

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

CLASS: B.TECH
BRANCH: CHEMICAL ENGG

SEMESTER: IV
SESSION: SP/2025

SUBJECT: CL223 CHEMICAL REACTION ENGINEERING-I

TIME: 3 Hours

FULL MARKS: 50

INSTRUCTIONS:

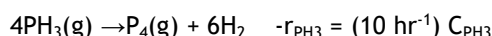
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data handbook/Graph paper etc. to be supplied to the candidates in the examination hall.

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|--|-----|-----|----|
| Q.1(a) Give an example of shifting order reaction. Write the rate equation. | [2] | CO1 | 2 |
| Q.1(b) For a chemical reaction, the ratio of the rate constant at 500 K to that at 400 K is 2.5. Given $R = 8.314 \text{ J}/(\text{mol}\cdot\text{K})$, Find the value of activation energy (in kJ/mol). | [3] | CO1 | 3 |
| Q.1(c) Write the steps involved in a chain reaction mechanism. Provide an example of a chain reaction and explain each step in the mechanism. | [5] | CO1 | 2 |
| Q.2(a) Aqueous A at a concentration $C_{A0} = 1 \text{ mol/liter}$ is introduced into a batch reactor where it reacts away to form product R according to stoichiometry $A \rightarrow R$. The concentration of A in the reactor is monitored at various times, as shown below: | [5] | CO2 | 3 |

t, min	0	100	200	300	400
$C_A, \text{ mol/m}^3$	1000	500	333	250	200

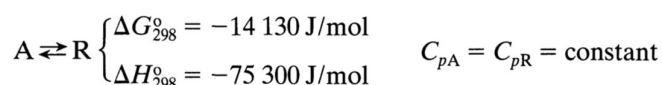
For $C_{A0} = 500 \text{ mol/m}^3$ find the conversion of reactant after 5 hours in the batch reactor. Also find the rate for the reaction.

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| Q.2(b) Consider a feed with concentrations $C_{A0} = 100$, $C_{B0} = 200$, and $C_{I0} = 100$ to a steady-flow isothermal gas-phase reactor. The reaction is $A + 3B \rightarrow 6R$. If $C_A = 40$ at the reactor exit, calculate the concentration of B, X_A , and X_B at the reactor exit. | [5] | CO2 | 3 |
| Q.3(a) Discuss the advantages of using multiple reactors for an auto catalytic reaction. | [2] | CO3 | 2 |
| Q.3(b) The elementary second-order liquid phase reaction $A + B \rightarrow C + D$ is carried out in an isothermal plug flow reactor of 2 m^3 volume. The inlet volumetric flow rate is $10 \text{ m}^3/\text{h}$. The initial concentrations of both A and B are 2 kmol/m^3 . The rate constant is given as $2.5 \text{ m}^3/(\text{kmol}\cdot\text{h})$. Find the percentage conversion of A. | [3] | CO3 | 3 |
| Q.3(c) The homogeneous gas decomposition of phosphine proceeds at 649°C with the first-order rate. | [5] | CO3 | 3 |



What size of plug flow reactor operating at 649°C and 460 kPa can produce 80% conversion of a feed consisting of 40 mol of pure phosphine per hour?

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|--|-----|-----|---|
| Q.4(a) Discuss the effect of pressure, temperature, and inert on equilibrium rate constant and thermodynamic equilibrium constant. | [2] | CO4 | 1 |
| Q.4(b) Write down the energy balance equation for an adiabatic operation performed in a steady flow reactor. Draw the relation between conversion and temperature for exothermic, endothermic, and isothermal reactions. | [3] | CO4 | 2 |
| Q.4(c) Determine the equilibrium conversion at 85°C for the elementary aqueous reaction | [5] | CO4 | 3 |



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- Q.5(a) Define microfluid and macrofluid. [2] CO5 1
- Q.5(b) Discuss the relationship between the F and E curves. [3] CO5 2
- Q.5(c) A sample of tracer hytane was injected as pulse into a vessel to be used as reactor and the effluent concentration is measured as a function of time. The data is collected is given below: [5] CO5 3

t (min)	0	1	2	3	4	5	6	7	8	9	10	12	14
C (g/m ³)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

Determine the data for E-curve. Evaluate the fraction of material leaving the reactor that has spent between 3 and 6 min in the vessel and the fraction of the material that has spent 3 min or less in the vessel.

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