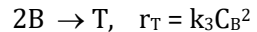
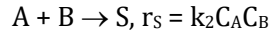
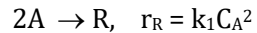


- (b) A and B react with each other as follows:



What ratio of A and B should be maintained in a mixed flow reactor so as to maximize the fractional yield of desired product S?

6 + 6 = 12

7. (a) Kinetic experiments on the solid catalyzed reaction $A \rightarrow 3R$ are conducted at 8 atm and 700°C in a basket type mixed reactor 960 cm³ in volume and containing 1 gm of catalyst of diameter, $d = 3$ mm. Feed consisting of pure A is introduced at various rates into the reactor and the partial pressure of A in the exit stream is measured for each feed rate. The results are as follows:

Feed rate, liter/hr	100	22	4	1	0.6
P_{Aout}/P_{ain}	0.8	0.5	0.2	0.1	0.05

Find a rate equation to represent the rate of reaction on catalyst of this size.

- (b) Explain the various factors which may intrude on the overall rate in case of heterogeneous catalytic reaction on porous solid catalyst pellets.

8 + 4 = 12

Group - E

8. Deduce a suitable RTD zero parameter model of a PFR

12

9. A sample of the tracer hytane at 320K was injected as a pulse to a reactor, and the effluent concentration was measured as a function of time, as per the data shown in the following table.

t (min)	0	1	2	3	4	5	6	7	8	9	10	12	14	17	20	23
C (g/m³)	0	1	5	8	10	12	11	9	8	6.5	5	3.0	2.2	1.5	0.6	0

Construct figures showing $C(t)$ and $E(t)$ as functions of time.

Determine the fraction of material leaving the reactor that has resided between 7 and 17 minutes.

4 + 5 + 3 = 12

CHEMICAL REACTION ENGINEERING (CHEN 3102)

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

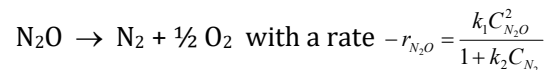
Group - A (Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) For the reaction $NO + \frac{1}{2} O_2 = NO_2$ carried out in presence of Pt-Rh catalyst, the reaction
- is considered as homogeneous
 - is considered as heterogeneous
 - may be either homogeneous or heterogeneous
 - none of the above.
- (ii) From the Arrhenius law the frequency factor
- does affect the temperature sensitivity of a reaction
 - does not affect the temperature sensitivity of a reaction
 - is dimensionless
 - is a measure of activation energy.
- (iii) A given reaction is much more temperature sensitive at
- low temperature
 - high temperature
 - all temperature levels
 - none of the above.
- (iv) If the metabolic activity of a human being is represented by a first order reaction, the magnitude of rate constant will be in terms of
- (nano-sec)⁻¹
 - m³/kmol-sec
 - (day)⁻¹
 - m⁶/kmol²-sec.
- (v) 1 liter / sec of gaseous reactant A is introduced into a mixed flow reactor having volume 4 liters. The stoichiometry is $A \rightarrow 3R$. The conversion is 50%, and under these conditions the residence time is
- 1 sec
 - 2 sec
 - $\frac{1}{2}$ sec
 - none of the above.

- (vi) For reaction under pore diffusion regime, the reaction rate
- varies directly with catalyst particle size
 - varies inversely with catalyst particle size
 - is independent of catalyst particle size
 - none of the above.
- (vii) A trickle Bed reactor is a _____ type reactor.
- PFR
 - CSTR
 - three phase packed bed
 - membrane module
- (viii) In RTD Analysis the variance is considered as
- first moment
 - second moment
 - extent of maximum mixedness
 - bye-passing.
- (ix) In reactor modelling with RTD system, the number of parameters cannot be
- zero
 - one
 - two
 - three.
- (x) The Karlovitz number is reciprocal of the
- Reynold's number
 - Mach number
 - Sherwood number
 - Damköhler number.

Group - B

2. (a) The primary reaction occurring in the homogeneous decomposition of nitrous oxide is found to be



Devise a suitable mechanism to support this rate equation.

- (b) Milk is pasteurized if it is heated to 63°C for 30 min, but if it is heated to 74°C it only needs 15 s for the same result. Find the activation energy of this sterilization process.

6 + 6 = 12

3. A small reaction bomb fitted with a very sensitive pressure-measuring device is flushed out and then filled with pure reactant A at one atmosphere pressure. The operation is carried out at 298K, at which the reaction does not proceed to any appreciable extent. The temperature is then rapidly increased to 373 K by plunging the bomb into boiling water and the following total pressure data are obtained.

t, min	1	2	3	4	5	6	7	8	9	10	15	20
Total pressure, P, atm	1.14	1.04	0.982	0.94	0.905	0.87	0.85	0.832	0.815	0.8	0.754	0.728

The stoichiometry of the reaction is $2A \rightarrow R$. After leaving the bomb in the bath for a period of one week the contents are analyzed for A and no A is detected. Find a rate expression which fits the data satisfactorily. Assume the gas behaves ideally.

12**Group - C**

4. The homogeneous reaction $A \rightarrow R$ is being carried out in a flow reactor system has the following rate law,

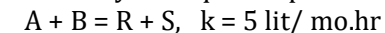
$$-r_A = \frac{kC_A}{(1 + K_A C_A)^2}$$

where, $k = 1 \text{ min}^{-1}$ and $K_A = 1 \text{ dm}^3/\text{min}$

The entering concentration of A is 2 mol/dm^3 . What type of reactor or combination of reactors would have the smallest volume to achieve 80% conversion? What will be the volume of each reactor if the initial flow rate of A is 200 mol/min .

12

5. One hundred moles of A per hour are available in a concentration of 0.1 mole/lit by a previous process. This stream is to be reacted with B to produce R and S. The reaction proceeds by the aqueous phase elementary reaction,

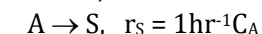
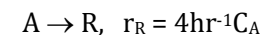


The amount of R required is 95 mol/hr . In extracting R from the reaction mixture A and B are destroyed, hence recycle of unused reactants is out of the question. Calculate the optimum reactor size and type as well as feed composition for this process.

Data: B costs \$ 1.25/mol in crystalline form. It is highly soluble in the aqueous solution and even present in large amounts does not change the concentration of A in solution. Capital and operating costs are \$ 0.015/hr.lit. for PFR and \$ 0.004/hr.lit for MFR.

12**Group - D**

6. (a) A 20 liter MFR is to treat a reactant which decomposes as follows



Find the feed rate and conversion of reactant so as to maximize profits. What are these on an hourly basis?

Data: Feed material A costs \$1/mol at $C_{A0} = 1 \text{ mol/lit}$, product R sells for \$5/mol and s has no value. The total operating cost of reactant and product separation equipment is \$25/hr + \$1.25/mol A feed to the reactor. Unconverted A is not recycled.