Major

Chemical Reactor Analysis and Design (CHL-103)

Marks: - 40 — 28th Nov, 06

Venue- II 378 — 10.30 AM – 12.30 PM

(There are two parts. Use separate answer script for each part)

Part - I

Q1. The elementary irreversible organic liquid phase reaction $A+B \rightarrow C$ is carried out in a flow reactor. An equal molar feed in A and B enters at 27^{0}C, and the volumetric flow rate is 2 dm^3/s.

a) Calculate the PFR and CSTR volumes necessary to achieve 85 % conversion when the reaction is carried out adiabatically.
b) What is the maximum inlet temperature one could have so that the boiling point of the liquid (550K) would not be exceeded even for complete conversion?
c) Plot the conversion and temperature as a function of PFR volume (i.e. distance down the reactor)
d) Calculate the conversion that can be achieved in a 500 dm^3 CSTR.

Additional data:

$H_A^o(273)$	=	- 20 kcal/mol
$H_B^o(273)$	=	- 15 kcal/mol
$H_C^o(273)$	=	- 41 kcal/mol
C_{Ao}	=	0.1 kmol/m^3
$C_{PA} = C_{PB}$	=	15 cal/mol.K
C_{PC}	=	30 cal/mol. K
k	=	0.01 dm^3/mol.s at 300K
E	=	10,000 cal/mol

(15)

Q2. Short Notes

(a) Show how to calculate volume of the reactor from the $(-1/r_A)$ versus X_A curve for a CSTR and a PFR.

(b) What is the expression for the Damkohler number for a third order reaction?

(c) Write two industrial applications of a CSTR.

(d) State the difference between space time and holding time of a reactor with example?

(e) Write the energy balance equation for an open system.

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Part – II

Q1. Derive in details the expression of time to reach for steady operation of a CSTR (with constant overflow) for any 1^{st} order liquid phase reaction. Can you write that time for a fast first order reaction?

(6)

Q2. An isothermal reversible reaction $A \rightleftharpoons B$ is carried out in an aqueous solution. The reaction is first-order in both directions. The forward rate constant is 0.4 h^{-1} and the equilibrium constant is 4.0. The feed to the plant contains 100 $kg.m^{-3}$ of ***A*** and enters at the rate of $12 m^3.h^{-1}$. Reactor effluents pass to a separator, where ***B*** is completely recovered. The reactor is a stirred tank of volume 60 m^3. A fraction **'*y*'** of the unreacted effluent is recycled as a solution containing 100 $kg.m^{-3}$ of ***A*** and the reminder is discarded.

Product ***B*** is worth Rs. 2/- per kilogram and operating costs are Rs. 50/- per cubic meter of solution entering the separator.

(a) What value of **'*y*'** maximizes the operational profit of the plant?
(b) What fraction of ***A*** fed to the plant is converted at the optimum?

(14)