NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
SUPPLEMENTARY EXAMINATIONS – AUGUST 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.

[8]

(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.

[12]

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]

(i) What type of reactor is preferred if the rate of heat evolution is high. Explain your answer. [4]

SECTION B

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

(b) Explain the difference between homogeneous and heterogeneous reactors, give oneexample of each. [8]

(c) List any two types of reactors. [2]

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. [8]

(b) Pure gaseous reactant A (C_{A0} = 100 millimol/l) is fed at a steady rate into a CSTR, of volume 0.1 litre, where it dimerises according to the reaction ($2A \longrightarrow R$). For different gas feed rates the following data is obtained:

Run number	1	2	3	4
v_0 (litre/hr)	10.0	3.0	1.2	0.5
C_{af} (millimol/litre)	85.7	66.7	50.0	33.4

Find the rate equation. [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. [6]

(b) (i) What is a catalyst

(ii) Explain how a catalyst speeds up the rate of reaction.

(iii) Give examples of solid catalysed reactions, write balanced equations for each. [14]

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 4.2 atm and 112^{o}C in a plug flow reactor which contains 0.012kg 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!!!