NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

REACTOR TECHNOLOGY

SCH 4208

Supplementary Examination Paper

July 2016

This examination paper consists of 4 pages

Time Allowed: 3 hours
Total Marks: 100
Special Requirements: Graph paper
Examiner's Name: Mr. B. Nyoni

INSTRUCTIONS

1. Answer all questions in Section A and any other three questions from Section B
2. Each question carries 20 marks
3. Show steps clearly in any calculation
4. Start the answers for each question on a fresh page
5. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	**20**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
TOTAL POSSIBLE MARKS	**100**

SECTION A

1. (a) (i) State the law of conservation of mass.

(ii) In what circumstances is the law of conservation of mass restricted. [4]

(b) The catalytic reaction A $\longrightarrow$ 4R is run at 3.2 atm and 120^{o}C in a plug flow reactor which contains 0.01kg of catalyst and uses a feed consisting of the partially converted product of 20 litres/hour of pure un-reacted A. The results are as follows:

Run	1	2	3	4
C_{Ain}, mol/liter	0.100	0.080	0.060	0.040
C_{Aout}, mol/liter	0.084	0.070	0.055	0.038

Use a graphical method to find the rate equation to represent this reaction. [16]

2. (a) Define the following terms :

(i) reaction rate,
(ii) order of reaction, and
(iii) rate constant [6]

(b) With the aid of one example each, distinguish between

(i) homogeneous and heterogeneous reactions

(ii) first order and pseudo first order reactions [8]

(c) In what scenario is shell and tube heat exchanger used as a reactor, give the name of such a reactor and briefly describe its structure and mode of operation. [6]

SECTION B

3. (a) With the aid of a flowchart diagram describe the main features of the Kompogas thermophilic dry digestion process. [5]

(b) The catalytic reaction A → 4R is run at 3.2 atm and 118°C in a plug flow reactor which contains 0.01kg of catalyst and uses a feed consisting of the partially converted product of 20 liters/hour of pure unreacted A. The results are as follows:

Run	1	2	3	4
C_{Ain}, mol/liter	0.100	0.080	0.060	0.040
C_{Aout}, mol/liter	0.084	0.070	0.055	0.038

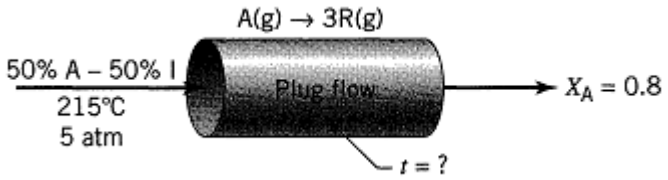
Use a graphical method to find the rate equation to represent this reaction. [15]

4. (a) Fixed-bed reactors and fluidized-bed reactors are some of the most important industrial reactors. With the aid of sketch diagrams explain their mode of operation and where they are applied. [6]

(b) A homogeneous gas reaction A → 3R has a reported rate at 215°C

$$-r_A = 10^{-2} C_A^{1/2}, \qquad [\text{mol/liter} \cdot \text{sec}]$$

Find the space time needed for 80% conversion of a 50% A -50% inert feed to a plug flow reactor operating at 215°C and 5 atm (C_{AO} = 0.0625 mol/liter)



[12]

(c) Explain why inerts are introduced into a reactor as feed. [2]

5 (a) Explain the term **mixed flow** as applied to mixed flow reactors. [4]

(b) Derive the performance equation of a CSTR. [16]

6. Ethyl acetate (M) is to be manufactured by the reversible esterification of acetic acid (A) with ethanol (B) to produce water (N) in an isorthermal batch reactor. A production rate of 10 tonne/day of ethyl acetate is required.

$$CH_3COOH + C_2H_5OH \longrightarrow CH_3COOC_2H_5 + H_2O$$

The reactor will be charged with a mixture containing 500 kg/m^3 ethanol and 250 kg/m^3 acetic acid, the remainder being water, and a small quantity of hydrochloric acid to act as a catalyst. The density of this mixture is 1045 kg/m^3 which will be assumed constant throughout the reaction. The reaction is reversible with a rate equation, over the concentration range of interest, which can be written as:

$$R_A = k_f C_A C_B - k_r C_M C_N$$

At the operating temperature of 100^{o}C the rate constants are:

$k_f = 8.0 \times 10^{-6}$ m^3/kmol.s
$k_r = 2.7 \times 10^{-6}$ m^3/kmol.s

The reaction mixture will be discharged when the conversion of the acetic acid is 30%. A time of 30 minutes is required between batches for discharging, cleaning and recharging. Determine the volume of the reactor required. [20]

END OF PAPER