MECM-103

M.E./M.Tech. I Semester

Examination, December 2014

Reactor Design and Stability

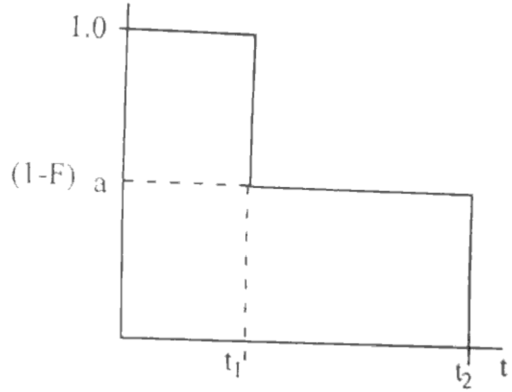
Time : Three Hours

Maximum Marks : 70

Note: Attempt any four questions. All questions carry equal marks, Draw neat sketch and assume suitable data wherever you required.

1\. a) Describe how to obtain the mean residence time and variance to calculate the number of tanks-in-series and the Peclet number.

b) The following (1-F) curve was obtained for a real rector.



It is desired to model the real reactor as a combination of two ideal reactors with parameters $n_{01} = bn_0$ and $V_1=aV$ where V is the total reactor volume and n_0 the volumetric flow rate. Determine the model and the model parameters.

b) Spherical particles of zinc blend of size R = 1mm are roasted in an 8% O_2 stream at 900°C and 1 atm. The stoichiometry of the reaction is
$2Z_nS + 3O_2 \rightarrow 2Z_nO + 2SO_2$

4. a) Explain continuous reaction model for porous catalyst and give electrical analog of a pore.

b) Show that the selectivity of two concurrent first order reactions occurring in flat shaped porous catalyst is independent of the effect of either heat or mass transfer if the activation energies of both reactions are equal.

OR

a) What is effectiveness factor? Explain.

b) In a fluidized bed catalytic reactor under isothermal conditions a first order reaction is carried out in the bubbling regime. Given overall mass transfer coefficient between bubbles and the dense phase Kga=0.7 sec^{-1}, catalytic first order reaction rate constant K=0.07 m^3/Kg-sec, bubbles superficial velocity U_b=0.13 m/sec, bed reactor height Z=0.55 m, Fraction of the fluidized bed reactor occupied by the dense phase ε_d=0.76 and the density of catalyst particles in dense phase P_d=15 Kg/m^3. Calculate fractional conversion in the fluidized bed.

5. a) Explain Trickle-Bed Reactor based on the following points:

i) Flow Regimes: the flow regime may be trickle flow, pulsing flow, bubble flow, or spray flow, depending on the flow rates and properties of the fluids and solid.

ii) Pressure Drop: The pressure drop for concurrent down flow of gas and liquid in a packed bed.

iii) Liquid Holdup and Wetted Area.

iv) The external mass transfer coefficients.

b) Show that the general energy balance for non-isothermal batch reactor, can simplify to an appropriate form for either adiabatic or isothermal reactor operation.

OR

a) Discuss how the steady state reactor temperature varies as a function of the steady state jacket temperature.

b) Consider the liquid-phase reaction: $A+B \rightarrow C$ ΔH_R=-5 kJ/mol, C_{PA}=7 J/mol-K, C_{PB}=3 J/mol-K, C_{PC}=10 J/mol-K $C_{Pj} \neq f(T)$. This reaction occurs in a wall-cooled CSTR (V=10 dm^3), with UA = 10 W/K and $T_a=T_0$. The inlet stream is an equimolar mixture of A and B, entering at v_0=100dm^3/min and F_{T0}=10 mol/s. Use the G(T) plot to answer the following question: Determine the extinction and ignition temperatures (provide numbers) when the coolant is shut off and the reactor becomes adiabatic. On the plot, Draw and label the R(T) curves for ignition and extinction and circle the bifurcation points.

******