

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination May 2012

TCE 2008 Chemical Reaction Engineering I

Duration of Examination 3 Hours

Instructions to Candidates:

1. Answer ALL FIVE questions.
2. Each question carries equal marks.
3. Show all your steps clearly in your calculation.
4. Start the answers for each question on a new page.

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1. Calculate the **individual** reactor volume as well as the **total** reactor volume for the following:

a) PFR followed by CSTR

[10]

b) CSTR followed by PFR.

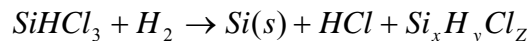
[10]

for the reaction data given in table, when intermediate conversion is 30% and final conversion is 70%, the molar flow rate is 52mol/min.

X	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85
$-r_A$ (mol/dm ³ s)	0.0053	0.0052	0.0050	0.0045	0.0040	0.0033	0.0025	0.0018	0.0012	0.001

2. a) The reaction $2A + 3B \rightarrow 5C$ is carried out in a reactor. If at a particular point, the rate of disappearance of A is $10 \frac{\text{mol}}{\text{dm}^3 \text{ s}}$, what are the rates of B and C? [6]

- b) For silicon to be used in the manufacture of microelectronic devices, it must contain less than 150 parts per trillion of impurities. This ultrapure silicon can be produced by reacting metallurgical silicon (98% pure) and HCl to form trichlorosilane and other products. This mixture is distilled and then the trichlorosilane is reacted with hydrogen at 1100 C to form polycrystalline silicon, HCl, and other silane products in the following reaction:



Set up a stoichiometric table for the following case: $x=1, y=2, z=2$.

The total pressure may be taken to be 2 atm and the feed is stoichiometric. Sketch the concentrations of each species as a function of conversion [14]

3. The elementary isomerization



is carried out at 20atm in a fluidized CSTR containing 100 kg of catalyst where 50% conversion is achieved. It is proposed to replace the CSTR with a PBR . The entering pressure was 20atm and the exit pressure was found to be 10atm.

- a. What would be the conversion if no pressure drop occurs? [10]
 b. What would be the conversion in the new PBR with pressure drop? [10]
4. The following data were reported for gas-phase constant volume decomposition of dimethyl ether at 504°C in a batch reactor. Initially, only $(CH_3)_2O$ was present:

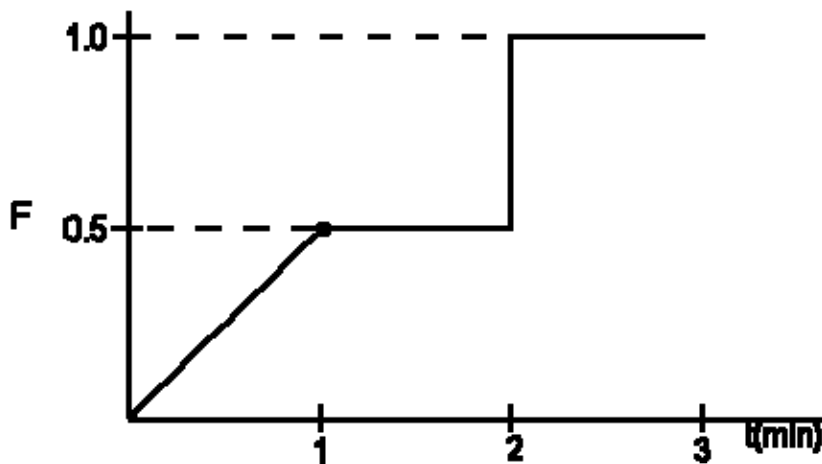
Time (s)	0	390	777	1195	3155	∞
Total pressure (mmHg)	312	408	488	562	799	931

Assuming that the reaction $(CH_3)_2O \rightarrow CH_4 + H_2 + CO$ is irreversible and goes to completion, determine using the integral method of analysis:

- a. the **reaction order** [10]
 b. the **specific reaction rate constant**. [10]
5. a) For the elementary reactions: $A \xrightarrow{k_1} B \xrightarrow{k_2} C$

with $k_1=0.1 s^{-1}$ and $k_2=0.2 s^{-1}$ with $C_{A0}= 2 mol/dm^3$. Plot the concentration of B and selectivity of B to C as a function of space time in a CSTR. [10]

- b) The F curves is shown below for a real reactor



What is the mean residence time? [10]