

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

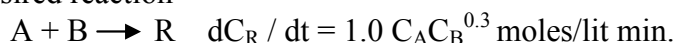
Total Marks: 70

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



ii. Undesired reaction

$A + B \longrightarrow S \quad dC_S / dt = 1.0 C_A^{0.5} C_B^{1.8} \text{ moles/lit min.}$ 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/M³

(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°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°K . **14**

Data:

$\Delta H_r = -6900 \text{ J/mol of butane}$

C_p of n-butane & iso-butane = $141 \text{ J/mol}^\circ\text{K}$

C_p of iso-pentane = $161 \text{ J/mol}^\circ\text{K}$

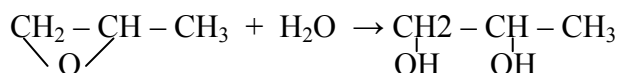
Activation energy = 65.7 KJ/mol

$K_c = 3.03$ at 60°C , $C_{A0} = 9.3 \text{ kgmol/m}^3$

OR

- Q.3** Propylene Glycol is produced in a glass lined batch reactor. The feed temperature is 14.5°C and the charge is 3.75 liter Methanol and 19 liter water with 0.1 % of H₂SO₄. Find the time required to achieve conversion of 50 %. Temperature of both the streams are 14.5 °C but on mixing temperature shoots up by 9.5°C due to heat of mixing. Operating Temperature = 51.5 °C **14**

Data:-



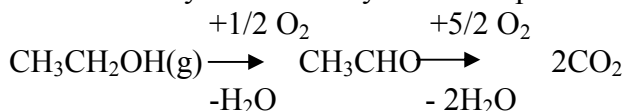
Reaction is zero order in excess of water.

$$k = 16.96 \times 10^{12} \times e^{-8064/RT} \text{ hr}^{-1}$$

	Propylene oxide	Methanol	Water
Mol. Wt.	58	32	18
Density, Kg/m ³	859	790	1000
C _p , cal/gmmole ⁰ C	35	19.5	18
Boiling Point, °C	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 Al₂O₃. 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.



- (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 2m³ slurry reactor. The molar feed rate of methyl linoleate to the reactor is 0.7 kmol/min. The partial pressure of H₂ is 6 atm (corresponding C_i = 0.014 kmol/m³) 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/m³

- (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



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

Data:

$$H_A (298 \text{ } ^\circ\text{K}) = -40,000 \text{ cal/mol}$$

$$H_B (298 \text{ } ^\circ\text{K}) = -60,000 \text{ cal/mol}$$

$$C_{pA} = 50 \text{ cal/mol/}^\circ\text{K}$$

$$C_{pB} = 50 \text{ cal/mol/}^\circ\text{K}$$

$$K_e = 1,00,000 \text{ at } 298 \text{ } ^\circ\text{K}$$

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

07
