Total No. of Questions :10]

SEAT No. :

P3412

[Total No. of Pages :3

[5670]-688

B.E. (Chemical Engineering)
PROCESS MODELING & SIMULATION (Paper-II)
(2015 Pattern) (Semester-II) (409349) (End Sem.)

Time : 2½Hours] ***[Max. Marks : 70***

Instructions to the candidates:

1) *Answer Q.1 or Q.2, Q.3 or Q.4, Q.5 or Q.6, Q.7 or Q.8, Q9 or Q10*
2) *Assume suitable data, if necessary.*
3) *Neat diagrams must be drawn wherever necessary.*
4) *Use of electronic pocket calculator is allowed.*

Q1) State the relevance of the equation of state relations in process modelling and simulation for the determination of the thermodynamic equilibrium. Give the relations for any three equations of state. Determine the thermodynamic equilibrium constant relation for the following reversible gas-Phase reaction: **[10]**

$$2A \Leftrightarrow 3B$$

Where k_1 and K_2 are the forward and backward rate constants respectively. start with the equilibrium criteria of equal chemical potentials of the components involved and assume ideal gas behaviour.

OR

Q2) Develop the complete batch-reactor model for a exothermic elementary reaction: **[10]**

$$3A \rightarrow 5B$$

Derive the overall material balance. component balances and energy balance equations starting from the basic laws of conservations. The reactor is jacketed and the temperature is controlled by a coolant flow F_{s0} through the jacket. if the reactor temperature is controlled by a proportional controller with gain Kc, explain the modification to be done in the final energy balance equation to accommodate the control law.

Q3) Derive the model equation for the laminar flow of a fluid through a packed bed column. **[10]**

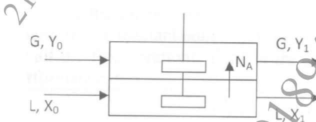
OR

Q4) Derive the model equations of a forward-feed triple-effect evaporator system. Draw a neat sketch of the system indicating all the variables and enlist all the assumptions. **[10]**

Q5) Develop the complete dynamic model of a plug-flow type liquid-liquid extraction column operating in continuous mode. In the extraction the solute present in an aqueous phase is extracted in a counter-current manner by an organic solvent. Use the finite-difference element method to illustrate the simplification of the differential equations involved in the models. **[16]**

OR

Q6) A continuous mixer-settler extraction unit is operating as a perfectly mixed stage as shown in the figure. Develop the steady-State and unsteady-state model equations relating the process assuming a linear equilibrium relation. list all the assumptions. **[16]**



Q7) A batch reactor carries out the following series-parallel reactions: **[16]**

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$
$$A \xrightarrow{k_3} D$$

The reactions obey 1[st]-order kinetics and are endothermic. Thus the reactor is heated by passing steam in the reactor jacket at a volumetric flowrate of F_{s0} Develop the complete model of the process. Enlist all the assumptions.

OR

Q8) The following gas-liquid reaction is carried out in a bubble column reactor. **[16]**

$$A + B \xrightarrow{K} C$$

The gas reactant 'A' is bubbled in the liquid reactant 'B' and the liquid product 'C' which is produced in the reaction is obtained from the overflow from the bubble reactor. The reaction mainly occurs around the liquid film surrounding the gas bubbles. Before reacting. the gas 'A' has to diffuse through the liquid phase film to react with the component 'B'. The gas-liquid interface concentration of 'A' is C_A*. the un-reacted gas is vented of the reactor from the top. Develop an appropriate dynamic model of the bubble reactor assuming the chemical reaction as the controlling step.

Q9) Explain the Runge kutta (RK) numerical integration method to solve the differential model equation of an isothermal CSTR processing a first-order reaction. **[18]**

$$A \xrightarrow{k} B$$

Initially at steady-State the CSTR is disturbed by a step increase in the inlet concentration of C_{A0} from 0.2 (steady-state value) to 0.7 mol/lit. iterate for five steps from time t=0 to 5 min to determine the intermittent component (A and B) concentrations using the RK4 method. Data given, k=0.5, τ=2 min

OR

Q10) A batch reactor, when modelled in a unsteady-state for a non-elementary reaction results in the following differential equation: **[18]**

$$\frac{dC_A}{dt} = -2C_A^3 + 12C_A^2 - 20C_A + 8.5$$

Where C_A is the concentration of the reactant in the reactor at time 't'. The initial concentration on the reactant $C_A(0) = 1$ mol/L. Simulate the given reaction model using the Euler's numerical integration method, till time t=0.5 min to determine the reactant concentration. Consider a step size of h=0.1 and show all the five iterations. Explain the effect of step size on the simulation performance.

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