Exam.Code:0912
Sub. Code: 33391

2056

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 useful measurable parameter is the respiratory quotient *(RQ)* with suitable example?
b. What is product yield with respect to substrate?
c. Write down dynamic model for batch reactor.
d. Write down advantage and disadvantage of batch reactor.
e. A chemostat has a liquid volume of 2 liters and is being fed at a rate of 8 liters per hour. Find dilution rate for this reactor.

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) 1.5 kg salt is dissolve in water to make 100 liters. Pure water runs into a tank containing this solution at a rate of 5 L $min.^{-1}$; salt solution overflows at the same rate. The tank is well mixed. How much salt in the tank at the end of 15 min.? Assume the density of salt solution is constant and equal to that of water. *(7, 3)*

3. a) A tank contains 1000 liters of brine with 15 kg of dissolved salt. Pure water enters the tank at a rate of 10 liters/min. The solution is kept thoroughly mixed and drains from the tank at the same rate. How much salt is in the tank?

(i) After t minutes?
(ii) After 20 minutes?

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?

(i) After t minutes?
(ii) After 1 hour? *(4, 6)*

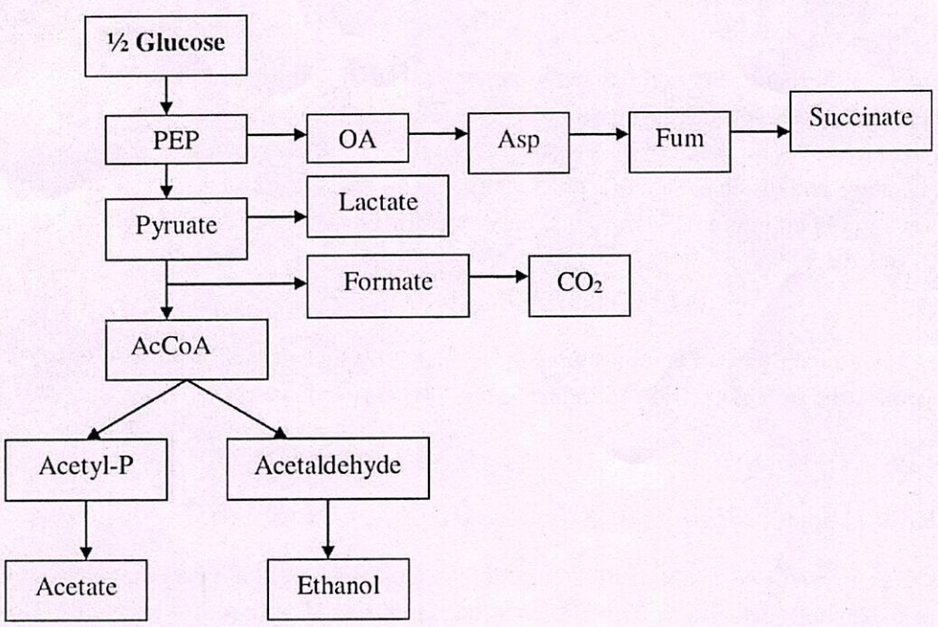
4. a) The enzymatic hydrolization of fish oil extract from crude oil has been carried out using lipase. One of the desired products is docosahexaenic. For the enzyme $V_{max} = 0.00266$ µmol/min. and K_m 0.052 M. The initial concentration of substrate 0.1M .Calculate the time needed to convert 80% substrate conversion .the reaction is carried out under isothermal conditions. If the enzyme is used as deactivates with half life 4.4hrs, what is the time required for 90% substrate conversion?

b) 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. *(6, 4)*

P.T.O.

SECTION-B

5. 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) An arrangement consists of two stirred tanks reactor connected in series. The first reactor has an operational volume of 75 liters and the second reactor having an operational volume of 25 liters. A sterile feed is given to the first rector containing 3.5 g/liter of substrate and fed at the rate of 15 liters/ hr. Using Monod's kinetic model to describe the growth kinetics, it is found that the value of K_s is 0.11 g/liter, $Y_{x/s}$ is 0.4 and maximum specific growth rate is 0.22 hr^{-1}. Determine the steady state concentration of substrate in the second reactor. *(5, 5)*

6. a) Fermentation by *Candida utilis*exhibits substrate inhibitionkinetics 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 specificgrowth 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).

b) Discuss the Monod chemostat model with recycle system. *(6, 4)*

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

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

Which is kinetically analysis by steady state leads to rate expression:

$$-\frac{ds}{dt} = \frac{\left(\frac{V_{m,s}}{K_{m,s}}\right)S - \left(\frac{V_{m,p}}{K_p}\right)P}{1 + \frac{S}{K_{m,s}} + \frac{P}{K_p}}$$

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. *(10)*

x-x-x