Exam.Code:0912
Sub. Code: 33391

2015

B.E. (Biotechnology) Eighth Semester

BIO-814: Modeling and Simulation of Bioprocesses

Time allowed: 3 Hours Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section. State clearly your assumptions.

x-x-x

1) Write briefly: *(2×5 = 10)*

a) Define metabolic engineering and what are the significance of metabolic Engineering?

b) What is product yield with respect to substrate?

c) Write down unsteady state mass balance for dynamic model of (CSTR)?

d) Write down advantage and disadvantage of fed batch reactor.

e) Define useful measurable parameter is the respiratory quotient (RQ) with suitable example?

SECTION-A

2. A) Assume that the cell can convert 67% of carbon source to biomass. Hexadecane and glucose are used as carbon sources. Calculate the stoichiometric coefficients of following reactions:

$$C_{16}H_{34} + \alpha_1 O_2 + \alpha_2 NH_3 \rightarrow \beta_1 (C_{4.4} H_{7.3} N_{0.86} O_{1.2}) + \beta_2 CO_2 + \beta_3 H_2O$$

$$C_6H_{12}O_6 + \alpha'_1 O_2 + \alpha'_2 NH_3 \rightarrow \beta'_1 (C_{4.4} H_{7.3} N_{0.86} O_{1.2}) + \beta'_2 CO_2 + \beta'_3 H_2O$$

B) Water enters a tank at the rate of 25 L/min. it is being withdrawn at the rate which varies according to $25(1-e^{-0.1t})$ L/min., where t is minutes. If the tank initially contains 50 L. How many gallons (liter) of water will the tank contains when the steady state is reached? *(7, 3)*

3. A) An electric heating-coil is immersed tank. Solvent at 15°C with heat capacity 2.1 kJ kg^{-1}°C is fed into the tank at of 15 kg h^{-1}. Heated solvent is discharged at the same flow rate. The tank is filled initially with 125 kg cold solvent at 10°C. The rate of heating by electric coil is 800 W. Calculate the time required for the temperature of solvent to reach 60°C.

B) The simple first order conversion of an enzyme *A* into product *B* may be complicated by the conversion *B* into new product *C*. This can be describing by the equation:

$$A \xrightarrow{K_1} B \xrightarrow{K_2} C$$

Each step of the reaction will have a unique rate constant K_1 for the conversion of an enzyme *A* into *B* and K_2 for the conversion of *B* to *C*. if the initial concentration of *A* at time A_0. Derive the concentration of *A*, *B*, and *C* in terms of time and rate constant. Also plot the concentration profile of reactant with time. *(4, 6)*

P.T.O.

4. A) Aspartase enzyme is used in batch reaction for manufacture of aspartic acid, a component of low calorie sweetener. In the substrate range of interest the conversion can describe using michalis- menten kinetics with 4.0 g l^{-1}. The substrate solution contains 1.5 g l^{-1} ammonium fumarate, the reaction stop when 85% of substrate is converted. At 32°C, V_{max} for enzyme 5.9 g l^{-1} h^{-1} and its half life is 10.5 d. At 37°C V_{max} increases to 8.5 g l^{-1} h^{-1} but the half life is reduced to 2.3 d. Which operating temperature would you recommended?

B) A tank contains 1000 liters of pure water. Brine that contains 0.05 kg of salt per liter of water enters the tank at a rate of 5 liters/min. Brine that contains 0.04 kg of salt per liter of water enters the tank at the rate of 10 liters/min. The solution is kept thoroughly mixed and drains from the tank at 15 liters/min. How much salt is left in the tank after 1 hour? *(5, 5)*

SECTION-B

5. A) In fed-batch fermentor, substrate stream is added continuously to the reactor. Develop a suitable mathematical model with the following kinetics:

$$r_X = \mu X\,, \quad \mu = \frac{\mu_{max} S}{K_S + S}, \qquad r_S = -\frac{r_X}{Y}\,, \; D = \frac{F_0}{V}$$

Convert the model in the dimensionless using the following transformation:

$$V' = \frac{V}{V_0}, \quad X' = \frac{X}{YS_0}\,, \quad S' = \frac{S}{S_0}\,, \; F' = \frac{F_0}{V_o \mu}\,, \; K'_S = \frac{K_S}{S_0}\,, \; \mu' = \frac{\mu}{\mu_m}\,, \; F' = \frac{dV'}{dt'} \text{ and } \quad t' = t\mu_m$$

B) Inversion of sucrose by Invertase follows substrate inhibition kinetics. The following data is given:

S_0 = 100 m mol l^{-1} S_{max} = 20m mol l^{-1}, K_m = 8 m mol l^{-1}, V_{max} = 4.45 m mol min.$^{-1}$ l^{-1}

Calculate productivity for CSTR to get the maximum product? *(6, 4)*

6. A) Discuss the Monod chemostat model with recycle system.

B) A two-stage chemostat system is used for production of secondary metabolites. The volume of each reactor is 0.5 m^3, the flow rate of feed is 50 L h^{-1}. Mycelial growth in the first reactor, second reactor is used for product synthesis. The concentration of substrate in the feed is 10 g l^{-1}. Kinetic parameters for organism are:

$$Y_{X/S} = 0.5 \text{ kg kg}^{-1}, \quad K_S = 1.0 \text{ kg m}^{-3}, \quad \mu_{max} = 0.12 \text{ h}^{-1}$$

i. Determine the cell and substrate concentrations entering the second reactor.

ii. What is the overall substrate conversion?

(4, 6)

7. **A)** Enzymatic isomerization glucose to fructose can be expressed by reaction mechanism:

$$E + S \leftrightarrow ES \leftrightarrow E + P$$

The kinetic parameter is:

$$\frac{V_{m,s}}{K_{m,s}} = 0.128 \quad , \quad \frac{V_{m,p}}{K_p} = 0.098 \quad , \quad \frac{1}{K_{m,s}} = 0.383 \quad , \quad \frac{1}{K_p} = 0.25$$

If the feed (glucose) concentration is 1.0 kg mole/liter and desired conversion is 40%. Compare the productivity in above rate expression in CSTR & FPR.

B) Fermentation by *Candida utilis* exhibits substrate inhibition kinetics in the form:

$$\mu = \frac{\mu_{max} \cdot S}{K_s + S + S^2/K_I}$$

Where S is the substrate, μ is the specific growth rate and μ_{max} is the maximum specific growth rate. For continuous fermentation using sterile feed, derive equation for the steady state variation of the biomass concentration (X), Substrate concentration (S) and their maximum productivity (DX). *(5, 5)*

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