NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

REACTOR TECHNOLOGY

SCH 4208

Second Semester Examination Paper

May 2016

This examination paper consists of 5 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:

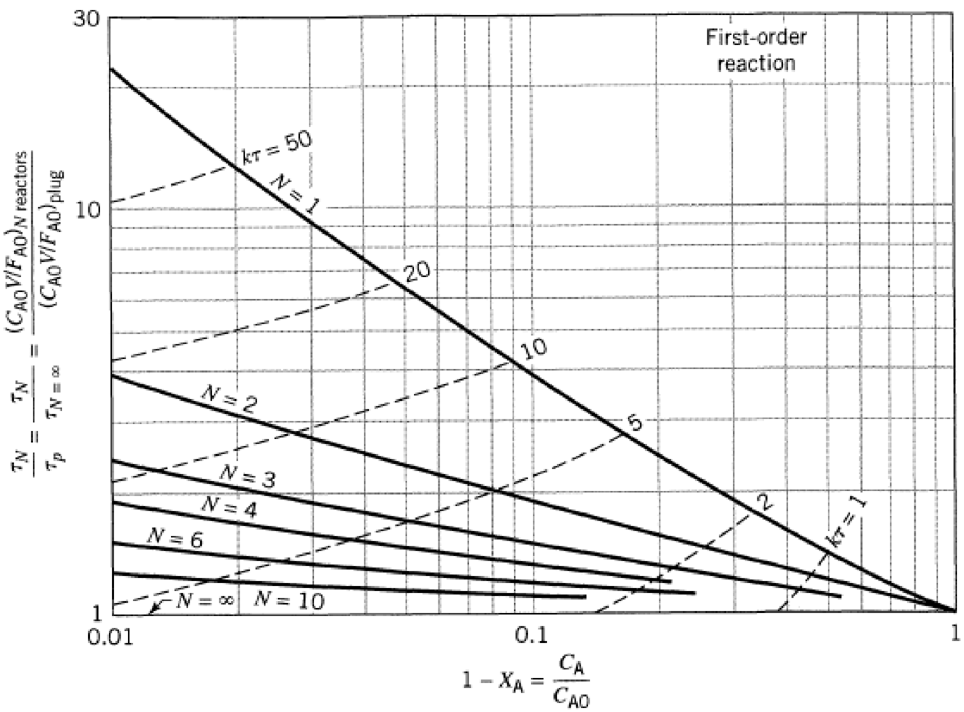
(i) reaction rate,
(ii) order of reaction, and
(iii) rate constant [6]

(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) The figure overleaf shows a comparison of performance of a series of N equal-size mixed flow reactors (CSTRs) with a single plug flow reactor for the first order reaction. With respect to the figure explain why the volume of a number of mixed flow reactors in series is theoretically the same as an equivalent volume of a single plug flow reactor. [6]



Comparison of performance of a series of N equal-size mixed flow reactors with a plug flow reactor for the first-order reaction

SECTION B

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

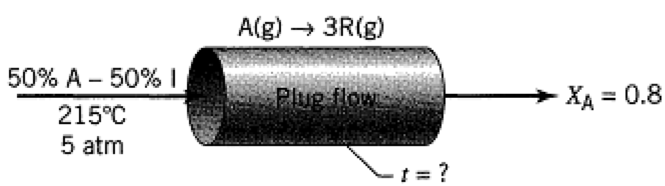
(b) Derive the performance equation of a batch reactor. [15]

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 $\longrightarrow$ 3R has a reported rate at 215^{o}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^{o}C and 5 atm (C_{AO} = 0.0625 mol/liter).

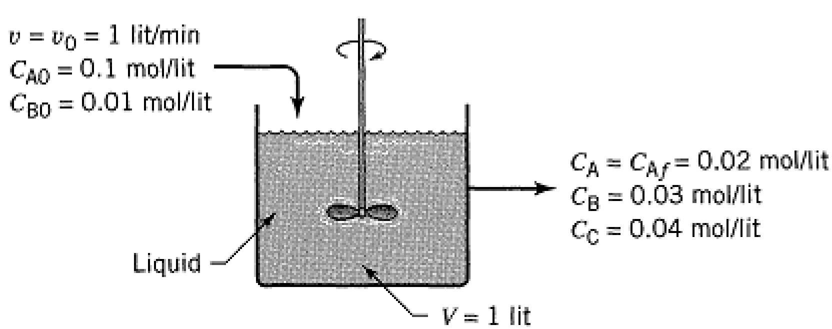


[12]

(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) One liter per minute of liquid containing A and B (C_{AO} = 0.10 mol/liter, C_{B}o = 0.01 mol/liter) flow into a mixed reactor of volume V = 1liter. The materials react in a complex manner for which the stoichiometry is unknown. The outlet stream from the reactor contains A, B, and C (C_{Af} = 0.02 mol/liter, C_{Bf} = 0.03 mol/liter, C_{Cf} = 0.04 mol/liter), as shown in the figure below. Find the rate of reaction of A, B, and C for the conditions within the reactor.



[12]

(c) Distinguish between elementary and non elementary reactions. [4]

6. The following equilibrium data was obtained for the adsorption of copper ions using a certain commercial adsorbent.

t (min)	0	20	40	60	80	100	120
t/q_t	-	451.4	735.1	992.9	1187.6	1384.8	1550.4
$\log(q_e - q_t)$	-1.11	-1.48	-1.63	-1.77	-1.99	-2.28	-

(a) Test the data for pseudo first and second-order kinetics and evaluate k_1 and k_2 if the models are as follows:

$$\log(q_e - q_t) = \log q_e - \frac{k_1 t}{2.303}$$ (pseudo first-order model)

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^{\,2}} + \frac{1}{q_e} t$$ (pseudo second-order model)

where: q_e is the amount of copper ion adsorbed per gram of adsorbent at equilibrium (mg/g), q_t is the amount of copper ion adsorbed per gram of adsorbent (mg/g) at time t, k_1 is the pseudo first-order rate constant (min^{-1}) and k_2 is the pseudo second-order rate constant (g/mg.min). [15]

(b) With the aid of a diagram, describe the type of reactor you will employ for the adsorption operation in industry. [5]

END OF PAPER