MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING

DEPARTMENT OF CHEMICAL AND PROCESSING ENGINEERING

REACTOR DESIGN

CODE: HCHE 324

SESSIONAL EXAMINATIONS

APRIL-MAY 2021

DURATION: 3 HOURS

EXAMINER: MR C.K. SIMENDE

INSTRUCTIONS

1. Answer **any 4** questions.
2. Each question carries 25 marks.

Question 1

(a) Explain what you understand by the following terms using examples if any:

i. Rate of reaction [1 mark]

ii. Chemical species [1 mark]

iii. Identity [4 marks]

iv. Decomposition [4 marks]

v. Combination [1 mark]

vi. Isomerization [2 marks]

(b) Derive the general mole balance over a boundary, hence shown that:

$$F_{j0} - F_j + \int_0^V r_j dV = \frac{dN_I}{dt}$$

[12 marks]

Question 2

a) The general mole balance (In - Out + Generation = Accumulation) over a boundary can be written symbolically as:

$$F_{j0} - F_j + \int_0^V r_j dV = \frac{dN_I}{dt}$$

Start from this **differential** equation and end up showing that the performance equation for a CSTR is the algebraic equation:

$$V = \frac{F_{j0} - F_j}{-r_j}$$

Of most importance in your answer is to **show exactly how each assumption applies** in the logical progression from the starting equation to this final equation. [9 marks]

(b) Outline the industrial applications of batch reactors and state its advantages and disadvantages. [8 marks]

(c) The CSTR volume required is greater than the PFR volume for the same conversion and reaction conditions. Why is this? [8 marks]

Question 3

With the aid of a diagram define the following types of reactors:

i. Batch reactor [5 marks]

ii. CSTR (Continuously Stirred Tank Reactor) [5 marks]

iii. Semi-batch reactor [7 marks]

iv. PFR (Plug Flow Reactor) [8 marks]

QUESTION 4

The elementary, liquid-phase, irreversible reaction A + B → C is to be carried out in a flow reactor. Two reactors are available, an 800 dm^3 PFR that can only be operated at 300 K and a 200 dm^3 CSTR that can be operated at 350 K. The two feed streams to the reactor mix to form a single feed stream that is equal molar in A and B, with a total volumetric flow rate of 10 dm^3/min. Which of the two reactors will give us the highest conversion? [25 marks]

Additional Information: at 300 K, k = 0.07 dm^3/mol-min

E = 85000 J/mol-K

$C_{A0B} = C_{B0B}$ = 2 mol/dm^3

$v_{A0} = v_{B0} = 0.5 * v_0$ = 5 dm^3/min

QUESTION 5

Species A enters a CSTR at a molar flow rate of 0.4 mol/s. Calculate the volume necessary to achieve 80% conversion in a CSTR. The rate of chemical reaction as a function of the conversion of reactant A given in Table 1.

Table 1: Reaction rate as a function of conversion

X	0.0	0.1	0.2	0.4	0.6	0.7	0.8
$-r_A$	0.45	0.37	0.30	0.195	0.113	0.079	0.05

Hint: Use the direct method and Levenspiel Plot. [25 marks]

END OF PAPER