A **Reg. No. :** | | | | | | | | | | |

Question Paper Code: 56902

B.E./B.Tech. DEGREE EXAMINATION, APRIL 2019

Sixth Semester

Chemical Engineering

15UCH602 – CHEMICAL REACTION ENGINEERING-I

(Regulation 2015)

Duration: Three hours | Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. Rate of a chemical reaction is independent of concentration of the reactants for a _______________ reaction — CO1- R

(a) Zero order (b) Third order (c) Consecutive (d) None of these

2. Kinetics of a solid catalyst reaction can be studied in a______ reactor — CO1- U

(a) Batch (b) Plug-flow (c) Mixed (d) None of these

3. In a CSTR____________ varies with time. — CO2- U

(a) Reaction rate (b) Concentration (c) Both (a) & (b) (d) Neither (a) nor (b)

4. Backmixing is most predominant in — CO2- R

(a) A well stirred batch reactor (b) A plug-flow reactor

(c) A single CSTR (d) CSTR's connected in serious

5. A multiple reaction may be classified as a ______ reaction — CO3- U

(a) Consecutive or side (b) Parallel or side (c) Mixed (d) all (a),(b) and (c)

6. The point selectivity of the product "Y" in the reaction $X \xrightarrow{K_1} Y$, $X \xrightarrow{K_2} Z$ is equal to — CO3- U

(a) K_1/K_2 (b) K_2/K_1 (c) K_1-K_2 (d) K_2-K_1

7. In a/an _______ reactor, there is exchange of heat with the surroundings with sizeable temperature variation. CO4- R

(a) Adiabatic (b) Isothermal (c) Non-adiabatic (d) None of these

8. A batch adiabatic reactor at an initial temperature of 373°K is being used for the reaction, $A \rightarrow B$. Assume the heat of reaction is -1kJ/mole at 373°K and heat capacity of both A and B to be constant and equal to 50J/mole.K. The temperature rise after a conversion of 0.5 will be CO4- U

(a) 5°C (b) 10°C (c) 20°C (d) 100°C

9. The residence time distribution of an ideal CSTR is CO5- R

(a) $1/\tau \exp(-t/\tau)$ (b) $\tau \exp(-t/\tau)$ (c) $\exp(-t/\tau)$ (d) $1/\tau (-t/\tau)$

10. The "E" curve for a non-ideal reactor defines the fraction of fluid having age between t and t+dt CO5- U

(a) At the inlet (b) At the outlet
(c) In the reactor (d) Averaged over the inlet and outlet

PART – B (5 x 2= 10 Marks)

11. Difference between elementary and non-elementary reactions. CO1- R

12. What situations recycle reactors are used? CO2- R

13. Define yield and selectivity. CO3- R

14. What is standard heat of reaction? CO4- R

15. On what aspects a non ideal flow will occur in the reactor – Explain? CO5- R

PART – C (5 x 16= 80 Marks)

16. (a) Determine an expression for rate of reaction interms of concentration and conversion for first order reaction using integral method of analysis. CO1- U (16)

OR

(b) (i) On doubling the concentration of reactant, the rate of reaction triples. Estimate the reaction order. CO1- U (4)

(ii) In studying the kinetics of decomposition reaction, the concentrations of reactants were determined analytically at different times. The following results were obtained ; CO1- Ana (12)

Time, (min)	0	10	20	40	100	125
Conc., mol/lit	0.10	0.0714	0.0556	0.0385	0.02	0.0167

Test the data to find the rate expression of reaction.

17. (a) (i) Derive an expression for the concentration of reactant in the exit stream from a series of mixed reactors of different sizes. Assume that the reaction follows first order kinetics and the holding time in the i^{th} reactor is τ_i. CO2-App (12)

(ii) Show that this expression reduces to the appropriate equation when all reactors are of the same size. CO2-App (4)

Or

(b) (i) Derive performance equation for a recycle reactor. CO2-App (6)

(ii) At present conversion is 2/3 for our elementary second-order liquid reaction $2A \rightarrow 2R$. When operating in an isothermal plug flow reactor with a recycle ratio of unity. What will be the conversion if the recycle stream is shut off? CO2-App (10)

18. (a) Substance A in the liquid phase reacts to produce R and S follows. CO3- Ana (16)

$$A \rightarrow R, \; A \rightarrow S$$

With $r_R = k_1C^2_A$ and $r_S = k_2C_A$. The feed with C_{A0}=1.0mol/l, C_{R0}=0mol/l and C_{S0}=0.30mol/l enters two mixed flow reactors in series (τ_1=2.5 min, τ_2=10 min).The composition leaving the first reactor is C_{A1} =0.40mol/l, C_{R1}=0.20mol/l and C_{S1}=0.70mol/l. Find the composition leaving the second reactor.

Or

(b) In a reactive environment, reactant A decomposes as follows: CO3- Ana (16)

$$A \xrightarrow{k_1} R \xrightarrow{K_2} S$$

where k_1 = 0.1 min-1and k_2= 0.1 min-1 R is to be produced from 1000 l/h of feed (C_{A0}= 1 mol/l , C_{R0}=C_{S0}=0).

(i) What size of plug flow reactor will maximize the concentration of R?

(ii) What is $C_{R,max}$ in the effluent stream from each of these reactors?

19. (a) Determine the equilibrium conversion for the following elementary reaction between 0°C to 100°C $A \leftrightarrow R$ at 298K, $\Delta G° = -14130$ J/mol, $\Delta H°_R = -75300$ J/mol, $Cp_A = Cp_R =$ constant. CO4- App (16)

(i) Construct a plot of temperature v/s conversion.

(ii) What restrictions should be placed on a reactor operating isothermally if conversion of 75% or higher is desired?

Or

(b) Discuss in detail about temperature progression for optimum reactor performance. CO4- Ana (16)

20. (a) Determine the mean residence time and the variance for a vessel from the following data : CO5- Ana (16)

t, min	0	1	2	3	4	5	6	7	8	9	10	12	14
E, min^{-1}	0	0.02	0.10	0.16	0.20	0.16	0.12	0.08	0.06	0.044	0.03	0.012	0

These RTD data are obtained from a pulse input.

Or

(b) (i) What is an ideal flow? Discuss the effects of non-ideal flow with examples. CO5- U (6)

(ii) Derive the equation for residence time distribution in mixed flow reactor. CO5- U (10)