MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

V^{th} SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS DEC-2021 (Descriptive Part-B)

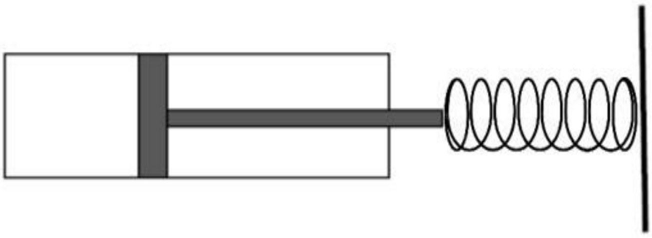
SUBJECT: CHEMICAL REACTION ENGINEERING [CHE 3151]

REVISED CREDIT SYSTEM

Time: 75+10 Min **Date: 28-12-2021** **Marks: 20 M**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Use graphs wherever relevant.
- Refer to the Formula Book provided.

1A.	Consider a cylindrical batch reactor that has one end fitted with a frictionless piston attached to a spring. The gas phase reaction $A + B \rightarrow 8C$  with the rate expression $-r_A = k\,C_A^2 C_B$ is taking place in this reactor, given $k = 1\left(\frac{ft^3}{lb\ mol}\right)^2 . s^{-1}$. Equal moles of A & B are present at $t = 0$ Initial volume is $0.15\ m^3$ The relationship between the volume of reactor and pressure within reactor is $V\ ft^3 = 0.1\ P\ atm$. Temperature of system is kept constant at $600^0 R$ Gas constant $= 0.73\ ft^3\ atm/lb\ mol^0 R$ What is the conversion of A when volume is $0.2\ ft^3$?	**4 M**
1B.	Water containing a radioactive species flows continuously through a well-mixed hold up tank. This gives time for radioactive material to decay into harmless waste. As it now operates, the activity of the exit stream is 1/7 of the feed stream. The plant would like to lower it still more. It was suggested that a baffle be inserted down the middle of the tank so that the holdup tank acts as two well-mixed tanks in series. Calculate the expected activity of the exit stream compared to the feed stream.	**3 M**

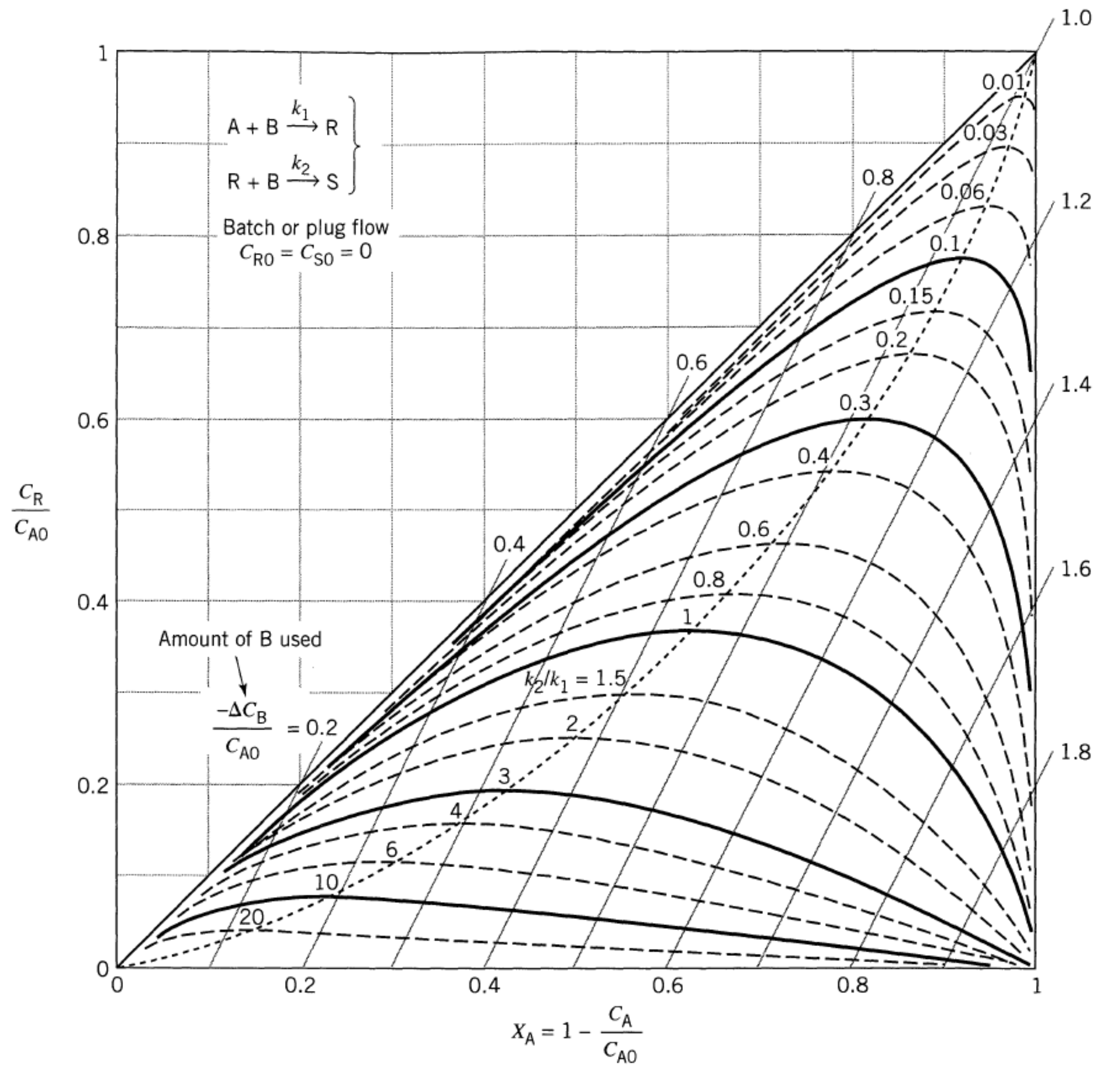
1C.

