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# B.M.S. College of Engineering, Bengaluru-560019

**Autonomous Institute Affiliated to VTU**

## October 2024 Supplementary Examinations

**Programme: B.E.** **Semester: VI**
**Branch: Chemical Engineering** **Duration: 3 hrs.**
**Course Code: 22CH6PCCR2** **Max Marks: 100**
**Course: Chemical Reaction Engineering-2**

**Instructions**: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

**Important Note:** Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

| | | | | CO | PO | Marks |
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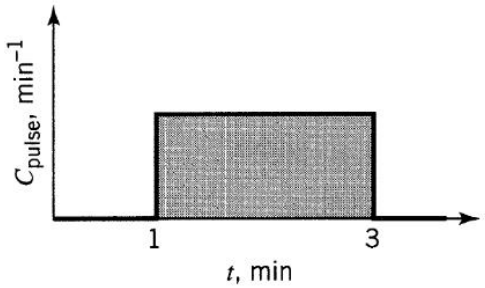
| | | | **UNIT – I** | | | |
| 1 | a) | | Explain with a neat sketch the causes of non-ideality in the flow reactors | *CO1* | *PO2* | **06** |
| | b) | | Derive the relation between F-curve and E-Curve for a residence time distribution experiment. | *CO1* | *PO2* | **06** |
| | c) | | Dispersed non-coalescing droplets react (A → R), as they pass through a contactor. Find the average concentration of A remaining in the droplets leaving the contactor if their RTD is given by the curve in below figure.<br>Data:<br>$C_{A0} = 2\frac{mol}{L}$;<br>$-r_A = kC_A^2$ ;<br>$k = 0.5\frac{L}{mol.min}$<br>  | *CO2* | *PO4* | **08** |
| | | | **UNIT – II** | | | |
| 2 | a) | | Derive the general rate expression for a fluid-fluid reaction system for an instantaneous reaction with a low $C_B$ value | *CO3* | *PO3* | **10** |
| | b) | | At high pressure carbon dioxide is absorbed into a solution of sodium hydroxide in a packed column. The instantaneous reaction is as follows.<br>$CO_2 + 2NaOH \Longleftrightarrow Na_2CO_3 + H_2O$<br>At a point in the column where, $P_A = 2\times10^5$ Pa and solution of 0.2N. Estimate the rate of absorption, the controlling resistance and what is happening in the liquid film?<br>*Data*<br>• $k_{AL} \times a$ =25 per hour and $k_{AG} \times a$ =0.8 $\frac{mol}{m^3 \times h \times Pa}$<br>• $\mathscr{D}_A = 1\times10^{-9}$ m$^2$/sec and $\mathscr{D}_B = 10\times10^{-8}$ m$^2$/sec<br>• $f_L$=0.1 and $H_A = 3000\ \frac{m^3 \times Pa}{mol}$<br>• $a = 100\ \frac{m^2}{m^3}$ | *CO3* | *PO3* | **10** |

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| | | | **OR** | | | |
| | 3 | a) | Develop an expression to estimate the rate for a fluid solid reaction, assuming gas film as the rate controlling step with a neat schematic diagram. | *CO3* | *PO3* | **10** |
| | | b) | Spherical particles of zinc blende of size R = 1 mm are roasted in an 8% oxygen stream at 900°C and 1 atm. The stoichiometry of the reaction is.<br>$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$<br>Assuming that, the reaction proceeds by the shrinking-core model calculate the time needed for complete conversion of a particle and the relative resistance of ash layer diffusion during this operation.<br>*Data*<br>• Density of solid, $\rho_B = 4.13$ gm/cm$^3$ = 0.0425 mol/cm$^3$<br>• Reaction rate constant, k" = 2 cm/sec<br>• For gases in the ZnO layer, $\mathscr{D}_e = 0.08$ cm$^2$/sec<br>Note that film resistance can safely be neglected as long as a growing ash layer is present. | *CO3* | *PO3* | **10** |
| | | | **Unit III** | | | |
| | 4 | a) | What are the characteristics of a good catalyst? | *CO4* | *PO3* | **04** |
| | | b) | Briefly explain about foreign substance which is used to decreases the rate of a chemical reaction. | *CO4* | *PO3* | **06** |
| | | c) | The mechanism of decomposition of *cumene* on the catalyst surface is given by the following reaction:<br>$C_6H_5CH(CH_3)_2 \rightarrow C_6H_6 + C_3H_6$<br>$C(g) \rightarrow B(g) + P(g)$<br>Mechanism:<br>$C + S \overset{\text{catalyst}}{\Longleftrightarrow} C.S$.....(Adsorption)<br>$C.S \overset{\text{Catalyst}}{\Longleftrightarrow} B.S + P$.....(Surface Reaction)<br>$B.S \overset{\text{Catalyst}}{\Longleftrightarrow} B + S$.....(Desorption)<br>Derive the rate expression if surface reaction controls | *CO4* | *PO3* | **10** |
| | | | **UNIT – IV** | | | |
| | 5 | a) | Discuss the various types of catalyst deactivation reactions. | *CO4* | *PO3* | **08** |
| | | b) | Oxidation of toluene is carried out over silica alumina spherical catalyst using 0.22 cm particles. It has been found that the pore volume per gram is 0.25 cm$^3$ and surface area per gram is 251 m$^2$. The experiment was conducted at 300°C. The reaction rate was found to be 1.3 cm$^3$/g.sec. Estimate the effectiveness factor for the reaction. | *CO4* | *PO3* | **12** |
| | | | **OR** | | | |
| | 6 | a) | Briefly explain the significance of Thiele Modulus for heterogeneous porous catalytic reactions | *CO4* | *PO3* | **08** |

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| | | b) | Derive a relationship to estimate the effectiveness factor for a first order catalytic reaction in a single cylindrical pore with a neat sketch depicting the concentration profile of reactant A. The reaction followed and rate is given as<br>A→ product and $-r_A^{''} = -\frac{1}{S}\frac{dN_A}{dt} = -k^{''}C_A$<br>State all the assumptions made to derive the expression. | *CO4* | *PO3* | **12** |
| | | | **Unit V** | | | |
| | 7 | a) | How experimental rate of a catalytic reaction is determined for an integral reactor? | *CO4* | *PO3* | **05** |
| | | b) | With a neat sketch explain *Carberry* basket type experimental mixed flow reactor and give its performance equation. | *CO4* | *PO3* | **05** |
| | | c) | Derive the overall rate expression for a slurry reactor. | *CO4* | *PO3* | **10** |

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