B.Tech. Seventh Semester (Chemical Technology) (C.B.S.)

Chemical Reaction Engineering

P. Pages : 2 **TKN/KS/16/7922**

Time : Three Hours * 0 2 5 9 * Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Answer **any four** questions.
3. Assume suitable data wherever necessary.
4. Diagrams and Chemical equations should be given wherever necessary.
5. Illustrate your answers wherever necessary with the help of neat sketches.
6. Use of slide rule, Logarithmic tables, steam tables, Mollier's chart, drawing instruments, Thermodynamic tables for moist air, Psychrometric charts and Refrigeration charts is permitted.

1. a) The reaction described by the data in table given below $A \rightarrow B$ is to be carried out in a CSTR. Species A enters the reactor at a molar flow rate of 0.4 mol/sec. Calculate the volume necessary to achieve 60% conversion in a CSTR. **10**

X	0	0.1	0.2	0.4	0.6	0.7	0.8
$-r_A \left(\frac{mol}{m^3.sec}\right)$	0.45	0.37	0.30	0.195	0.113	0.079	0.05

b) Develop the design equations for two CSTRS in series. Show its graphical interpretation. **10**

2. a) The reversible gas-phase decomposition of nitrogen tetroxide, N_2O_4 to nitrogen dioxide, NO_2, $N_2O_4 \rightleftharpoons 2NO_2$ is to be carried out at constant temperature. The food consists of pure N_2O_4 at 340 k and 202.6 kPa. The concentration equilibrium constant, K_C, at 340K is 0.1 mol/dm^3. **10**

i) Calculate the equilibrium conversion of N_2O_4 in a constant volume batch rector.

ii) Calculate the equilibrium conversion of N_2O_4 in a flow reactor.

b) Derive $V = V_o\left(\frac{P_o}{P}\right)(1+EX)\frac{T}{To}$ for variable volume batch reactor. **10**

3. The gas-phasereaction $2NOCl \rightarrow 2No + Cl_2$ is carried out at 425ºC and 1641 kPa. Pure NOCl is to be fed and the reaction follows an elementary rate law. It is desired to produce 20 tons of NO per year in a microreactor system using a bank of ten microreactors in parallel. Each microreactor has 100 channels with each channel 0.2mm square and 250mm in length. **20**

Plot the molar flow rates as a function of volume down the length of the reactor. The volume of each channel is 10^{-5}dm^3.

Data : To produce 20 tons per year NO at 85% conversion would require a feed rate of 0.0226 mol/sec of NOCl or 2.26×10^{-5} mol/sec per channel. The rate constant is $k = 0.29 \frac{dm^3}{mol.sec}$ at $500\,k$ with $E = 24\ \frac{kcal}{mol}$.

4. a) **10**

Derive $\ell n\, t_{½} = \ell n \frac{2^{\alpha-1}-1}{(\alpha-1)k} + (1-\alpha)\,\ell n\, C_{A_O}$ where $t_{½} = \text{Half life}$.

b) The reaction of trityl (A) and methanol (B) $A + B \rightarrow C + D$ was carried out in a solution of benzene and Pyridine at 25ºC. Pyridine reacts with HCl that then precipitates as pyridine hydrochloride there by making the reaction irreversible. **10**

time (min)	0	50	100	150	200	250	300
$C_A \times 10^3$ (mol/dm^3)	50	38	30.6	25.6	22.2	19.5	17.4

The initial concentration of methanol was 0.5 mol/dm^3. Determine the reaction order with respect to trityl using integral method of data analysis.

5. A sample of the tracer hytane at 320 k was injected as a pulse to a reactor and the effluent concentration was measured as a function of time, resulting in the data shown in table below. **20**

t (min)	0	1	2	3	4	5	6	7	8	9	10	12	14
(Cg/m^3)	0	1	5	8	10	8	6	4	3.0	2.2	1.5	0.6	0

Construct figures showing C(t) & E(t) as a function of time. Calculate mean residence time for the reactor.

6. a) What are the advantages of use of CSTRS in series ? Explain with graphical interpretation. **10**

b) Calculate the activation energy for the decomposition of benzene diazonium chloride to give chlorobenzene and nitrogen : **10**
benzene diazonium chloride $\rightarrow$ chlorobenzene + N_2.
Using the information in table below for this first order reaction.

k (sec^{-1})	0.00043	0.00103	0.0018	0.00355	0.00717
T (k)	313.0	319.0	323.0	328.0	333.0

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