INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
End–Spring Semester Examination 2022–23

Date of Examination: _____ Session: (FN/AN) _____ Duration: 3 hrs. Full Marks: __50__

Subject No.: __CH21206__ _____Subject: REACTION ENGINEERING

Department/Center/School: ___CHEMICAL ENGINEERING

Specific charts, graph paper, log book etc., required

Special Instructions (if any): _____

<div align="center">PART-A</div>

Q1. [4+4 = 8 marks]

For the reaction system $A \rightarrow B \rightarrow C$, in a continuous reactor where each reaction is irreversible, liquid phase and possessing first order kinetics, determine,

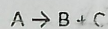(a) τ_{max} and Y_{Bmax} in a PFR

(b) τ_{max} and Y_{Bmax} in a CSTR

for the case when yield of B is the maximum by showing proper derivation.

Q2. [6+6 = 12 marks]

The elementary irreversible gas-phase reaction

$$A \rightarrow B + C$$

is carried out adiabatically in a PFR packed with a catalyst. Pure A enters the reactor at a volumetric flow rate of 20 dm³/s at a pressure of 10 atm. pressure and a temperature of 450 K. Assume that $\Delta P = 0.0$

(a) Formulate the conversion and temperature profile down the plug-flow reactor from the starting and find the corresponding equations to be solved. Also write the initial condition.

(b) What catalyst weight is necessary to achieve 80% conversion in a CSTR?

Additional information:

$C_{PA} = 40$ J/mol.K $\qquad\qquad C_{PB} = 25$ J/mol.K $\qquad\qquad C_{PC} = 15$ J/mol.K

$H^0_A = -70$ kJ/mol $\qquad\qquad H^0_B = -50$ kJ/mol $\qquad\qquad H^0_C = -40$ kJ/mol

All heats of formation are referenced to 273 K.

$$k = 0.133 \, \exp\left[\frac{E}{R}\left(\frac{1}{450} - \frac{1}{T}\right)\right] \frac{dm^3}{kg.cat \, s} \text{ with } E = 31.4 \, kJ/mol$$
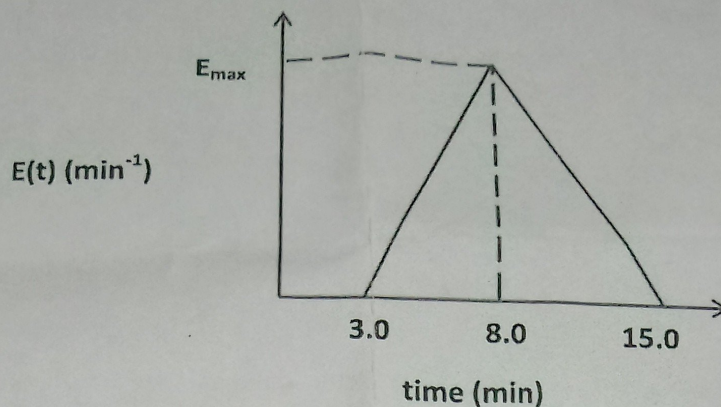
Q3.   [2 + 3 = 5 marks]

The residence time distribution for a real reactor is shown in the above diagram.

(a) What is the value of E_{max}?

(b) What is the value of mean residence time (t_m) in min?

PART-B

Q4.   [1 marks]

How can you express mass transfer co-efficient in terms of concentration difference and mole flux for a solid catalytic gas phase reaction?

Q5.   [4 marks]

For solid catalytic gas phase reaction, how the rate of the reaction is dependent on the gas phase velocity and catalyst particle size? Explain with logic by proper figure showing control regimes.

Q6.   [1 + 4 = 5 marks]

Define "Effective Diffusivity". Write the expression of it explaining all the terms in that.

Q7.   [2 marks]

How effectiveness factor is related to Thiele modulus for various shapes of the catalyst?

Q8.   [3 marks]

Make a flow diagram for determination of Effectiveness factor starting from the bulk density of the reactant gas.

Q9.   [5 marks]

Why Thiele Modulus for a reversible reaction is more than an irreversible reaction?

Q10.   [5 marks]

For a solid fluid non catalytic reaction, what are the reaction models you can predict? Explain them with their practicability.