Exam.Code:0912
Sub. Code: 6729

1058

B.E. (Bio-Technology)
Eighth Semester
BIO-804: Modeling and Simulation of Bio-Processes

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.

x-x-x

Write briefly: *(1×10 = 10)*

a) Define respiratory quotient *(RQ)*?
b) Write down steady state and dynamic mass balance equation?
c) What do you understand by structured and un-structured models?
d) What do you understand by data smoothing?
e) Write down characteristics of batch reactor.
f) Reactor choice for zero order kinetics ____ and ____.
g) List two advantage and disadvantage of fed batch reactor.
h) What is product yield with respect to substrate?
i) Define metabolic engineering.
j) What is the purpose of metabolic Engineering?

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:

$$C_{16}H_{34} + \alpha_1 O_2 + \alpha_2 NH_3 \rightarrow \beta_1 (C_{4.4} H_{7.3} N_{0.86} O_{1.2}) + \beta_2 CO_2 + \beta_3 H_2 O$$

$$C_6H_{12}O_6 + \alpha'_1 O_2 + \alpha'_2 NH_3 \rightarrow \beta'_1 (C_{4.4} H_{7.3} N_{0.86} O_{1.2}) + \beta'_2 CO_2 + \beta'_3 H_2 O$$

b) Using the following model equations predict the time.

$$\frac{dx}{dt} = \mu x \qquad \mu = \frac{\mu_{max} S}{K_s + S} \qquad Y_{\frac{x}{s}} = \frac{\Delta X}{\Delta S}$$

(7, 3)

3. a) In an experiment to measure the effect of a drug on leishmaniasis, infected hamsters were given subcutaneous injections at intervals of 3 days in 4 different doses which resulted in 100% survival. A table of the dosage vs parasite burden is given below. From an exponential fit, the drug concentration needed to reduce the parasite load of the spleen to 50% was determined to be 2.5 mg/kg body weight. Would you agree with this estimate?

Drug dose (mg/kg body weight)	0	1.5	2.4	5.7	11.2
Parasite burden ($\times 10^{-8}$)	6	5.1	4.9	1.0	0.3

b) Water is flowing into a well-stirred tank at 150 kg/hr and methanol is being added at 30 kg/hr. The resulting solution is leaving the tank at 120 kg/hr. there are 100 kg of fresh water in the tank at the start of the operation and the rates of input and output remain constant thereafter. Calculate the outlet concentration (mass fraction f methanol) after 1 hr. what would be the steady state methanol mass fraction. *(6, 4)*

P.T.O

4. a) *Aspergillus niger* is used to convert glucose to gluconic acid via gluconolactone. If the conversion follows the first order consecutive reaction with K_1 and K_2 rate constant, derive the t_{max} at which the concentration of intermediate (gluconolactone) is maximized and also derive the maximum concentration (C_{Lmax}) gluconolactone. Provided that the initial concentration of glucose at zero time G_0.

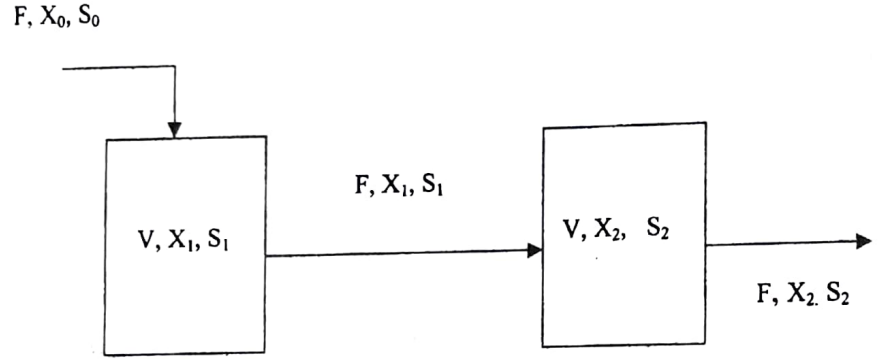
b) Lipase is being investigated as an additive to laundry detergent for removal of stains from fabric. The general reaction is ---

Fats → Fatty acid + glycerol

The Michaelis constant for pancreatic lipase is 5 mM. At 60 °C, lipase is subjected to deactivation with half life of 8 min. Fat hydrolysis under specific condition which simulates a top - loading washing machine. The initial fat concentration is 45 mM and maximum reaction rate of hydrolysis is 0.07 m mol l^{-1} s^{-1}. How long does it take for the enzyme to hydrolyse 80% of the fat present? *(5, 5)*

SECTION-B

5) Discuss the balance equations for each component as given in two chemostat model arranged in series.



