



INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
Mid-Autumn Semester Examination 2022-23

Date of Examination: _____ Session: (FN/AN) _____ Duration: 2 hrs. Full Marks: 30

Subject No.: CH21206

Subject: Reaction Engineering

Department/Center/School: Chemical Engineering

Specific charts, graph paper, log book etc., required No

Special Instructions (if any): Answer the questions writing in which Part those belong

PART-A

Q1.

[2+2+2+3 = 9]

The reversible isomerization m -Xylene \rightleftharpoons para-Xylene follows elementary rate law kinetics. If X_e is the equilibrium conversion,

(a) Show for a batch and a PFR: $t = \tau = \frac{X_e}{k} \ln \frac{X_e}{X_e - X}$

(b) Show for a CSTR: $\tau = \frac{X_e}{k} \left(\frac{X_e}{X_e - X} \right)$

(c) Determine the volume efficiency, defined as $\frac{V_{PFR}}{V_{CSTR}}$, for $X/X_e = 0.5$

(d) For the same $X/X_e = 0.5$, what would be the volume efficiency for two CSTRs in series with the sum of the two CSTR volumes being the same as the PFR volume?

Q2.

[6]

The liquid-phase reaction $A \rightarrow B$ was carried out in a CSTR. For an entering concentration of 2 mol/dm^3 , the conversion was 40%. For the same reactor volume and entering conditions as the CSTR, the expected PFR conversion is 48.6%. However, the PFR conversion was, amazingly, 50% exactly. Brainstorm reasons for the disparity. Quantitatively show how these conversions came about (i.e., the expected conversion and the actual conversion).

PART B

Q3. a) Write different steps associated with a gas phase solid catalytic reaction to form product.

The reaction is: $A \rightarrow B$.

[3.5]

b) What do you mean by active sites in a solid catalyst? How do you express its concentration?

[1+1=2]

c) From the following rate equation, state the reaction, adsorption mechanism and reaction kinetics with logic.

[1+2+2=5]

$$-r'_N = \frac{kP_N}{(1 + K_1P_N + K_2P_C)^2}$$

d) Derive this rate law, considering a suitable rate limiting step consistent with the given rate expression as in the question c). Keep all notations same and name the notations.

[4.5]