NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF FIRST SEMESTER EXAMINATIONS – MAY 2014
REACTOR TECHNOLOGY – SCH 4208 (FOR TTE STUDENTS ONLY)
TIME: 3 HOURS

Instructions to candidates:

1. Answer all questions in Section A and any three questions in Section B.
2. Show all your steps clearly in any calculation
3. Start the answers for each question on a new page.

Additional material:

Graph paper

SECTION A

1 (a) (i) State the law of conservation of mass
(ii) In what circumstances is the law of conservation of mass restricted. [10]

(b) State and explain three factors that affect the rate of reaction. [10]

2 (a) (i) With the aid of examples, distinguish between elementary and non elementary reactions. [8]
(ii) For any two types of reactors, discuss the advantages and limitations of each type of reactor. [8]
(iii) What type of reactor is preferred if the rate of heat evolution is high. Explain your answer [4]

SECTION B

3 (a) With the aid of a diagram describe the main features of a batch reactor. [5]

(b) In a process for the production of hydrogen required for the manufacture of ammonia, natural gas is to be reformed with steam according to the reactions:

$$CH_4 + H_2O \rightleftharpoons CO + 3H_2, \quad K_p(\text{at } 1173 \text{ K}) = 1.43 \times 10^{13} \text{ N}^2/\text{m}^4$$

$$CO + H_2O \rightleftharpoons CO_2 + H_2, \quad K_p(\text{at } 1173 \text{ K}) = 0.784$$

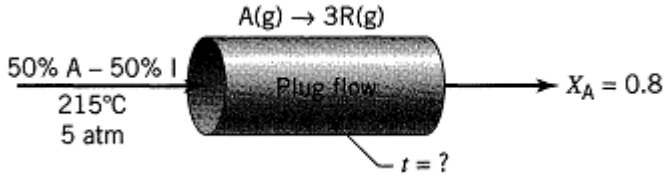
The natural gas is mixed with steam in the mole ratio $1CH_4 : 5H_2O$ and passed into a catalytic reactor which operates at a pressure of 3 MN/m^2 (30 bar). The gases leave the reactor virtually at equilibrium at 1173 K.
Show that for every 1 mole of CH_4 entering the reactor, 0.950 mole reacts, and 0.44 mole of CO_2 formed. [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. [10]

(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]

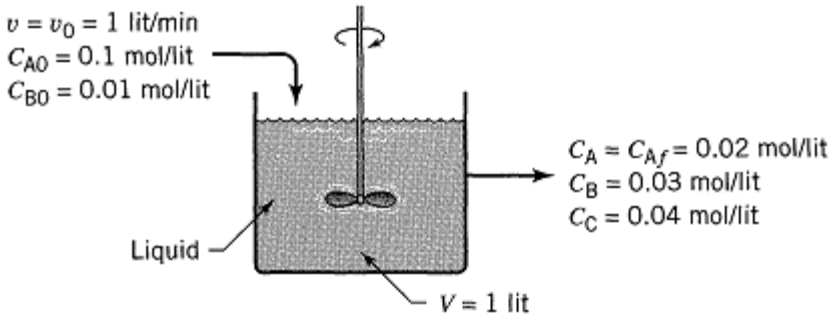
5 (a) (i) Explain the term **mixed flow** as applied to mixed flow reactors.

(ii) Give another name that is commonly used for mixed flow reactor

[5]

(b) Give two examples of solid catalyzed reactions, write balanced equations for each. [5]

(c) 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.



[10]

6 **(a)** Any type of reactor with known contacting pattern may be used experimentally to explore the kinetics of catalytic reactions. List the five experimental methods you have studied. [5]

(b) The catalytic reaction A $\longrightarrow$ 4R is run at 3.2 atm and 118^{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 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]

End of question Paper!!!