BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BE **SEMESTER :V**
BRANCH: BIOENGINEERING **SESSION : MO/19**

SUBJECT: BT5027 REACTION ENGINEERING

TIME: 3 HOURS **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Define '**order**' and '**molecularity**' of a reaction. [2]
Q.1(b) Determine the correlation between the **reaction time** and **activation energy**. [4]
Q.1(c) The maximum allowable temperature for a reactor is 800 K. At present our operating set point is 780 K, the 20K margin of safety to account for fluctuating feed, sluggish controls, etc. Now, with a more sophisticated control system we would be able to raise our set point to 792 K with the same margin of safety that we now have. By how much can the reaction rate, hence, production rate, be raised by this change if the reaction taking place in the reactor has activation energy of 175 kJ/mol? [6]

Q.2(a) Derive the performance equation of a constant volume batch reactor. [2]
Q.2(b) Derive the second order rate equation by integral method consider $A+B \rightarrow R$ [4]
Q.2(c) A 10 minute experimental run shows that 75% of liquid reactant is converted to product by a half-order rate. What would be the fraction converted in a half an hour run? [6]

Q.3(a) For the reaction $A \rightarrow 3R$; with 40% inert present. Calculate ε_A. [2]
Q.3(b) Derive the rate equation for **1st order varying volume** reactor. [4]
Q.3(c) A liquid reactant stream (1 mol/liter) passes through **two MFR in a series**. The concentration of A in the exit of the first reactor is 0.5 mol/liter. Find the concentration in the exit stream of the second reactor. The reaction is second-order with respect to A and $V_2/V_1 = 2$. [6]

Q.4(a) Write one advantage and one disadvantage of batch reactor. [2]
Q.4(b) The off gas from a boiling water nuclear power reactor contains a whole variety of radioactive trash, one of the most troublesome being Xe-133(half life = 5.2 days). This off gas flows continuously through a large hold up tank in which its mean residence time is 30 days, and where we can assume that the contents are well mixed. Find the fraction of activity removed in the tank. [4]
Q.4(c) An aqueous feed of A and B (400 L/min, A: 100 mmol/L, and B: 200 mmol/L) is to be converted to product in a mixed flow reactor. The kinetics of the reaction are represented by $A+B \rightarrow R$, $-r_A = 200 C_A C_B$ mol/L. min. Find the volume of reactor needed for 99.9% conversion of A to product. [6]

Q.5(a) Write the units of: (a) E; (b) E_θ [2]
Q.5(b) With diagram write the relationship between E curve and F curve. [4]
Q.5(c) Calculate mean residence time and plot the E curve for the following data: [6]

t (min)	0	5	10	15	20	25	30	35
C_{pulse} (g/L)	0	3	5	5	4	2	1	0

Q.6(a) Define effectiveness factor with equation. [2]
Q.6(b) A gas containing A (2 mol/m^3) is fed (1 m^3/hr) to a plug flow reactor with recycle loop (0.02 m^3 loop volume, 3 kg of catalyst), and the output composition from the reactor system is measured (0.5 mol/m^3). Find the rate equation for the decomposition of A for **very large recycle**, n = 0.5 [4]
Q.6(c) In the absence of pore diffusion resistance a particular first-order gas phase reaction proceeds as $-r_A = 10^{-6}$ mol/cm^3.s. $C_{A0} = 1.8\times10^{-5}$ mol/cm^3, $C_A = 10^{-5}$ mol/cm^3. Diffusivity is 10^{-3} cm^2/s. What size of spherical catalyst pellets would ensure that pore resistance effects do not intrude to slow the rate of reaction? [6]

Q.7(a) Write the Michaelis-Menten equation for enzyme kinetics. [2]

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Q.7(b) In an exponentially growing batch culture of *Saccharomyces cerevisiae*, the cell density is 20 g/l (DCW), the specific growth rate (μ) is 0.4 h^{-1} and substrate uptake rate is 16 g/L.h. Calculate the cell yield coefficient $Y_{x/s}$. [4]

Q.7(c) Enzyme E catalyzes the transformation of reactant A to product R as follows: **A→R,** [6]

$$-r_A = \frac{200 C_A C_{E0}}{2 + C_A} \quad \text{mol/L. min}$$

If we introduce enzyme (C_{E0} = 0.001 mol/L) and reactant (C_{A0} = 10 mol/L) into a batch reactor and let the reaction proceed, find the time needed for the concentration of reactant to drop to 0.025 mol/L.

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