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RM-7027

B. E. - III (Sem. VI) (Chemical) Examination

May / June – 2010

Chemical System Modelling

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :

☛ **B. E. - 3 (Sem. 6) (Chemical)**

Name of the Subject :

☛ **Chemical System Modelling**

☛ Subject Code No. : 7 0 2 7 ☛ Section No. (1, 2,.....) : **1&2**

Seat No. :

Student's Signature

(2) Answer each section in **separate** answer book.
(3) Figures to the right indicate full marks.
(4) Make necessary assumptions wherever required and clearly mention it.
(5) Symbols used have conventional meaning.
(6) All notations carry their usual meaning.

SECTION - I

1 (a) What is modelling? Discuss the types of modelling in detail. **5**

(b) Discuss the fundamental laws used in modelling. **6**

(c) What is black-box principle? Discuss its benefits and limitations. **7**

2 (a) A continuous flow distribution column is fed with a binary mixture of A and B. The relative volatility of the mixture is constant by considering the plate above the feed plate, derive the difference equation that relates the liquid composition to the plate number n if the overall plate efficiency is 100%. Reduce the equation to a linear one with constant coefficients. Show that axis translation required involves the points where the equilibrium and operating lines intersect. **9**

OR

(a) Develop a model and obtain an expression for extraction of benzoic acid in a steady state operation with two stages. The input feed stream is Toluene and Benzoic acid mixture and solvent is water. Each stage consists of a mixer and a settler, with counter current flow through the stages. **9**

(b) 160 cm^3/s of a solvent S is used to treat 400 cm^3/s of a 10% by weight solution of A in B, where A is being extracted from B under un-steady state conditions in a single stage. Using a counter current mode of operation in a liquid-liquid extraction column. The volume of B (V_1) is 100 dm^3 and the volume of solvent V_2 is 75 dm^3. The distribution coefficient m=3 and the densities of A, B and S are 1200, 1000 and 800 kg/m^3 respectively. All the quantities are expressed on a solute free basis. **9**

(i) What is the composition of the final raffinate and fraction extracted after 1 min?

(ii) If 50% of A is to be extracted then what is the time required if V_1 and V_2 are same?

3 Answer any **two** : **7×2=14**

(a) The water input rate to a reservoir is $10^6 \exp(-t/100)$ liters per day where t is in days. Initially if 10^9 liters of water was stored, find the volume of water at the end of 60 days.

(b) Develop a model for small slice of constant diameter cylindrical pipe sketched below. The flow is turbulent and plug flow. Density and velocity of fluid are changing in Z direction.

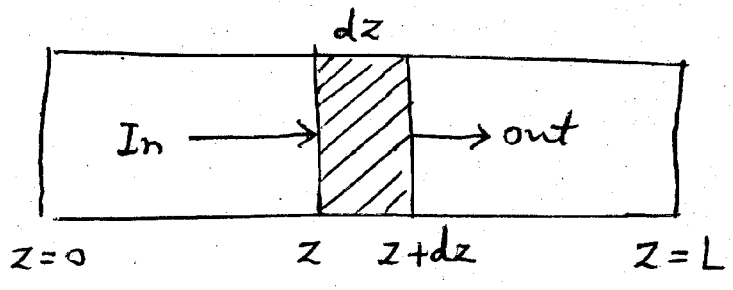

Fig. 1

(c) Differentiate steady state and dynamic modelling with examples of each.

SECTION - II

4 (a) Answer the following : **10**

(i) If the function is tabulated at unequal intervals, then we use _____ and _____ formula. **1**

(ii) Write down the equation to solve $\frac{dy}{dx} = f(x, y)$ by Runge-Kutta 4th order method explaining each term. **2**

(iii) In the linear programming method (simple method) a basic feasible solution lies at _____ points of feasibility region. **1**

(iv) In curve fitting by the method of averages, the no. of groups to be formed should be equal to the number of parameters. **1**

(v) State which method can be used to find the pressure at 167°F for the table given below : **2**

Temp (°F)	100	110	120	130
Pressure (lb/in^2)	211.9	247.0	286.4	330.0

(vi) Simpson's rule is one of the methods to carry out numerical _____ of a polynomial in order to find area between two ordinates. **1**

(vii) Write down the trapezoided rule equation for three points exlaining each term. **2**

(b) Maximize $f = 8.1x_1 + 10.8x_2$ subject to following constraints. **10**

$0.8x_1 + 0.44x_2 \leq 24000$

$0.05x_1 + 0.1x_2 \leq 2000$

$0.1x_1 + 0.36\ x_2 \leq 6000$

Use simplex method of linear programming.

5 Answer the following (any **two**) **16**

(a) The thermal conductivity of graphite varies with temperature according to the equation $K = K_0 - \alpha T$

Experimentally it is only possible to obtain a mean conductivity over a temperature range. It is required to find the point conductivity from mean conductivity given below.

T(°C)	390	500	1000	1500
K_m	1.41	1.38	1.19	1.15

K_m is determined between T and 25°C in kilo-erg/cm^2 sec °C cm^{-1}. Use method of averages.

(b) The pressure of certain gas was determined as a function of time as shown below : **8**

Time (T) units	0	2	4	6	8
Pressure (P) units	50	54	58	70	84

Estimate the pressure of T = 3 units by Newton's forward difference method.

(c) Evaluate $\int_0^2 \frac{1}{1+x^2}\,dx$ using Trapezoidal rule **8**

for five points.

6 Answer the following (any **two**) **14**

(a) Solve the equation **7**

$x^3 - 4x^2 + 7x - 5 = 0$ by Tartaglia's method.

(b) Explain hierarchy of solving optimization problem in any process industry and discuss the obstacles in solving optimization problems. **7**

(c) The heat capacity of a gas is tabulated at series of temperatures. **7**

T(°C)	20	50	80	110	140	170	200	230
C_p (J/mol C)	28	29	29.5	29.7	29.9	29.99	30.2	30.5

Calculate the change in enthalpy for 2 moles of this gas going from 20 to 170°C.