EX/PG/CHE/T/111B/ 5/2017

M. CHEM ENGG. 1ST. SEM. EXAM. - 2017

ADVANCEED CHEMICAL ENGINEERING KINETICS AND REACTOR DESIGN

Time: three hour

Full marks: 100

Answer any five questions
Assume any missing data
All questions carry equal marks
Symbols have usual significance

1) Draw a labeled schematic of a non-isothermal batch reactor. Derive mass and energy balance equations for a liquid phase first order reaction taking place in a non-isothermal batch reactor. Derive a relation between temperature and conversion.

2) A first order liquid phase endothermic reaction A→B taking place in a non-isothermal batch reactor. Calculated time required for 50% conversion.

   Data:

   $\Delta H = 70{,}000$ kJ/kmol

   $C_P = 2.5$ kJ/kg.K

   $k = 2X10^{14}\exp(-15000/T)\ h^{-1}$

   $M_A = 50$ kg/kmol

   $T_0 = 600K$

   Initial charge = 300 kg

   Composition of charge = 15% A

3) Draw a labeled schematic of a non-isothermal plug flow reactor. Formulate material and energy balance equations. Modify these equations for adiabatic and isothermal operation.

4) Discuss with diagram shrinking core model for non-catalytic gas-solid reactions assuming spherical particles. Starting from material balance, derive time versus conversion relations for gas-film controlling, ash layer controlling and chemical reaction controlling cases.

5) Discuss transport mechanism in a slurry reactor. Derive design equation for a slurry reactor operating as CSTR. Also derive rate equation for a fixed bed recycle reactor.

6) Explain with a diagram, showing different transport resistances, the mechanism of gas liquid reaction in presence of solid catalyst particles. Derive an expression for overall reaction rate considering all resistances involved in the process.

$$A(g) + bB(l) \rightarrow \text{Product}$$

What would be the form of rate equation in case of C_{Bl} is very high and C_{Al} very high.

7) In an industrial waste water treatment plant, waste water is treated in a recycle bio reactor. The out stream from the reactor is taken to a clarifier where unreacted biomass is settled and the effluent is taken out. In the reactor an undesirable biomaterial A is produced by a first order chemical reaction which affects the settling process in the clarifier causing loss of active biomass with the effluent. To decrease the amount of A in the recycle stream, the recycle stream is treated in a CSTR. The effluent from CSTR contains less A, and recycled in the bioreactor. It was found that the concentration of A in the reactor should not exceed 275 mg/l. calculate safe recycle ratio to maintain process conditions.

Data:

Concentration of A at the inlet of CSTR = 1000 mg/l

Rate constant in bioreactor = 0.005/h

Rate constant in CSTR = 0.5/h

Residence time in bioreactor = 8 h

Residence time in CSTR = 0.5 h

8) Write Short notes on:
   a) CSTR recycle reactor
   b) Pore diffusion model and significance of Thiele modulus
   c) Contacting schemes for three phase gas-liquid-solid reactor
   d) Non-catalytic Gas-Solid reaction – Shrinking particle size