BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE (BITS) PILANI – Pilani Campus

FIRST SEMESTER, 2017 – 2018 | CHE F311 Kinetics and Reactor Design | Mid-Semester Test

Time: **9.00 to 10.30 AM** **Maximum Marks: 90 | Date:** 09. 10. 2017 (Monday) | **CLOSE and OPEN BOOK**

INSTRUCTIONS

1. **This question paper consists of two parts. Part A is close book and Part B is open (only text) book.**
2. **Part-B answer book will be supplied after you return Part-A answer book.**
3. **Make and state suitable, logical and justifiable assumptions if necessary.**
4. **Give just 2 iterations for iterative procedure(s).**
   Be to the point. Do not be descriptive. Use as less words as possible.

PART A (CLOSE BOOK)

Q1. [Marks 34] (a) Derive, systematically, the design equations (both differential & integral forms) for a PBR, in terms of conversion **[6]; (b)** In an ideal CSTR, what is the concentration at the exit if it is *C* in the bulk of the reactor? **[1]; (c)** Define LHSV and GHSV **[4]; (d)** For a general reaction: $aA + bB \rightarrow cC + dD$, taking place in a flow reactor, build the complete stoichiometric table, giving all the expected aspects. Do not forget to define the nomenclature, say *I* can be used for inert **[9]; (e)** Give the physical significances of $\boldsymbol{\delta}$, $\boldsymbol{\varepsilon}$ and ***Da*** (hope, you know what they stand for in KRD/CRE!) **[6]; (f)** Define half-life of a reaction. Take an irreversible (elementary) reaction (A → P) of order α. For a constant-volume batch reactor, derive an expression for half-life. How can you extend this to time required for the concentration to fall to 1/n of the initial value? Show: how this method helps us to determine the rate law parameters? **[8].**

Q2. [Marks 20] Draw **very clearly.** Label all parts of the figures in such a manner that they become self-explanatory. Do not write description: **(a)** On Levenspiel plot, show that we can model a PFR with a large number of CSTRS in series **[3]; (b)** A typical Levenspiel plot for a reversible reaction in an isothermal flow reactor **[2]; (c)** Conversion, for a first order reaction, as a function of number of tanks in series for different *Da* (0.1, 0.5 and 1) **[6]; (d)** Change in gas-phase volumetric flow rate down the length of reactor for $\boldsymbol{\delta} = 0$, > 0 and < 0 **[3]; (e)** Effect of pressure drop on P, C_A, $-r_A$, X and v. Show the qualitative trends of these profiles against those without the pressure drop (implying draw 2 profiles for each parameter- one with pressure drop and one without pressure drop). Take reaction order > 0 and the usual meaning of parameters as they have in KRD/CRE **[6].**

PART B (ONLY OPEN TEXT BOOK)

Q3. [Marks 20] The following data were reported for a gas-phase constant-volume decomposition of dimethyl ether at 504ºC in a batch reactor. Initially, only $(CH_3)_2O$ was present.

Time (s)	390	777	1195	3155	∞
Total Pressure (mm Hg)	408	488	562	799	931

(a) Why do you think the total pressure measurement at $t = 0$ is missing? Can you estimate it? **(b)** Assuming that the reaction [$\mathbf{(CH_3)_2O \rightarrow CH_4 + H_2 + CO}$] is irreversible and goes to completion, determine the reaction order and specific reaction rate.

Q4. [Marks 16] Calculate the equilibrium conversion and concentrations for the gas-phase reaction $A \rightleftarrows 3C$ carried out in a flow reactor with no pressure drop. Pure A enters at a temperature of 400 K and 10 atm. At this temperature, $K_c = 0.25\ (dm^3/mol)^2$.

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