NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination August 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 liquid phase reaction A→ Products
Which is to take place in a PFR. The following data was obtained a batch reactor

x	0	0.4	0.8
$-r_A$ (mol/dm^3 s)	0.01	0.008	0.002

If the molar feed of A to the PFR is 2 moles, what PFR volume is necessary to achieve 80 % conversion under identical conditions as those under which the batch data was obtained? **(20 marks)**

2. A mixture of 28% SO_2 and 72% air is charged to a flow reactor in which SO_2 is oxidized.

$$2SO_2 + O_2 \rightarrow 2SO_3$$

Set up a stoichiometric table to determine the concentrations of each of the reacting species and write the rate of reaction solely as a function of conversion. Assume the reaction is elementary with k = 200 dm^3/mol s .Total pressure is 1485 kPa and the temperature is constant at 227ºC. **(20 marks)**

3. 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)

4. 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)**

5. **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

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

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)