

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.

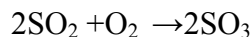
1. Consider the liquid phase reaction $A \rightarrow \text{Products}$

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% SO₂ and 72% air is charged to a flow reactor in which SO₂ is oxidized.



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 $k = 200 \text{ dm}^3/\text{mol s}$. Total pressure is 1485 kPa and the temperature is constant at 227°C. **(20 marks)**

3. The elementary isomerization



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?

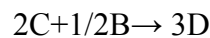
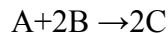
(20 marks)

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 following 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:

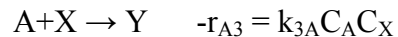
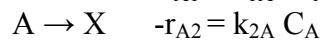
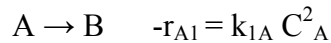


are elementary. Write the net rates of formation for A, B, C and D.

$$k_{1A} = 0.1 (\text{dm}^3/\text{mol})^2/\text{min}, k_{2D} = 2 (\text{dm}^3/\text{mol})^{3/2}/\text{min}$$

(15 marks)

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



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

$$k_{1A} = 0.5 e^{-10,000/T} \text{ min}^{-1}, T \text{ in degrees Kelvin}$$

$$k_{2A} = 50 e^{-20,000/T} \text{ min}^{-1}, T \text{ in degrees Kelvin}$$

$$k_{3A} = 100 e^{-5,000/T} \text{ min}^{-1}, T \text{ in degrees Kelvin}$$

(5 marks)