QPC: RD20BTECH413 AR 20 Reg. No ☐☐☐☐☐☐☐☐☐☐

GIET UNIVERSITY, GUNUPUR – 765022

B. Tech (Fifth Semester – Regular) Examinations, December – 2022

BPCCH5020 – Chemical Reaction Engineering - I

(Chemical Engineering)

Time: 3 hrs Maximum: 70 Marks

Answer ALL Questions

The figures in the right hand margin indicate marks.

PART – A: (Multiple Choice Questions) **(1 x 10 = 10 Marks)**

Q.1. Answer ***ALL*** questions CO # PO #

a. Given the reaction $N_2 + 3H_2 = 2NH_3$, what is the relation between the rates of formation and disappearance of the three reaction components? CO1 PO1

(i) $(-r_{N2}) = 3(-r_{H2}) = 2\, r_{NH3}$ (ii) $(-r_{N2}) = \frac{1}{3}(-r_{H2}) = \frac{1}{2}\, r_{NH3}$

(iii) $6(-r_{N2}) = \frac{1}{3}(-r_{H2}) = \frac{1}{2} r_{NH3}$ (iv) $(-r_{N2}) = \frac{1}{2}(-r_{H2}) = \frac{1}{3} r_{NH3}$

b. According to collision theory the rate constant K is proportional to CO2 PO1

(i) T (ii) T^0

(iii) T^2 (iv) $T^{0.5}$

c. The unit of rate constant for second order reaction is __________ CO1 PO1

(i) $\text{Mole.(lit)}^{-1}.\text{sec}^{-1}$ (ii) $\text{Mole.lit. sec}^{-1}$

(iii) $(\text{Mole})^{-1}.(\text{lit}).\text{sec}^{-1}$ (iv) $(\text{Mol})^{-1.}\ (\text{lit.})^{-1}\ \text{Sec}^{-1}$

d. A zero order reaction (A → R) with rate constant 0.2 mol/ lit. min, occurs in a batch reactor. Find the time required to achieve 60 % conversion with initial concentration of reactant 1 mol/lit. CO2 PO2

(i) 10 min (ii) 3 min

(iii) 1min (iv) 0.5 min

e. For gas phase reaction ____ is best option for continuous process. CO3 PO1

(i) PFR (ii) MFR

(iii) Both PFR and MFR (iv) None of the above

f. Time required for concentration of reactant to fall down to its half value from original value is CO3 PO2

(i) Reaction life (ii) Half life

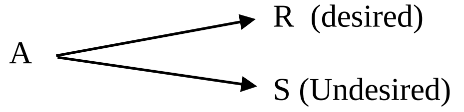
(iii) Holding time (iv) Mean time

g. For ideal PFR CO1 PO1

(i) Axial diffusivity is infinity, radial diffusivity is zero (ii) Axial diffusivity is zero, radial diffusivity is zero

(iii) Axial diffusivity is zero, radial diffusivity is infinity (iv) Axial diffusivity is infinity, radial diffusivity is infinity

h. Consider the decomposition of A by either one of two paths: CO1 PO1



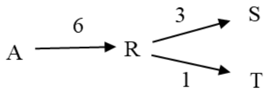
The rate constants are 15 $\frac{m^3}{hr.mol}$ and 5 $\frac{1}{hr}$, for the reactions giving products R and S, respectivly. The concentration of A is C_A. Relative rates of formation of R and S i.e. $\frac{r_R}{r_S}$ will be?

(i) $\frac{r_R}{r_S} = 0.33C_A$ (ii) $\frac{r_R}{r_S} = 3C_A^2$

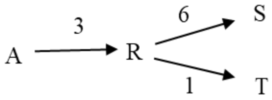
(iii) $\frac{r_R}{r_S} = 0.33C_A^2$ (iv) $\frac{r_R}{r_S} = 3C_A$

i. Chemical A reacts to form R ($k_1 = 6$ hr^{-1}) and R reacts away to form S ($k_2 = 3$ hr^{-1}) In addition R slowly decomposes to form T ($k_3 = 1$ hr^{-1}). The appropriate stoichiometric reaction can be represented as:

(i)



(ii)



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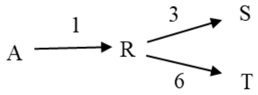
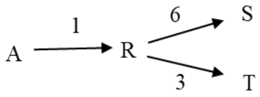


(iv)



j. In order to achieve the same conversion under identical reaction conditions and feed flow rate for a reaction of positive order, the volume of an ideal continuous stirred tank reactor (CSTR) is CO2 PO1

(i) always greater than that of an ideal plug flow reactor (PFR) (ii) always smaller than that of an ideal PFR

(iii) same as that of an ideal PFR (iv) smaller than that of an ideal PFR only for the first-order reaction

PART – B: (Short Answer Questions) (2 x 10 = 20 Marks)

