Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VIII (NEW) EXAMINATION – WINTER 2018

Subject Code: 2180503 **Date: 29/11/2018**

Subject Name: Process Modeling, Simulation & Optimization

Time: 02:30 PM TO 05:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Describe in detail the principles of formulation of mathematical models. **03**

(b) Explain the fundamental laws of physics and chemistry with their applications to simple chemical systems. **04**

(c) Consider a batch reactor in which the following first-order consecutive reactions are carried out. **07**

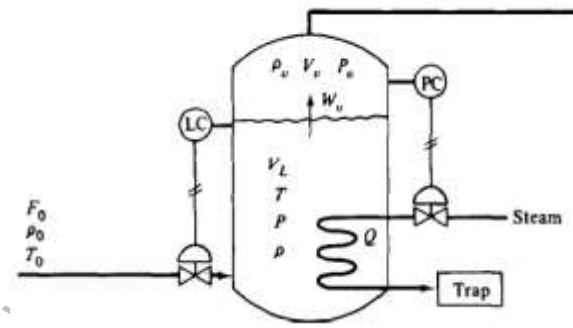
$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

Reactant A is charged into the vessel. Steam is fed into the jacket to bring the reaction mass up to a desired temperature. Then cooling water must be added to the jacket to remove the exothermic heat of reaction and to make the reactor temperature follow the prescribed temperature-time curve. This temperature profile is fed into the temperature controller as a set-point signal. Derive the temperature profiles for the process and metal wall for the batch reactor described above.

Q.2 **(a)** Write the various equations of motion for process modeling. **03**

(b) List the various professional simulators and equation solver software. **04**

(c) Consider the vapourizer sketched in the figure. **07**



Liquefied petroleum gas (LPG) is fed into a pressurized tank to hold the liquid level in the tank. We will assume that LPG is a pure component: propane. The liquid in the tank is assumed perfectly mixed. Heat is added at a rate Q to hold the desired pressure in the tank by vapourizing the liquid at a rate W_v (mass per time). Heat losses and the mass of the tank walls are assumed negligible. Gas is drawn off the top of the tank at a volumetric flow rate F_v. F_v is the forcing function or load disturbance. Derive the model equations for the system for steady state model and liquid and vapour dynamics model.

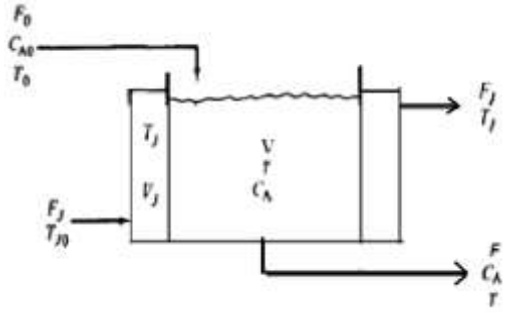
OR

(c) List the structural components of general purpose sequential modular program. **07**

Q.3 **(a)** Find the values of x and z (both > 0) that maximize the function: **03**
$U = -x^2 + 10x + xz - z^2 + 8z + 2$

(b) A poster is to contain 300 cm^2 of printed matter with margins of 6 cm at the top and bottom and 4 cm at each side. Find the overall dimensions that minimize the total area of the poster. **04**

(c) An irreversible, exothermic reaction $A \xrightarrow{k} B$ is carried out in a single perfectly mixed CSTR as shown in figure. **07**



The reaction is nth-order in reactant A and has a heat of reaction λ (Btu/lbmol of A reacted). Negligible heat losses and constant densities are assumed. To remove the heat of reaction, a cooling jacket surrounds the reactor. Cooling water is added to the jacket at a volumetric flow rate F_J, and with an inlet temperature of T_{Jo}. The volume of water in the jacket V_J is constant. The mass of the metal walls is assumed negligible so the thermal inertia of the metal need not be considered. Derive the model equations with the assumption of a perfectly mixed cooling jacket.

OR

Q.3 **(a)** State objective functions in terms of the adjustable variable for chemical reactor. **03**

(b) A box with a square base and open top is to hold 1000 cm^3. Find the dimensions that require the least material (assume uniform thickness of material) to construct the box. **04**

(c) What is a linear programming problem? State the linear programming in standard form and write down its application in chemical industries. **07**

Q.4 **(a)** Minimize the quadratic function: $f(x) = x^2 - x$ using quasi-newton method. **03**

(b) Explain random search and grid search method for unconstrained multivariable optimization. **04**

(c) Discuss feature of basic tearing Algorithm. **07**

OR

Q.4 **(a)** Classify the methods to solve unconstrained multivariable problems. **03**

(b) The total annual cost of operating a pump and motor (C) in a particular piece of equipment is a function of the size (horsepower) of the motor (X), **04**

$$C = 500 + X + \frac{4500}{X}$$

Find the motor size that minimizes the total annual cost. Use Newton's method from the starting point of $X_o = 10$. Does the solution converge? Solve the equation analytically and determine actual solution.

(c) Discuss the optimizing recovery of waste heat with suitable figure and equations. **07**

Q.5 **(a)** Determine convexity or concavity for the following functions. **03**

$f(x) = 4x_1^2 + 6x_1x_2 + 3x_2^2 + 5x_3^2 + x_1x_3 - 3x_1 - 2x_2 + 15$

(b) Explain the application of optimization in fitting vapour-liquid equilibrium data. **04**

(c) The analysis of labor costs involved in the fabrication of heat exchangers can be used to predict the cost of a new exchanger of the same class. Let the cost be expressed as a linear equation. **07**

$C_c = \beta_0 + \beta_1 A + \beta_2 N$

Where β_0, β_1, and β_2 are constants, N = number of tubes, A = shell surface area. Estimate the values of the constants β_1, β_2 and β_3 from the data in following table.

Labor cost ($)	310	300	275	250	220	200	190	150	140	100
Area (A), m^2	120	130	108	110	84	90	80	55	64	50
Number of tubes (N)	550	600	520	420	400	300	230	120	190	100

OR

Q.5 **(a)** Explain black box model. **03**

(b) Minimize f(x) = $x^4 - x + 1$ using Newton's method. Take starting point = 0.64 **04**

(c) Solve the following non-linear function with constraints using Lagrange multiplier method. **07**

Minimize: f(x, y) = $Kx^{-1}y^{-2}$, Subject to: g(x,y) = $x^2 + y^2 = a^2$

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