Consider an organism which follows the Monod equation where μ_m =0.5h^{-1} and K_S =2 g/l

a) In continuous perfectly mixed vessel at steady state with no cell death if S_0 =50 g/l and $Y_{X/S}$= 1(g cells/g substrate), what dilution rate D will give the maximum total rate of cell production?

b) For the same value of D using tanks, find out cell concentration and substrate concentration for first and second tank. *(10)*

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

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

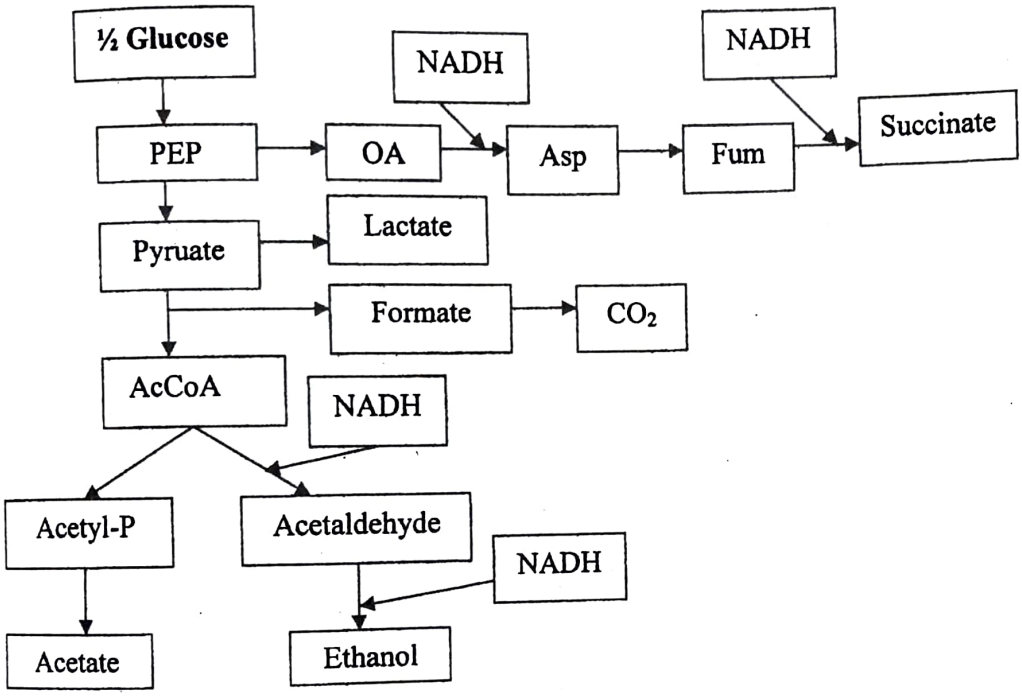
Convert the model in the dimensionless using the following transformation:

$$V' = \frac{V}{V_0}, \quad X' = \frac{X}{YS_0}, \quad S' = \frac{S}{S_0}, \quad F' = \frac{F_0}{V_o\mu}, \quad K'_S = \frac{K_S}{S_0}, \quad \mu' = \frac{\mu}{\mu_m}, \quad F' = \frac{dV'}{dt'} \text{ and}$$

$$t' = t\mu_m$$

b) Discuss the Monod chemostat model with recycle system. *(7, 3)*

7. a) The metabolic pathway for aromatic amino acid synthesis is given bellow; identify the Substrate, products, intermediates. Construct the stoichiometric model and develop the matrix Form.



b) 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. *(4, 6)*

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