Roll No ....

CM-6004-CBGS

B.E. VI Semester

Examination, December 2020

Choice Based Grading System (CBGS)

Chemical Reaction Engineering-I

Time : Three Hours

Maximum Marks : 70

Note : i) Attempt any five questions. All questions carry equal marks.

ii) All parts of each question are to be attempted at one place.

iii) Assume suitable values for missing data, if any.

1. a) Define the rate of reaction and discuss its dependence on reactant concentration.

   b) Differentiate between order and molecularity of reaction.

2. a) Define order of reaction and describe which variable affecting the rate of reaction.

   b) Describe collision and activated complex theory.

3. a) In a train of CSTRs of equal volume, an irreversible, constant density 1^{st} order reaction is carried out. Show that if the number of CSTR is very large, the total volume of all the reactors in chain tends to that of a PFR for same extent of conversion.

   b) 1 lit/s of 20% ozone - 80% air mixture a 1.5 atm and 93°C passes through PFR. Under these conditions ozone decomposes by homogeneous reaction
   $2O_3 \rightarrow 3O_2 \; -r_{ozone} = kC^2_{ozone}$. What size reactor is needed for 50% decomposition of ozone? (k = 0.05 lit/mol.s)

4. a) The gas phase decomposition of dinitrogen pentoxide at 335 K, $2\,N_2O_5 \rightarrow 4\,NO_2 + O_2$ is first order in N_2O_5. During one experiment it was found that an initial concentration of 0.249 M dropped to 0.0496 M in 230 s. What is the value of the rate constant, k, in s^{-1} ?

   b) Concentration vs. time data is collected for the decomposition of H_2O_2.

   $$2\,H_2O_2(aq) \rightarrow 2\,H_2O(l) + O_2(g)$$

1	time	$[H_2O_2]$
2	0	0.02
3	200	0.016
4	400	0.0131
5	600	0.0106
6	800	0.0086
7	1000	0.0069

   Use these data to determine the rate law and the numerical value of the rate constant.

5. a) Define space time and space velocity. Derive the performance equation for CSTR.

   b) Consider an isothermal batch reactor for a given conversion of the reactant

   aA + bB → cC + dD

   Where component A is the limiting reactant. The stoichiometric coefficients are: a = 1, b = 2, c = 1 and d = 0. The initial moles of components. A, B, C and D are N_A = 0.001 gmol, N_B = 0.003 gmol, N_C = 0.0 gmol, N_D = 0.0 gmol, respectively. A mixture of A and B is charged into a 1-liter reactor. Determine the holding time required to achieve 90% fractional conversion of A (X_A = 0.9). The rate constant is $k = 1.0 \times 10^5[(\text{liter})^2/(\text{gmol}^2 \cdot \text{min})]$ and the reaction is first order in A, second order in B and third order overall.

6. a) At present, conversion is 66.67% for the elementary second order liquid reaction $2A \rightarrow 2R$ when operating in an isothermal PFR with recycle ration of unity. Determine the conversion if the recycle stream is shut off.

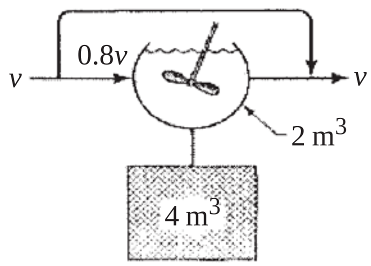
   b) An aqueous reactant stream (4 mol A/lit) passes through a MFR followed by a PFR. Find the concentration at the exit of the PFR if in the MFR $C_A = 1$ mol/lit. The reaction is 2nd order with respect to A, and the volume of the PFR is three times that of the MFR.

   c) Show that for a 1st order, constant density reaction carried out in two CSTRs in series, minimum total volume is required when the two MFRs are equal in size.

7. a) Draw schematics to show the non-ideal flow patterns which may exist in process equipments.

   b) What do you mean by axial dispersion? Write the significance of dispersion coefficient. Also discuss the extent of dispersion number for PFR and MFR.

   c) The second order aqueous reaction $A+B \rightarrow R+S$ is run in a large tank reactor ($V = 6m^3$) and for an equimolar feed stream conversion of reactants is 60%. Unfortunately, agitation in our reactor is rather inadequate and tracer tests of the flow within the reactor give the flow model sketched in fig. What size of mixed flow reactor will equal the performance of our present unit? (Assume $C_{A0} = C_{B0} = 100$ and $v = 100$ m^3/hr)



8. Write short notes on any three:
    a) Order and molecularly of reaction
    b) Yield and Selectivity
    c) Tank and Series model
    d) RTD dispersion model

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