Type: DES

Q1. Appraise the significance of Chemical Reaction Engineering in the economics of a chemical plant? (3)

Q2. Derive a mechanism for this elementary reaction A+B-> R with a rate expression $-r_A= k\ C_A\ C_B$ (2)

Q3. At room temperature sucrose is hydrolyzed by the catalytic action of the enzyme sucrase as follows Sucrose -> products.

Starting with a sucrose concentration C_{A0}= 1 mmol/l and an enzyme concentration C_{E0} = 0.01 mmol/l, the following kinetic data are obtained in a batch reactor

C_A mmol/l	0.84	0.68	0.53	0.38	0.27	0.16	0.09	0.04	0.018	0.006	0.0025
t hr	1	2	3	4	5	6	7	8	9	10	11

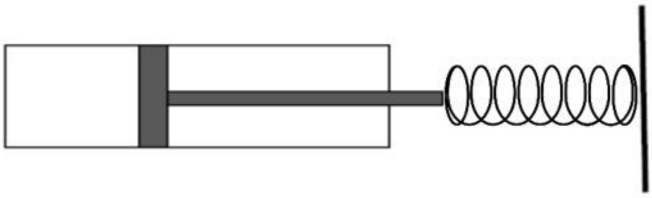
i) Deduce mechanism of this non chain enzymatic reaction.

ii) Determine whether this data can be reasonably fitted by a kinetic equation of the Michaelis-Menten type $-r_A = k_3\ C_A\ C_{E0} / (C_A + C_M)$ where C_M = Michaelis constant. If the fit is reasonable, evaluate the constants k_3 and C_M. Use any method. (5)

Q4. The data shown is typical of gas-solid catalytic exothermic reaction carried out adiabatically.

X_A	0	0.2	0.4	0.5	0.6	0.8
$F_{A0}/-r_A$ Kg cat.	60	30	20	18	20	30

Given F_{A0}= 2 mol/s. Deduce the packed bed reactor weight necessary to achieve 80% conversion? (4)



Q5.

Consider a cylindrical batch reactor that has one end fitted with a frictionless piston attached to a spring. The gas phase reaction A+B-> 8C with the rate expression $-r_A= k\, C_A^2 C_B$ is taking place in this reactor, given k=1 $(ft^3/lb\ mol)^2 s^{-1}$. Equal moles of A & B are present at t=0. Initial volume is 0.15 ft^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 600^0R

Gas constant= 0.73 ft^3 atm/ lb mol ^{0}R

Calculate the conversion of A when volume is 0.2 ft^3. (3)

Q6. Describe an ideal reactor. Explain hydrodynamic steady state. Interpret plug flow. (3)

Q7. For a reaction n>=1, in a recycle reactor, for minimum volume of reactor, for a given conversion which of the following is preferred? Justify.

a) High recycle b) Low recycle c) All d) Insufficient data (3)

Q8. Suggest a reactor/s set up **without recycle** to perform an autocatalytic reaction. Justify your choice. (3)

Q9. Gas 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.

i) Would this help? Justify and present the necessary calculations. (3 Marks).

ii) Suggest a scheme better than the baffle in the middle of the tank (1 Mark). (4)

Q10. Chemical A reacts to give R (k_1 = 5 hr^{-1}) and R reacts to form S (k_2 = 2hr^{-1}). In addition, R decomposes to give T (k_3 = 1hr^{-1}), all reactions being elementary. If a solution containing 2 mol/liter of A is introduced into a CSTR, a space time of 46.4 minutes is required to obtain maximum of the desired product R. Deduce the maximum concentration of R? (3)

Q11. The liquid phase reaction of aniline with ethanol produces wanted monoethylaniline (MEA) and unwanted diethylaniline(DEA)

$C_6H_5NH_2 + C_2H_5OH \xrightarrow{k_1} C_6H_5NHC_2H_5$ (MEA) + H_2O
$C_6H_5NHC_2H_5$ (MEA) + $C_2H_5OH \xrightarrow{k_2} C_6H_5NH(C_2H_5)_2$ (DEA)+ H_2O; $k_1 = 1.25\ k_2$.
For an equimolar feed to a plug flow reactor, predict the concentrations of aniline, ethanol and DEA when the concentration of MEA is at its highest? (4)

Q12. The desired liquid phase reaction

A+B -> P+ R; $r_R = r_P = k_1\ C_A\ C_B^{0.5}$

is accompanied by the undesired side reaction

A+B -> S+T; $r_S = r_T = k_2\ C_A^{0.5}\ C_B$

Arrange the contacting schemes for product distribution from the most favourable to the least favourable

1) PFR 2) PFR with side streams of B 3) PFR with side streams of A 4) CSTR. Justify. (3)

Q13. Derive an expression for conversion for a first order reaction, in a real CSTR modelled using bypass (**ONLY**). (Evaluation of model parameter **NOT** required). (3)

Q14. Explain the following in the context of non-ideal reactors

i) Residence time distribution function

ii) Mean residence time.

iii) RTD for CSTR with bypass

iv) RTD for a PFR with dead volume. (2)

Q15. A sample of the tracer hytane at 320 K was injected as a pulse to a reactor, and the effluent concentration was measured as a function of time resulting in the below data:

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
E(t) min^{-1}	0	0.02	0.1	0.16	0.2	0.16	0.12	0.08	0.06	0.044	0.03	0.012	0

a) Calculate the mean conversion in the reactor for a first order, liquid phase, irreversible reaction in a completely segregated fluid. A -> R. The specific reaction rate is 0.1 min^{-1} at 320 K.(2 Marks)

b) Derive the equation for mean conversion when the RTD is equivalent to an ideal PFR.(3 Marks) (5)