Paper Code: CH-502	Roll No.										

B. TECH.
FIFTH SEMESTER EXAMINATION, 2015-2016
CHEMICAL REACTION ENGINEERING-II

Time: 3 Hours *Total Marks: 100*

Note: Attempt ***ALL*** questions. Assume suitable data, if required. All question carry equal marks.

1. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) Differentiate between chemical and physical adsorption. Describe Langmuir adsorption isotherm with suitable assumptions and derivations.

(b) Discuss the rate equation for heterogeneous reactions. Also explain the effect of heat during catalytic reactions with suitable examples.

(c)The following kinetic data are obtained in an experimental Carberry type basket reactor using 100 gm of catalyst in the paddles and different flow rates from run to run:

$A \rightarrow R$, $C_{Ao} = 10$ mol/m^3

F_{Ao}, mol/min	0.14	0.42	1.67	2.5	1.25
C_A, mol/m^3	8	6	4	2	1

Determine the amount of catalyst needed in a packed bed reactor for 75% conversion of 1000 mol A/min of a $C_{Ao} = 8$ mol/m^3 feed.

2. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) Discuss the term 'Effectiveness factor of a catalyst'. A feed consisting 30% of 50 μm, 40% of 100 μm and 30% of 200 μm radius particles, is to be fed continuously in a thin layer onto a moving grate crosscurrent to a flow of reactant gas. For the planned operating conditions the time required for complete conversion is 5, 10 and 20 min for three sizes of particles. Find the conversion of solids on the grate for a residence time of 8 min in the reactor.

(b) Discuss 'Recycle Reactor'. Also derive design equation of CSTR along with the suitable assumptions.

(c) An aqueous reactant stream (4 mol A/ litre) passes through a CSTR followed by a PFR. Find the concentration at the exit of the PFR, if in CSTR, C_A=1.0 mole/litre. The reaction is second order wrt A, and the volume of the PFR is 3 times that of CSTR.

3. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) What do you understand with Hot spot in tubular reactor? Also derive design equation of PFR along with the suitable assumptions.

(b) Give the procedure for determination of the rate controlling steps for progressive conversion. Derive the equation for shrinking core model when diffusion through chemical reaction control.

$$t/\tau = 1-\{r_C/R\} = 1-\{1- X_B \}^{1/3}$$

(c) Derive design equation of *'Semi batch reactor'* along with the suitable assumptions.

4. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) In an experiment, to determine the pore volume and catalyst particle porosity, the following data were obtained on a sample of activated silica (granular, 4 to 12 mesh size). Calculate *pore volume*, *density* of solid and *porosity* of silica. Given that:

Mass of catalyst sample placed in chamber= 101.5gm

Volume of He displaced by sample = 45.1 cm^3

Volume of Hg displaced by sample = 82.7 cm^3

(b) Differentiate between shrinking core model and progressive conversion models. Spherical solid particles containing B are roasted isothermally in an oven with gas of constant composition. Solids are converted to a firm nonflaking product according to the SCM as follows:

$A(g) + B(s) \rightarrow R(g) + S(s)$, C_A =0.01 kmol/m^3, ρ_B =20 kmol/m^3

From the following conversion data (by chemical analysis) or core size data (by slicing and measuring) determine the rate controlling mechanism for the transformation of solid.

SNo.	*t, sec*	X_B	*dp, mm*
1	240	1	1
2	360	1	1.5

(c) What is the mechanism of catalytic reactions? Describe the general characteristics of the catalyst and Impregnation method for the preparation of catalyst.

5. Attempt any ***TWO*** parts of the following: - **(10x2)**

(a) Discuss about the 'Microbial Fermentation'. In a number of separate runs different concentrations of substrate and enzyme are introduced into a batch reactor and allowed to react. After a certain time the reaction is quenched and the vessel contents analyzed. From the results found below, find a rate equation to represent the action of enzyme on substrate.

Run	C_{Eo}, mol/m^3	C_{Ao}, mol/ m^3	C_A, mol/m^3	t, hr
1	3	400	10	1
2	2	200	5	1
3	1	20	1	1

(b) For the following reaction, determine the amount of catalyst needed in a packed bed reactor with a very large recycle rate (assume mixed flow) for 40% conversion of A to R for a feed rate of 2000 mol/hr of pure A at 3.2 atm and 117°C. For the reaction at this temperature

$$A \rightarrow 4R$$

It is given that, $-r'_A = 96\ C_A$ mol/kg cat .hr , C_{Ao} = 100 mol/m^3

(c) Discuss about the 'M-M Kinetics'. Substrate A and enzyme E flow through a mixed flow reactor ($V=18.0 \times 10^{-3}$ m^3). From the entering and leaving concentrations and flow rate, find rate equation to represent the action of enzyme on substrate.

C_{Eo}, mol/litre	C_{Ao}, mol/ m^3	C_A, mol/litre	v, litre/hr
0.02	200	0.04	9.0
0.01	300	0.15	12.0
0.001	690	0.60	3.6