B.E./B.TECH. Degree Examination, December 2020

Seventh Semester

CH16008- PROCESS MODELING AND SIMULATION

(Regulation 2016)

Time: Three hours Maximum : 80 Marks

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. A reboiler with 'C' components in the feed has how many degrees of freedom?

   a) C+2 b) C+3 c) C+4 d)2C+1

2. Which of the following equations represent the Navier-stokes equation for an incompressible viscous flow?

   a) $\rho = \rho g - \nabla P - \mu \nabla^2 v$

   b) $\rho \frac{Dv}{Dt} = \rho g - \nabla P - \mu \nabla^2 v$

   c) $\rho \frac{Dv}{Dt} = \rho g - \mu \nabla^2 v$

   d) $\rho \frac{Dv}{Dt} = \rho g - \nabla P - \mu$

3. Choose the MATLAB function to handle stiff ODEs.

   a) ODE 45 b) ODE 23s c) ODE23 d)ODE 13

4. Which of the following is an example of distributed parameter system?

   a) Blower b)Heat Exchanger c)Absorption column d) CSTR

5. Write the auxiliary equations used in mathematical modeling.

6. A dilute solution at 20°C is added to a well-stirred tank at the rate of 180 kg/hr. A heating coil having an area of 0.9 m^2 is located in the tank and contains steam condensing at 150°C. The heated liquid leaves at 120 kg/hr and at the temperature of the solution in the tank. There is 500 kg of solution at 40°C in the tank at the start of the operation. The overall heat-transfer coefficient is 342 kg/hr m^2°C and the heat capacity of water is 1 k cal/kg °C. Sketch the information flow diagram for calculating the outlet temperature.

7. Elucidate the need for empirical modeling in heat transfer.

8. Write the population balance model equation for crystallization.

PART B - (4 X16 = 64 marks)

9. (a) The data represent the relationship between pressure **X** and reaction rate **Y** for an oil reservoir modeling problem. Does the data fit linearly or a second order fit? Obtain the constants in the equation using least squares regression. Tabulate the errors. **(16)**

X	5.435	4.635	3.835	3.035	2.325	1.435	0.635
Y	1.000	1.280	1.700	2.200	2.970	4.350	7.500

(OR)

(b) Develop the equations for the steady state tray compositions for a 6 plate absorption column having an equilibrium relationship $\mathbf{y_m = ax_m + b}$. The gas feed composition is 0.3kgmol solute/kgmol inert and the liquid feed is pure. Write a computer code for solving the matrix of equations for the following set of parameters. a= 0.85; b=2; L = 50 kg mol/min and G = 80 kg mol/min **(16)**

10. (a) Develop the mathematical model for an ideal binary distillation column separating a mixture of Benzene and Toluene with constant relative volatility and theoretical trays with 100 % efficiency. The Vapour- Liquid Equilibrium relationship can be expressed as $\mathbf{y_n = \alpha x_n/(1+(\alpha-1)x_n)}$. Perform the degrees of freedom analysis for this system. **(16)**

(OR)

(b) Consider Liquefied Petroleum Gas (LPG) fed into a pressurized tank. The liquid in the tank is assumed to be perfectly mixed. Heat is added to the tank at a specified rate to hold the desired pressure in the tank by vapourizing the liquid. Formulate a steady state, liquid phase dynamics, liquid -vapour phase dynamics and the thermal equilibrium model for the vaporization of LPG. Clearly state the assumptions. **(16)**

11. (a) Consider a zero order reaction taking place in a tubular packed bed reactor filled with catalyst particles. Both convective and dispersion thermal effects are present in this reactor due to the presence of catalyst particles. Derive the temperature profile equation along the length of the reactor. **(16)**

(OR)

(b) (i) Consider the flow of a compressible gas down a pipe line. Develop the material balance and energy balance equation by assuming density does not vary with distance. Sketch the information flow diagram. **(8)**

(ii) Consider a hot fluid at a temperature T_a flowing inside a pipe surrounded by a layer of insulating material. The pipeline is exposed to ambient conditions at T_b. Derive an expression for calculating the flux at the outer wall. **(8)**

12. (a) Formulate a mathematical model to describe the dynamic behaviour of a packed bed adsorption column considering interphase mass transfer and the adsorption equilibrium represented by Langmuir isotherm. State the assumptions clearly. **(16)**

(OR)

(b) Solve the unsteady state heat equation using Explicit method. **(16)**

$$\frac{\partial^2 U(x,t)}{\partial^2 x} - \frac{\partial U(x,t)}{\partial t} = 0$$

Boundary Conditions: U(0,t) = U(1,t) = 0; U(x,0) = sin(πx).

Choose an appropriate step size for the grid and compute the values for u(x,t) for x and t in the domain (0,1). Write a computer code for implementing the Explicit method.