NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Supplementary Examination October 2009

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. Consider the production of ethyl benzene

2ethylene + toluene → ethyl benzene + propylene

The gas feed consists of 25% toluene and 75% ethylene. Set up a stoichiometric table to determine the concentrations of each of the reacting species and then to write the rate of reaction solely as a function of conversion. Assume the reaction is elementary with $k_T = 250\ dm^6/mol^2\ s$. The entering pressure is 8.2 atm and the entering temperature is 227 C. Reaction takes place isothermally with no pressure drop**.**

(20 marks)

2. The elementary isomerization

$A \rightarrow B$

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?
b. What would be the conversion in the new PBR with pressure drop?

(20 marks)

3. In order to study the photochemical decay of aqueous bromine in bright sunlight, a small quantity of liquid bromine was dissolved in water contained in a glass battery jar and placed in direct sunlight. The follow3ing data were obtained:

Time (min)	10	20	30	40	50	60
Br_2 ppm	2.45	1.74	1.23	0.88	0.62	0.44

Determine whether the reaction rate is zero-, first-, or second-order in bromine, and calculate the reaction rate constant. **(20 marks)**

4. a) The reactions:

$$A+2B \rightarrow 2C$$
$$2C+1/2B \rightarrow 3D$$

are elementary. Write the net rates of formation for A, B, C and D.
$k_{1A} = 0.1(dm^3/mol)^2/min$, $k_{2D} = 2(dm^3/mol)^{3/2}/min$

(15 marks)

b) The following reactions were found to occur while trying to make a desired product B

$$A \rightarrow B \qquad -r_{A1} = k_{1A} C^2_A$$
$$A \rightarrow X \qquad -r_{A2} = k_{2A} C_A$$
$$A+X \rightarrow Y \qquad -r_{A3} = k_{3A} C_A C_X$$

Species X and Y are both foul pollutants
What is the instantaneous selectivity of B with respect to the foul pollutants X and Y?
Additional Information
$k_{1A} = 0.5\ e^{-10,000/T}\ min^{-1}$, T in degrees Kelvin
$k_{2A} = 50\ e^{-20,000/T}\ min^{-1}$, T in degrees Kelvin
$k_{3A} = 100\ e^{-5,000/T}\ min^{-1}$, T in degrees Kelvin

(5 marks)

5. The irreversible elementary gas phase reaction $2A \rightarrow B+C$ is currently carried out in a packed bed reactor containing 100 kg of catalyst. The entering pressure is 20 atm and the exit pressure is 4 atm. Currently 50% conversion is achieved. It is proposed to add a CSTR with 200 kg of catalyst downstream of the PBR. There is no pressure drop in the CSTR. The flow rate and temperature remain unchanged.

a) What would be the overall conversion in such an arrangement?
b) Is there better way to carry out the reaction, and if so what is it? **(20 marks)**