

Register Number:.....

**M.TECH DEGREE EXAMINATIONS: NOV/DEC 2024**

(Regulation 2018)

First Semester

**BIOTECHNOLOGY**

P18BTI1202: Bioprocess Modelling and Simulation

**COURSE OUTCOMES**

**CO1:** Conceptualize mathematical and engineering concepts in bioprocess modeling and simulation

**CO2:** Identify and analyze mathematical model in biochemical engineering systems

**CO3:** Select the appropriate components of SuperPro Design software

**CO4:** Apply the concepts of MATLAB and SIMULINK in bioprocess systems.

**CO5:** Ability to solve and analyze data using MATLAB

**CO6:** Apply, design and interpret process flowsheeting using SuperPro Design software

**Time: Three Hours**

**Maximum Marks: 100**

**Answer all the Questions:-**

**PART A (10 x 1 = 10 Marks)**

1. Assertion (A): Unsteady state CFSTR, concentration varies with time CO1 [K3]  
Reason (R): Lumped parameter model assumes variation with time but not with space.
- a) Both A and R are true and R is the correct explanation of A      b) A is false but R is true
- c) Both A and R are true but R is not a correct explanation of A      d) Both are false
2. Burning a charcoal is an example of CO1 [K3]
- a) Homogeneous, catalytic      b) Homogeneous, Non-catalytic
- c) Heterogeneous catalytic      d) Heterogeneous non-catalytic
3. Which of the following statements is not correct about order of a reaction. CO2 [K3]
- 1) The order of a reaction can be a fractional number.
- 2) Order of a reaction is experimentally determined quantity.
- 3) The order of a reaction is always equal to the sum of the stoichiometric coefficients of reactants in the balanced chemical equation for a reaction.
- 4) The order of a reaction is the sum of the powers of molar concentration of the



A) Performing the experiment

B) Model hypothesis

C) Evaluation of model

D) Experimental Design

a) D, C, B, A

b) A, B, C, D

c) B, D, A, C

d) C,D, A, B

**PART B (10 x 2 = 20 Marks)**

11. Enlist the typical characteristics of an ideal batch reactor. CO1 [K2]
12. Differentiate Lumped parameter model and distributed parameter model with an example. CO1 [K2]
13. For an enzyme fermentation process, would you prefer batch operation or continuous operation? Justify your opinion with respect to the economical aspect of the operation CO2 [K3]
14. What are the advantages and disadvantages of the scale-up process? CO2 [K2]
15. A continuous process is set up for treatment of waste water. Each day,  $10^5$  kg cellulose and  $10^3$  kg bacteria enter in the feed stream, while  $10^4$  kg cellulose and  $1.5 \times 10^4$  kg bacteria leave in the effluent. The rate of cellulose digestion by the bacteria is  $7 \times 10^4$  kg day<sup>-1</sup>. The rate of bacterial growth is  $2 \times 10^4$  kg day<sup>-1</sup>; the rate of cell death by lysis is  $5 \times 10^2$  kg day<sup>-1</sup>. Write balances for cellulose and bacteria in the system. CO3 [K3]
16. List any two software to perform Life Cycle Assessment (LCA) CO3 [K2]
17. How would you register a pure component and a stock component using Superpro designer? CO4 [K2]
18. How models are represented using mathematical equation? CO4 [K2]
19. Sucrose, 342.3 g, is dissolved in one liter of water at "room temperature." Calculate the composition by various measures. CO5 [K2]
20. A startup company proposes to use corn stover as a feedstock (39% cellulose, 26% hemicellulose and 23% lignin, 12% ash) to produce ethanol. The company claims to have discovered a new process that can produce 492 L ethanol/ dry metric ton (139 gal ethanol / dry ton) of feedstock. Scrutinize the feasibility of the estimates provided by the company. CO6 [KL]

**PART C (10 x 5 = 50 Marks)**

21. A fermentation slurry containing *Streptomyces kanamyceticus* cells is filtered using a CO1 [K1]

continuous rotary vacuum filter. The slurry is fed to the filter at a rate of 120 kg/h, where 1 kg of slurry contains 60 g of cell solids. To improve filtration rates, particles of diatomaceous earth filter aid are added at a rate of 10 kg/h. The concentration of kanamycin in the slurry is 0.05% by weight. Liquid filtrate is collected at a rate of 112 kg/h, and the concentration of kanamycin in the filtrate is 0.045% (w/w). The filter cake, containing cells and filter aid, is removed continuously from the filter cloth.

(a) What percentage of the filter cake is water?

(b) If the concentration of kanamycin dissolved in the liquid within the filter cake is the same as that in the filtrate, how much kanamycin is absorbed per kg of filter aid?

(c) Present your solution in the form of Material Balance table.

22. Our winery takes grain in, and puts wine into the market. The bottleneck of the operation is the fermenter operation. The fermenter is loaded with 10% sugar (assuming a density of  $1000 \text{ kgm}^{-3}$ ) and yeast before fermentation. This leads to a 5 h delay before fermentation starts. The fermentation takes 5 days to obtain a 4% alcohol mixture. Finally, to unload the fermenter contents, and clean the fermenter, requires another 3 h. Assume that the final product, wine (4% alcohol), also has a density of  $1000 \text{ kgm}^{-3}$ . Determine the fermenter size needed if a daily production of 240 L of wine is needed. CO6 [K1]
23. Derive a modeling equation for the non-isothermal CSTR when the volume of the reactor (V) remains constant. CO2 [K2]
24. A chemical engineer needs to determine the temperature at which the vapor pressure of a substance is equal to 100 kPa. The vapor pressure  $P(T)$ (in kPa) is given by the equation:  

$$P(T) = 10. T - 200 \ln (T) - 100$$
where T is the temperature in degrees Celsius. Use the Newton-Raphson method to find the temperature T that satisfies  $P(T) = 0$  with an initial guess of  $T_0 = 50^\circ\text{C}$ . Perform one iteration of the method. CO2 [K3]
25. Enlist the advantages of using SuperPro Designer over Aspen software. CO3 [K2]
26. List four unit procedure for gas-liquid separation. CO3 [K2]
27. "Freeze-drying is viewed as the optimal method of choice for dehydration because of the preservation of quality" - Justify the statement. CO4 [K3]
28. How do you achieve smoothing of curve using MATLAB CO4 [K3]
29. Construct a flow-sheet for enzymatic hydrolysis of lignocellulosic biomass. CO5 [K4]
30. Enumerate the steps involved in solving a higher ODE using MATLAB. CO6 [K3]

**Answer any TWO Questions**

**PART D (2 x 10 = 20 Marks)**

31. Consider finding the root of  $f(x) = e^{-x} (3.2 \sin(x) - 0.5 \cos(x))$  on the interval [3, 4], with  $\epsilon_{\text{step}} = 0.001$ ,  $\epsilon_{\text{abs}} = 0.001$  using bisection method. 10 COL [K4]

32. A reaction, 10 COL [K4]



is being carried out isothermally in a constant volume batch reactor. Initially, the reactor is charged with A at a concentration of  $C_{A0}$ . Determine the concentration of A in the reactor as a function of time. Also illustrate graphically on the Concentration of A as a function of time t for an  $O_{RA}$  th order reaction in a constant volume batch reactor.

33. Design a complete flow-sheeting for the production of bio-ethanol from sweet potato. Add a note on the Techno-Economic Analysis while designing the above plant. 10 COL [K6]

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