Roll No._____

National Institute of Technology Hamirpur (H.P.)

Department of Chemical Engineering

Subject: CHD 312 – Chemical Reaction Engineering-I

Class: B. Tech. **Branch:** Chemical Engineering **Semester:** V

Full Marks: 50 End Semester Examination, 2020 **Time:** 2 hours

Instructions:

- Answer all the questions. Write down all parts (a, b, c) of the question in same place.
- Graph paper is required.
- Write Name, Roll No., subject code and subject name at the top of the 1st page of answer sheet. Put page number and signature at every page of the answer sheet.
- Answer sheet is to be submitted as a single pdf file within 15 min after the scheduled time to Google classroom of Chemical Reaction Engineering. The file name should be your Roll No. followed by subject Code (e.g. – 1870XXCHD312).
- Missing data may be suitably assumed, if any.

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1. a) CSTR and PFR of various sizes are connected in series as shown in Fig. 1. For a reaction of order greater than 1, the (1/rate)-concentration curve is concave downward. What could be the best possible rearrangement for optimum size of the reactors? Explain graphically. (4)

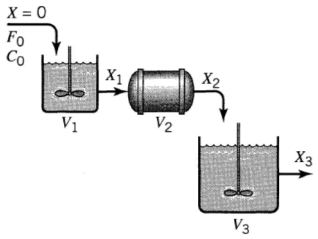

Fig. 1

b) Following data were obtained for the reaction, $A + B + C \rightarrow Products$.

Run No.	Initial concentration of A (mol/L)	Initial concentration of B (mol/L)	Initial concentration of C (mol/L)	Initial rate of reaction (mol/L.sec)
1	1.0	1.0	1.0	4.0×10^{-3}
2	2.0	1.0	1.0	8.0×10^{-3}
3	2.0	2.0	1.0	8.0×10^{-3}
4	1.0	1.0	2.0	8.0×10^{-3}

i) Find out the rate expression which is in accordance with the data.
ii) Estimate the rate constant. (6)

2. A liquid phase reaction, $A \rightarrow R$, is planned to study in a steady state flow reactor. A conversion of 85% of A is to be achieved with a feed stream of 1000 mol A/h at C_{Ao} = 1.5 mol/L. The following rate vs. concentration data is obtained.

C_A (mol/L)	0.1	0.2	0.4	0.5	0.6	0.7	0.8	1.0	1.3	2.0
$-r_A$ (mol/L.min)	0.1	0.3	0.6	0.5	0.25	0.1	0.06	0.05	0.045	0.042

Using graphical method,
i) calculate the volume required if a PFR is used.
ii) calculate the volume required if a CSTR is used. (14)

3. A liquid phase elementary reaction, $A+B \rightarrow R+S$, is carried out in a PFR. For equimolar amounts of A and B ($C_{Ao}=C_{Bo}$= 0.9 mol/L), 90% conversion is achieved in it. If a CSTR, 10 times as large as the PFR is connected in series after the PFR. Calculate the exit concentration of A from the CSTR. (10)

P.T.O.

4. Calculate the heat of reaction for synthesis of ammonia $N_2 + 3H_2 \rightarrow 2NH_3$ at 150°C in kJ/mol N_2 reacted and in kJ/mol H_2 reacted. Standard heat of formation of ammonia at 25°C is – 11020 cal/mol N_2. The mean heat capacities are given as $C_{P\text{-}H2}$ = 6.992 cal/mol.K, $C_{P\text{-}N2}$ = 6.984 cal/mol.K, $C_{P\text{-}NH3}$ = 8.92 cal/mol.K. (8)

5. a) Based on shrinking core model, explain the concentration profiles if diffusion through gas-layer and chemical reaction control the process. (4)

   b) For irreversible 1st order reaction, $A \xrightarrow{k_1} R \xrightarrow{k_2} S$, which of the following schemes will favour the formation of *S*? Explain. (4)

   A.

   B.

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