	Q2. Answer ALL questions	CO #	PO #
a.	What do you mean by performance equation of a reactor? Write its factors on which it depends.	CO1	PO1
b.	A 1100-K n-nonane thermally cracks (breaks down into smaller molecules) 20 times as rapidly as at 1000 K. Find the activation energy for this decomposition.	CO2	PO1
c.	On doubling the concentration of reactant, the rate of reaction doubles. Find the reaction order.	CO2	PO1
d.	If $-r_A = -(dC_A/dt) = 0.2$ mol/liter.sec when $C_A = 1$ mol/liter, what is the rate of reaction when $C_A = 8$ mol/liter, assuming the order 1.6?	CO2	PO1
e.	Reaction with high activation energies are very temperature sensitive. Show in the diagram.	CO1	PO1
f.	Calculate ε_A for a reaction A+ Inerts= 2R + Inerts having 20% inerts in the reactant initially.	CO1	PO1
g.	The rate equation for autocatalytic reaction $A + R \xrightarrow{k} R + R$ is $-r_A = \frac{-dC_A}{dt} = kC_AC_R$. plot a graph of ($-r_A$) versus C_A.	CO1	PO1
h.	Use ideal gas to calculate C_{A0} if the gas mixture contains 50 mole% A and 50% mole% inert in a closed vessel at a pressure of 10 atm and temperature of 150 0C.	CO2	PO2
i.	Which is the most favorable contacting pattern to get maximum R in $A \rightarrow R \rightarrow S$ among PFR and MFR? Justify the answer.	CO2	PO1
j.	What is the importance of product distribution in multiple reactions with respect to single reaction for designing?	CO2	PO1

PART – C: (Long Answer Questions) **(10 x 4 = 40 Marks)**

Answer ALL questions — Marks | CO # | PO #

3.a. Discuss about the classification of reactions with example? — 5 | CO1 | PO1

b. For the following stoichiometry, find the reaction orders with respect to A and B. $A + B = Products$ — 5 | CO2 | PO2

Given

CA	4	1	1
CB	1	1	8
-rA	2	1	4

(OR)

c. In the mid nineteenth century the entomologist Henery Fibre noted that Franch ants busily bustled about their business in hot days but were rather sluggish on cool days. Checking his results with Oregon ants, I found — 5 | CO2 | PO2

Running speed, m/hr	150	160	230	295	370
Temperature, 0C	13	16	22	24	28

What activation energy and Arrhenius constant presents this change in bustliness?

d. A human being (75 kg) consumes about 6000 kJ of food per day. Assume that the food is all glucose and that the overall reaction is — 5 | CO2 | PO2

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O \quad -\Delta H_r = 2816\ kJ$$

Find man' metabolic rate (the rate of living, loving and laughing) in terms of mole of oxygen used per m^3 of person per second.

4.a. Liquid A decomposes by first-order kinetics, and in a batch reactor 50% of A is converted in a 5-minute run. How much longer would it take to reach 75% conversion? — 5 | CO2 | PO2

b. Derive the performance equation for a variable volume batch reactor following 1st order rate kinetics. — 5 | CO2 | PO2

(OR)

c. Calculate the first order rate constant for the disappearance of A as per the gas phase reaction $A \rightarrow 1.6\,R$, if the volume of the reaction mixture, starting with pure A increases 50% in 4 minutes. The total pressure of the system remains constant at 1.2 atm and the temperature is 25^{0}C. — 5 | CO2 | PO2

d. Derive the performance equation of second order of the — 5 | CO2 | PO2

A + B → Product, having initial concentration C_{A0} and C_{B0} of A and B respectively constant volume batch reactor.

5.a. A homogeneous gas phase reaction with stoichiometry and the kinetics $A \rightarrow S$, $-r_A = kC_A^2$ takes place with 50% conversion in a mixed flow reactor. Find the conversion if this reactor is replaced by another MFR having volume 6 times the first MFR all remain unchanged. Find the conversion if this reactor is replaced by a PFR of the same size- all else remain unchanged. — 10 | CO3 | PO2

(OR) — CO3 | PO2

c. Derive an expression relating the volume of PFR and conversion from material balance and draw $1/(-r_A)$ vs. X_A plot. — 5 | CO2 | PO2

d.	In the isothermal batch reactor having first order kinetics the conversion of liquid reactant A is 70% in 13 minutes. Find the space time to effect this conversion in PFR and in a MFR.	5	CO3	PO2
6.a.	The desired liquid phase reaction $A + B \rightarrow R + T \quad \frac{dC_R}{dt} = \frac{dC_T}{dt} = k_1 C_A^{1.5} C_B^{0.3}$ is accompanied by the unwanted side reaction $A + B \rightarrow S + U \quad \frac{dC_S}{dt} = \frac{dC_U}{dt} = k_2 C_A^{0.5} C_B^{1.8}$ From the stand point of favourable product distribution, order the contacting pattern of continuous flow operation, from the most desirable to least desirable.	5	CO3	PO2
b.	Discus about the quantitative treatment of product distribution for unimolecular type first order reaction A → R → S in a batch reactor.	5		
	(OR)		CO3	PO2
c.	Derive the expression of C_A, C_R and C_S for quantitative product distribution of a unimolecular type first order reaction $A \rightarrow R \rightarrow S$ in a mixed flow reactor. Evaluate its $C_{R,max}$ and its corresponding space time. Draw the concentration-time graph.	(6+2+1+1)	CO1	PO1

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