

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

ADVANCED 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 $A \rightarrow B$ taking place in a non-isothermal batch reactor. Calculate time required for 50% conversion.

Data:

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

$$C_p = 2.5 \text{ kJ/kg.K}$$

$$k = 2 \times 10^{14} \exp(-15000/T) \text{ h}^{-1}$$

$$M_A = 50 \text{ kg/kmol}$$

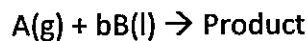
$$T_0 = 600\text{K}$$

$$\text{Initial charge} = 300 \text{ kg}$$

$$\text{Composition of charge} = 15\% \text{ A}$$

- 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.



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