slugs, I Pray, I watch my beauty grow, and finally the day comes when the melon ripens. I then harvest and feast. Of course, some years are sad, like 1980, when a bluejay flew off with the seed. Anyway, six summers were a pure joy and for these I have tabulated the number of growing days versus the mean daytime temperature during he growing season. Does the temperature affect the growth rate ? If so, represent this by activation energy. 15

Year	1976	1977	1982	1984	1985	1988
Growing days	87	85	74	78	90	84
Mean temp. °C	22	23·4	26·3	24·3	21·1	22·4

10. Enzyme E catalyses the fermentation of substrate A (the reactant) to product R. Find the size of mixed flow reactor needed for 95% conversion of reactant in a feed stream (25 litre/min) of reactant (2 mol/litre) and enzyme. The kinetics of the fermentation at this enzyme concentration are given by :

$$A \longrightarrow R \quad -r_A = 0 \cdot 1 C_A / (1 + 0 \cdot 5 C_A) \text{ mol lit}^{-1}\text{min}^{-1}. \quad 15$$