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# GUJARAT TECHNOLOGICAL UNIVERSITY

**BE - SEMESTER– V (New) EXAMINATION – WINTER 2019**

**Subject Code: 2150403** **Date: 04/12/2019**

**Subject Name: Basics of Reaction Engineering**

**Time: 10:30 AM TO 01:00 PM** **Total Marks: 70**

**Instructions:**

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Notations and symbols have their conventional meanings.**

**Q.1** **(a)** Explain different types of ideal reactors. **03**

**(b)** What do you understand by instantaneous fractional yield and overall fraction yield of a product? **04**

**(c)** Explain the Arrhenius theory of temperature dependency. Explain with the help of a graph that how activation energy affects temperature sensitivity of reaction. **07**

**Q.2** **(a)** Define the following terms: **03**

i) Rate constant ii) Molecularity iii) Order of reaction

**(b)** Show that for a second order irreversible reaction $2A \rightarrow$ products, $\frac{1}{C_{Ao}} \frac{X_A}{1-X_A} = kt$. **04**

**(c)** Define autocatalytic reactions. Derive an expression to find its kinetics. Explain plots of rate of reaction Vs. time and concentration Vs. time **07**

**OR**

**(c)** The rate constant of a reaction is measured at different temperatures is reported below. Calculate the activation energy for this reaction. **07**

| Temperature, K | 278 | 298 | 308 | 318 |
|---|---|---|---|---|
| Rate constant, k, $sec^{-1}$ | $2.16 \times 10^5$ | $42.2 \times 10^5$ | $516 \times 10^5$ | $4520 \times 10^5$ |

**Q.3** **(a)** Explain the classification of reaction in details with examples. **03**

**(b)** Find the first order rate constant for the disappearance of A in the gas phase reaction $2A \rightarrow R$, if on holding the pressure constant, the volume of the reaction mixture starting with 80 % of A decreases by 20% in 3 minutes. **04**

**(c)** Explain the kinetic models for non-elementary reactions with examples. **07**

**OR**

**Q.3** **(a)** Explain the significance of space time and space velocity. **03**

**(b)** Consider a feed $C_{Ao} = 200$, $C_{Bo} = 200$, $C_{io} = 100$ (inert) to a steady flow reactor. The isothermal gas phase reaction is $A + 3B \rightarrow 6R$. If $C_A = 40$ at the reactor exit, what is $C_B$, $X_A$ and $X_B$ there? **04**

**(c)** Explain the kinetics of reactions of shifting order. **07**

**Q.4** **(a)** How mixing of different composition of fluid is the key to the formation of intermediate for irreversible reactions in series? **03**



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| | | | |
|---|---|---|---|
| | **(b)** | Find the conversion after 1 hour in a batch reactor for $A \rightarrow R$ $-r_A = 3C_A^{0.5}$ mol$^{0.5}$/lit$^{0.5}$.hr, $C_{Ao}$ = 1 mol/lit. | **04** |
| | **(c)** | Derive the $C_{Rmax}$ and $t_{Rmax}$ for the first order reactions given below: $A \rightarrow R \rightarrow S$ | **07** |
| | | **OR** | |
| **Q.4** | **(a)** | Explain the size comparison of single ideal CSTR with PFR. | **03** |
| | **(b)** | Derive the design equation of recycle reactor. | **04** |
| | **(c)** | Write a short note on differential method and integral method of analysis of data. | **07** |
| **Q.5** | **(a)** | Derive the performance equation of ideal batch reactor. | **03** |
| | **(b)** | Write a short note on optimum temperature progression. | **04** |
| | **(c)** | A first order irreversible reaction A → B is carried out in a plug flow reactor followed by an equal size CSTR in series. The concentration of A in the feed is 1 kmol/m$^3$ and the residence time in each reactor is 3600 sec. The specific reaction rate constant for the reaction is 1/3600 sec$^{-1}$. Find the conversion of A at the exit of the system. | **07** |
| | | **OR** | |
| **Q.5** | **(a)** | Derive the performance equation of ideal plug flow reactor (PFR). | **03** |
| | **(b)** | Discuss the different ways in which rate of reaction can be defined. | **04** |
| | **(c)** | Discuss in detail the qualitative product distribution for series reactions. | **07** |

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