B.E./B.TECH. Degree Examination, December 2020

Semester - VI

CH16605- Chemical Reaction Engineering-I

(Regulation 2016)

Time: Three hours Maximum : 80 Marks

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. The order of an elementary reaction $A + B \rightarrow P$ is -------
 a)0 b)1 c)2 d) cannot be determined
2. Recycle reactor acts like a CSTR, when recycle ratio R= -------
 a)0 b)1 c)2 d) infinity
3. Product distribution is the main concern in the ------------------ reaction.
 a) Single b) Multiple c) both d) none of the above
4. K >>> ------- indicates that in practical complete conversion may be possible and the reaction can be considered as irreversible.
 a) 0 b)1 c)2 d) infinity
5. State the factors affecting the rate of homogeneous reaction.
6. Find the conversion (X_A) for a constant volume PFR for the initial and final concentration of reactant is (C_{A0})100 and 60 mol of A (C_A).
7. Breifly write about instantaneous yield and its significance.
8. Find the equilibrium constant (K_{298K}) of reaction A forming R, if $\Delta G_{0,\ 298K}$ = -14130 J/mol

PART B - (4 X16 = 64 marks)

9. (a) (i) Every May 22 I plant one watermelon seed. I water it, I fight slugs, I pray, I watch my beauty grow, and finally the day comes when the melon ripens. I then harvest and feast. Of course, some years are sad, like 1980, when a blue jay flew off with the seed. Anyway, six summers were a pure joy and for these I've tabulated the number of growing days versus the mean daytime temperature during the growing season. Does the temperature affect the growth rate? If so, represent this by an activation energy. **(10)**

Year	1976	1977	1982	1984	1985	1988
Growing days	87	85	74	78	90	84
Temperature,°C	22	23.4	26.3	24.3	21.1	22.7

(ii) A certain reaction rate is given by **(6)**

$-r_A = 0.005\ C_A^2$ mol/cm^3. min.

If the concentration is to be expressed in mol/liter and time in hours, what would be the value and units of rate constant?

(OR)

(b) (i) Which reactor is used in small scale industries in general and why? Derive its performance equation considering the reactor is ideal. **(8)**

(ii) Derive an integrated rate expression for first order variable volume process. **(8)**

10. (a) (i) For an irreversible first-order liquid-phase reaction (C_{AO} = 10 mol/liter), conversion is 90% in a plug flow reactor. If two-thirds of the stream leaving the reactor is recycled to the reactor entrance, and if the throughput to the whole reactor-recycle system is kept unchanged, what does this do to the concentration of reactant leaving the system? **(12)**

(ii) Which reactor is preferred for gaseous reactions and why? **(4)**

(OR)

(b) For any reactions of positive order, tubular reactor is the best. Prove it by your own example and derive the respective performance equation. **(16)**

11. (a) (i) Derive an expression for the maximum intermediate concentration C_{Rmax} and the reaction time t_{rmax}. For the series reaction $A \rightarrow R \rightarrow S$, the formation of R is a first order reaction, whereas t, the decomposition of R to form S follows zero order with a rate constant k_1 and k_2 respectively. Explain the product distribution with a neat graph. **(12)**

(ii) Compare series and parallel reactions with respect to their control of product distribution. **(4)**

(OR)

(b) (i) Relate and explain the overall yield of PFR and CSTR **(4)**

(ii) In a reactive environment, chemical A decomposes simultaneously to form R and S with $r_R = C_A$ mol/liter and r_s = 1 mol/liter respectively. For a feed stream C_{A0} = 4 mol/liter, what size ration of two mixed reactors will maximize the production rate of R? Also give the composition of A and R leaving these two reactors. **(12)**

12. (a) The elementary irreversible liquid phase reaction A + B forming C, is carried out in a MFR. An equal molar feed in A and B enters the reactor at 27 °C, and the volumetric flow rate is 2 L/s. Calculate the volume of reactor to achieve 86% conversion when the reaction is carried out adiabatically. **(16)**

Data: The standard heat of formation for A, B and C are -20, -15 and -41 k Cal/mol respectively.

(OR)

(b) The reversible first order aqueous reaction A forming R is to be carried out in a PFR. For a maximum permissible feed temperature of 95°C (368 K) and a feed rate of 1000 mol/min of reactant A, what is the optimum temperature progression in the PFR? 80% conversion of reactant A is expected and the concentration of A in the feed is C_{A0}= 4 mol/l and C_{R0} = 0. Also, calculate the space time and volume needed for 80% conversion of a feed of F_{A0} = 1000 mol/min with C_{A0} = 4 mol/l and C_{R0} = 0. **(16)**

$=r_A = k_1 C_A - k_2 C_R$

$k_2 = 34 \times 10^6 \exp(-48900/RT)$, min^{-1}

$k_2 = 1.57 \times 10^{18} \exp(-123800/RT)$, min^{-1}