

Total No. of Questions :10]

SEAT No. :

P3699

[Total No. of Pages : 4

[5561]-336

B. E. (Chemical)

PROCESS MODELING & SIMULATION

(2012 Course) (Semester - II) (409349)

Time : 2 ½ Hours]

[Max. Marks : 70

Instructions to the candidates:

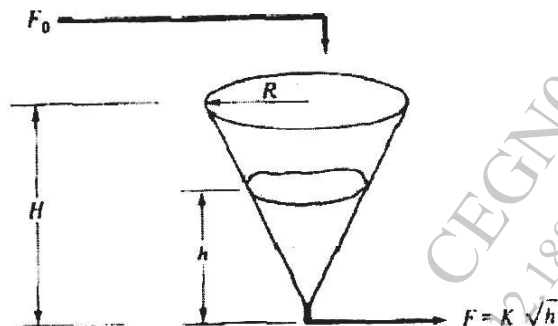
- 1) *Answer 5 questions.*
- 2) *Neat diagrams must be drawn wherever necessary.*
- 3) *Assume suitable data, if necessary.*
- 4) *Use of logarithmic tables slide rule, Mollier charts, electronic pocket calculator and steam tables is permitted.*

Q1) Explain the fundamental differences between stochastic, empirical and mechanistic models. What are some of the factors which make it easier or harder to develop such models? **[10]**

OR

Q2) What are some of the advantages and disadvantages in developing and using empirical versus mechanistic models for process applications? **[10]**

Q3) A fluid of constant density ρ is pumped into a cone-shaped tank of total volume $H\pi R^2/3$. The flow out of the bottom of the tank is proportional to the square root of the height h of liquid in the tank. Derive the equations describing the system. **[10]**



OR

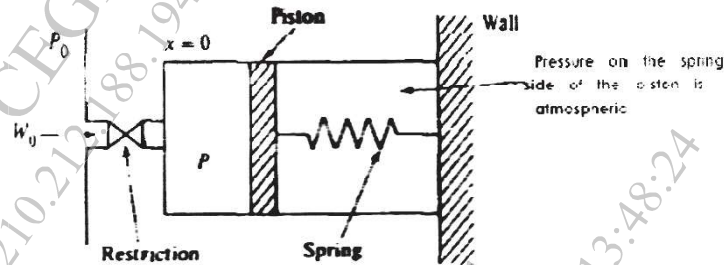
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- Q4)** A perfect gas with molecular weight M flows at a mass flow rate W , into a cylinder through a restriction. The flow rate is proportional to the square root of the pressure drop over the restriction :

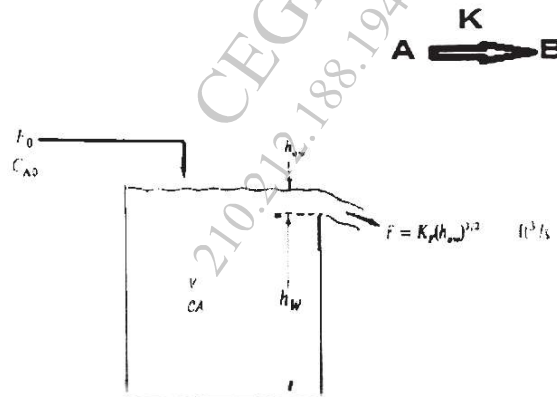
$$W_0 = k_0 \sqrt{P_0 - P}$$

Where P is the pressure in the cylinder and P_0 is the constant upstream pressure. The system is isothermal. Inside the cylinder, a piston is forced to the right as the pressure P builds up. A spring resists the movement of the piston with a force that is proportional to the axial displacement x of the piston. [10]

$$F_s = K_s x$$



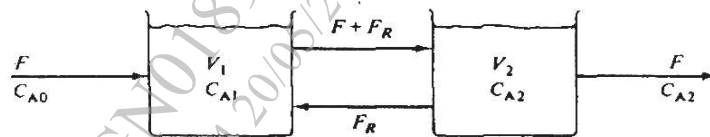
- Q5)** A perfectly mixed, isothermal CSTR has an outlet weir. The flow rate over the weir is proportional to the height of liquid over the weir, $h_{w,ss}$, to the 1.5 power. The weir height is h_w . The cross-sectional area of the tank is A . Assume constant density. A first-order reaction takes place in the tank : [16]



OR

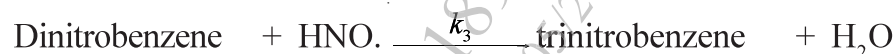
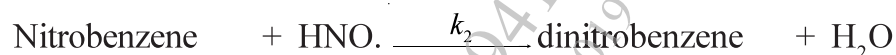
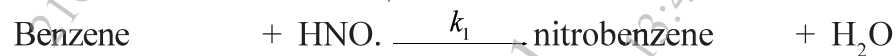
- Q6)** Develop the equations describing an “inverted” batch distillation column. This system has a large reflux drum into which the feed is charged. This material is fed to the top of the distillation column (Which acts like a stripper). Vapor is generated in a reboiler in the base. Heavy material is withdrawn from the bottom of the column. Derive a mathematical model of this batch distillation system for the case where the tray holdups cannot be neglected. [16]

- Q7) An isothermal irreversible reaction $A \xrightarrow{K} B$ takes place in the liquid phase in a constant-volume reactor. The mixing is not perfect. Observation of flow patterns indicates that a two-tank system with back mixing, as shown in the sketch below, should approximate the imperfect mixing. Assuming F and F_R are constant, write the equations describing the system. [16]



OR

- Q8) Benzene is nitrated in an isothermal CSTR in three sequential irreversible reactions :



Assuming each reaction is linearly dependent on the concentrations of each reactant, derive a dynamic mathematical model of the system. There are two feed streams, one pure benzene and one concentrated nitric acid (98 wt%). Assume constant densities and complete miscibility. [16]

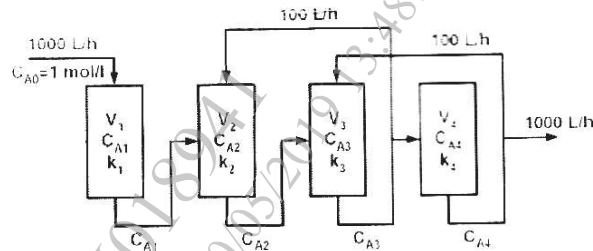
- Q9) A chemical reaction takes place in a series of four continuous stirred tank reactors arranged as shown in the figure. The chemical reaction is a first -order irreversible reaction of the type.



The conditions of temperature in each reactor are such that the value of the rate constant k_1 is different in each reactor. Also, the volume of each reactor V_i is different. The values of the rate constants and reactor volumes are given in the table below. The following assumptions can be made regarding this system : The system operates at steady state, there are only reactions in the liquid phase, there is no change in volume or density and the rate of disappearance of component A in each reactor is given by :

$$R_i = V_i k_i C_{A,i}$$

Formulate the material balances and solve the resulting system using Gaussian elimination method. Compare the two methods.



A small company is planning to produce a chemical (B) From a reactant (A) in a continuous process. The conversion of A to B occurs via the following main reaction : $A \rightarrow B + 2C$. for which the rate of consumption is given as $(r_A)_{\text{main}} = K_1 C_A$ [18]

OR

Q10) What is Process Simulation? By taking any example, explain it with Chemcad as software. [18]

