Seat No.: _____ Enrolment No.______

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Regular Examination January / February 2011

Subject code: 713001N

Subject Name: Advance Reactor Design

Date: 31/01 /2011 **Time: 02.30 pm – 05.00 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) For the following liquid phase reactions in parallel, product R is desired out of two products R & S. **07**

i. Desired reaction

$A + B \rightarrow R \quad dC_R / dt = 1.0\ C_A C_B^{0.3}$ moles/lit min.

ii. Undesired reaction

$A + B \rightarrow S \quad dC_S / dt = 1.0\ C_A^{0.5} C_B^{1.8}$ moles/lit min. 90% conversion of A is desired .Feed comprises of pure A & pure B in equal proportion with density of 20 mol/lit of each. Assuming that B is introduced into reactor in such a way that C_B = 1 moles/lit, throughout the reactor. Find the Overall fractional yield. If production rate of A is 160 ton/day find size of the reactor.

Data: M.W of A & B = 32, M.W of R & S = 64

Density of Mixture = 1200 kg/M^3

(b) (i) Derive design equation for CSTR operating at steady state when X, v_0, C_{A0} and F_{A0} are specified. **07**

(ii)In CSTR if variables v_0, C_{A0}, V and F_{A0} are specified, find the temperature and conversion at which CSTR will operate stable.

Q.2 (a) Derive the design equation for maximum rate of cell production for bioreactors. **07**

(b) With a neat diagram explain different types of loop reactors used in industry. **07**

OR

(b) With reference to the exothermic reaction in CSTR, express the thermal behavior of a CSTR. (Plot heat generation rate vs temperature). Discuss the stability of a CSTR when operating at different temperatures. **07**

Q.3 n-butane, C_4H_{10} is to be isomerized to iso-butane in a PFR. The reaction is exothermic and is carried out adiabatically in liquid phase under high pressure using trace amount of catalyst. The rate constant is 31.1 hr^{-1} at 360^{o}K. Calculate the PFR volume necessary to process 16 kgmol/hr of a mixture of 90 mole% n-butane and 10 mole% iso-pentane (inert). The feed enter at 330^{o}K. **14**

Data:

ΔH_r = -6900 J/mol of butane

C_p of n-butnae & iso-butane = 141 J/mol/^{o}K

C_p of iso-pentane = 161 J/mol/^{o}K

Activation energy = 65.7 KJ/mol

K_c = 3.03 at 60^{o}C, C_{Ao} = 9.3 kgmol/m^3

OR

Q.3 Propylene Glycol is produced in a glass lined batch reactor. The feed temperature is 14.5^0C and the charge is 3.75 liter Methanol and 19 liter water with 0.1 % of H_2SO_4. Find the time required to achieve conversion of 50 %.Temperature of both the streams are 14.5 ^0C but on mixing temperature shoots up by 9.5^0C due to heat of mixing. Operating Temperature = 51.5 ^0C **14**

Data:-

$$\underbrace{CH_2 - CH}_{O} - CH_3 + H_2O \rightarrow \underset{OH}{CH2} - \underset{OH}{CH} - CH_3$$

Reaction is zero order in excess of water.

$k = 16.96\times10^{12}\times e^{-8064/RT}\ hr^{-1}$

	Propylene oxide	Methanol	Water
Mol. Wt.	58	32	18
Density,Kg/m^3	859	790	1000
C_p ,cal/gmmole^0C	35	19.5	18
Boiling Point,^0C	34.3	64	100

Q.4 **(a)** The oxidation of ethanol to form acetaldehyde is carried out on a catalyst of 4 wt% copper, 2 wt% chromium on Al_2O_3. Acetaldehyde gets oxidized to form carbon dioxide which is undesirable. The reaction is carried out in three fold excess of oxygen and in dilute concentration (0.1% ethanol, 1% oxygen and 98.9% nitrogen). Consequently, the volume change with the reaction can be neglected. Determine the concentration of acetaldehyde as a function of space time. **07**

If 3 tonnes/day of acetaldehyde is to be produced, find the size of reactor.

$$CH_3CH_2OH(g) \xrightarrow[-H_2O]{+1/2\ O_2} CH_3CHO \xrightarrow[-\ 2H_2O]{+5/2\ O_2} 2CO_2$$

(b) Explain working of trickle bed reactor with a neat sketch. **07**

OR

Q.4 **(a)** A mixture of coal particles is burnt in air on a moving grate. The grate is moving with a velocity of 1 m/min. The composition and complete conversion for particle mixture is given in the table. Calculate the minimum length of the grate to achieve average conversion of (a) 80% (b) 95% **07**

Mixture Composition (%)	Particle size (μ)	Complete conversion time (min)
25	50	10
50	75	15
25	100	20

(b) Derive the design equation for adiabatic batch reactor. **07**

Q.5 **(a)** Methyl linoleate is to be converted to methyl oleate in a $2m^3$ slurry reactor. The molar feed rate of methyl linoleate to the reactor is 0.7 kmol/min. The partial pressure of H_2 is 6 atm (corresponding $C_i = 0.014\ kmol/m^3$) and the reactor is considered to be well-mixed. Calculate the catalyst charge necessary to achieve 30% conversion for a 60 μm particle size. The reaction is internal diffusion controlling. **07**

Data:

Resistance to gas absorption $r_b = 0.08$ min

For 80 μm particle, Specific combined resistance to internal diffusion, reaction and external diffusion, $r_{cr} = 0.28\ min.kg/m^3$

(b) Derive the performance equation for fluidized bed reactor. **07**

OR

Q.5 **(a)** For elementary solid-catalyzed liquid phase reactions, plot equilibrium conversion as a function of temperature. 07

$$\longleftarrow A \longrightarrow \qquad B$$

Determine the adiabatic equilibrium temperature and conversion when pure A is fed to the reactor at a temperature of 300 ^{o}K.

Data:

H_A (298 ^{o}K) = -40,000 cal/mol

H_B (298 ^{o}K) = -60,000 cal/mol

C_{pA} = 50 cal/mol/^{o}K

C_{pB} = 50 cal/mol/^{o}K

K_e = 1,00,000 at 298 ^{o}K

(b) Discuss Inter-stage cooling for exothermic reactions. **07**

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