Consider the following elementary reaction

$A + B \rightarrow R$, rate constant k_1

$R + B \rightarrow S$, rate constant k_2

1 mole of A & 1.2 mole of B are rapidly mixed. On completion of the reaction 0.58 mole of R is found to be present in the mixture. Find k_2/k_1, concentration of reactants and product S at the end of the reaction.



Distribution of materials in a batch or plug flow reactor for the elementary series-parallel reactions

3 M

2A.

A photochemical decay of aqueous bromine is studied in bright sunlight. A small quantity of liquid bromine was dissolved in water contained in a glass battery jar and placed in direct sunlight. The following data were obtained at 25°C:

Time (min)	0	10	20	30	40	50	60
C_{Br_2} (PPM)	3.40	2.34	1.59	1.08	0.74	0.50	0.34

Determine whether the photochemical reaction is zeroth order, first order, or second order using the integral method and calculate the reaction-rate constant.

3 M

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<td>2B.</td>
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For the following enzymatic reactions derive rate law for Enzyme-Substrate-Complex-1 ($r_{E.S}$), Enzyme-Substrate-Complex-2 ($r_{E.Q}$) and product (r_P) expressed only in concentrations of enzyme (C_E), substrate (C_S), product species (C_Q):

1. $\boldsymbol{E + S \leftrightarrow E.S}$
Enzyme + Substrate 1 ↔ Enzyme-Substrate-Complex 1

2. $\boldsymbol{E.S \rightarrow Q}$
Enzyme-Substrate-Complex 1 → Product Species Q

3. $\boldsymbol{E + Q \leftrightarrow E.Q}$
Enzyme + Product Species Q ↔ Enzyme-Substrate-Complex 2

4. $\boldsymbol{E.Q \rightarrow P + E}$
Enzyme-Substrate-Complex 2 → Product P + Enzyme
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<td>2C.</td>
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A radioactive tracer was injected as a pulse to a reactor and the effluent concentration was measured as a function of time.
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<tr><td>t (min)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>8</td><td>10</td><td>12</td><td>15</td><td>18</td><td>21</td></tr>
<tr><td>$\boldsymbol{C\ (\frac{g}{m^3})}$</td><td>0</td><td>2</td><td>6</td><td>9</td><td>16</td><td>14</td><td>12</td><td>10</td><td>8</td><td>6</td><td>3</td><td>1</td><td>0</td></tr>
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From the C-curve and RTD plots:
a) Determine the fraction of material leaving between:
i. t_1=1 min and t_2=5 min.
ii. t_1=6 min and t_2=21 min.
b) Determine the mean residence time.
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