Ref. No. EX/CHE/T/312/2017(OLD)

Bachelor of Engineering in Chemical Engineering 2017(Old)

3rd Year 1st Semester

Chemical Reaction Engineering

PART-I

Assume any missing Data

Answer any three questions

All questions do not carry equal marks

Time 3 Hours

Total Marks for each part: 50

1. a)For an irreversible 1st order liquid phase reaction, conversion obtained from a PFR is 90% when CA_0=20mol/L. If two thirds of the stream leaving the reactor is recycled to the entrance keeping the throughput to the reactor-recycle system unchanged, determine the conversion showing the derivation. 12

1. b) For a series reaction, $A \rightarrow R \rightarrow S$ determine $\frac{C_S}{C_{A0}}$ for a CSTR. For the two consecutive reactions, the rate constants are k_1 and k_2. 4

2. a) What is the significance of Damköhler number? 2

2. b) For spherical configuration of catalyst, correlate the effectiveness factor with Thiele modulus. 6

2. c) For fluidized bed catalytic reactor, derive all performance equations stating the assumptions. 5

2. d)You have been asked to design an adiabatic CSTR for a second order homogeneous reaction 2A ⟶ B. State the design equations you will plan to use. 5

3. Consider the autocatalytic reaction A⟶ R with $-r_A$=0.001$C_AC_R$mol/L.s. You have to process 1.5L/s of CA_0=10mol/L feed to the highest possible conversion possible using a set of four 100L CSTRs connected as you wish with any feeding arrangement. Sketch your recommended design and feeding arrangement and determine the final concentration of reactant A. 16

4. a) A feed containing particles with radii with following distribution:30% 50μm, 40%100μm, 30% 200μm. was fed to an incinerator. The time required for complete combustion of particles of different radii is 5, 10 and 20 minutes respectively. Determine the conversion of solid for a residence time of 8 minutes. 10

4. b)For the parallel reactions A+B ⟶ R (desired) and A+B ⟶S(unwanted)with $\frac{dC_R}{dt} = C_A C_B^{0.3}$; $\frac{dC_S}{dt} = C_A^{0.5} C_B^{1.8}$. Recommend a few reactor options and their feeding arrangements. 6

[Turn over

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Group B

Answer Question no 1 and any two from rest of the questions

Use separate Answerscript for Group A & Group B

Assume any missing data

1. Prove that $t_{opt} = \frac{(\ln k_1 - \ln k_2)}{(k_1 - k_2)}$ for irreversible series reaction. 10

2. Derive the final expression for autocatalytic reaction. 8

   Prove that $t/t_c = 1 - 3(R_c/R_p)^2 + 2(R_c/R_p)^3$ for ash film controlled diffusion in non catalytic heterogeneous reactor, where t_c is complete conversion time, R_c is instantaneous radius of particle, R_p is solid particle radius. 12

3. The zero order homogeneous gaseous decomposition A→ rR is carried out in an isothermal constant volume batch reactor with 20% inerts, and the pressure rises from 1 to 3 atm in 2 min. If the same reaction take place in a constant pressure batch reactor, what is the fractional volume change in 4 min if the feed is at 3 atm and consist 40% inerts. Use the following expression: $V=V_0(1+\epsilon_A x_A)$. 8

   Liquid A decomposes by 2nd order reaction kinetics and in a batch reactor. 50% of A is converted in 5 in run. How much longer will it take to reach 75% conversion. 12

4. Derive the expression to determine the volume of Plug flow reactor. 5

   A mixture consisting of 80 mole% of A (40 mole/L) and 20 mole% of impurity B (5 mole/L). To be of satisfactory quality the mole ratio A to B in the mixture must be 100. D reacts with A & B as follows: A+D→ R, $-r_A = 21\ C_A C_B$ and B+D→ S, $-r_B = 168\ C_B C_D$. Assuming that the reaction go to completion, how much D need to be added to a batch of mixture to bring the desired quantity. 15