BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION MO/2022)

CLASS: BTECH **SEMESTER : V**
BRANCH: CHEMICAL/P&P **SESSION : MO22**
SUBJECT: CL302 CHEMICAL REACTION ENGINEERING-I
TIME: 03 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Tables/Data handbook/Graph paper etc., if applicable, will be supplied to the candidates

---

Q.1(a) For the given reaction [2] CO1

$$H_2 + Br_2 \rightarrow 2HBr$$

the rate is given by

$$r_{HBr} = \frac{k_1[H_2][Br_2]^{1/2}}{k_2 + [HBr]/[Br_2]}$$

Predict the molecularity of the reaction?

Q.1(b) What is activation energy? Plot energy vs reaction coordinate for exothermic and endothermic reaction. [4] CO1

Q.1(c) Decomposition of phosphine follows the following stoichiometry: [4] CO1
$4PH_3 \rightarrow P_4 + 6H_2$. If at an instant rate of the decomposition is 2×10^{-4} kmol/m^3.s, calculate the rate of formation of phosphorus and hydrogen.

Q.2(a) Why is recycle reactor best for autocatalytic reaction? [2] CO3

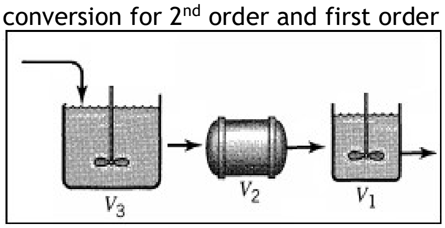
Q.2(b) A first order liquid phase reaction is planned to carry out in two equal volume CSTRs. The reactors are connected in series and in parallel in two different cases. Compare the final conversion for two arrangements. Data: F_{A0} =10 kmol/s, k = 1 s^{-1}, C_{A0} = 1 kmol/m^3, V_{CSTR} = 1m^3. [3] CO3

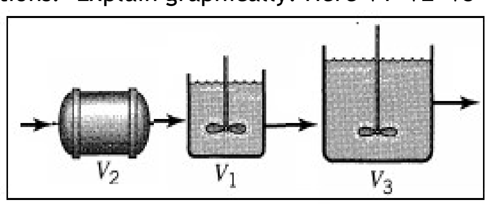
Q.2(c) A liquid phase reaction A → P is carried out in a batch reactor. The initial feed concentration is 1 kmol/m^3. Find the order of the reaction and rate constant by using differential method. The kinetic data is given in the following table: [5] CO3

Time(s)	0	30	60	90	120	150	180	600
Conc. of A, kmol/m^3	1	0.74	0.55	0.42	0.29	0.24	0.16	2.5×10^{-3}

Q.3(a) Write down the general mole balance equation for batch and plug flow reactors. [2] CO3

Q.3(b) Which combination from the following figure should be preferred to achieve highest conversion for 2nd order and first order reactions? Explain graphically. Here V1<V2<V3 [3] CO2





Q.3(c) The 2nd order gas phase reaction $CH_3CHO \rightarrow CH_4 + CO$ is being carried out in a PFR at 520°C and 1 atm. pressure. The initial feed rate of acetaldehyde is 0.1 kg/s and the rate constant is 0.43 m^3/kmol.s. What will be the volume of reactor for 35% decomposition reaction. [5] CO2

Q.4(a) In order to study temperature dependence on rate constant of a first order reaction the following data is obtained from experiment. Calculate activation energy, and frequency factor of the reaction rate constant based on Arrhenius rate expression. R = 8.314 J/mol.K [2] CO4

Temp (^{0}C)	300	310	320	330	335
k (s$^{-1)}$	0.000195	0.000886	0.00366	0.0139	0.0262

PTO

Q.4(b) Draw a suitable schematic for a non-isothermal batch reactor with wall heat transfer. Write mass and energy balance equation and derive an expression for maximum adiabatic temperature change in the reactor. [3] CO4

Q.4(c) A liquid phase first order reversible reaction A ↔ B takes place in a plug flow reactor. The feed enters the reactor at 30^0 C at a rate of F_{A0} = 0.1 kmol/min. The feed composition is C_{A0}=1.0 kmol/m^3. The reaction is exothermic and maximum allowable reaction temperature is 90^0C. The following table provides optimum temperature progression and corresponding optimum rate data at different temperatures in the reactor. Calculate volume of the reactor for 80% conversion. [5] CO4

x_{Ae}	0.81	0.77	0.68	0.6	0.55	0.52	0.4	0.29	0.23	0.19	0.18	0.12
$1/-r_A$	100	50	25	16	11.5	10	5	2.5	1.67	1.25	1.0	0.5
$T(^0C)$	35	41	48	52	55	58	64	77	85	90	92	104

Q.5(a) Schematically show different type of situations which cause the non-ideality in a reactor. What is meant by RTD in a reactor. [2] CO5

Q.5(b) Explain with diagram C-curve for pulse input in a tubular reactor. Mathematically show that the area under E-curve is unity. [3] CO5

Q.5(c) Name different models applicable for real CSTR and tubular reactor. What is the significance of dispersion number. [5] CO5

From the time versus tracer concentration data in the reactor effluent stream, calculate fractional conversion for a first order chemical reaction whose rate constant is 5×10^{-2} sec^{-1} employing segregated flow model.

Time(s)	0	10	20	30	40	50	60	70	80	90	100	110	120
C(kmol/L)	0	0.1	0.3	0.6	0.7	0.65	0.6	0.4	0.1	0.08	0.04	0.02	0.00

:::::21/11/2022 M:::::