Exam.Code:0912
Sub. Code: 6729

2062

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 significances?

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

c) A chemostat has a liquid volume of 4liters and is being fed at a rate of 8 liters per hour. Find dilution rate for this reactor.

d) What is product yield with respect to substrate?

e) Define useful measurable parameter is the respiratory quotient *(RQ)*?

SECTION-A

2. A) Production of single- cell protein from hexadecane is described by the following reaction equation:

$$C_{16}H_{34} + aO_2 + bNH_3 \rightarrow cCH_{1.66}O_{0.27}N_{0.20} + dCO_2 + eH_2O$$

Where $cCH_{1.66}O_{0.27}N_{0.20}$ represents the biomass, If $RQ = 0.43$ determine the stoichiometric coefficients.

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.

C) 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 it is being withdrawn at the rate which varies according to $25(1-e^{-0.1t})$ L/min., where t is minutes.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? *(5, 3, 2)*

3. A) Dean and Hinshelwood proposed two-compartment model shown bellow for a bacterial cell.

$$\frac{dX_1}{dt} = \alpha_1 X_2 \rightleftarrows \frac{dX_2}{dt} = \alpha_2 X_1$$

The rate of changes of component X_1 and X_2 follow the equations shown in the boxes above with α_1 and α_2 being kinetic constants. Solve this model of X_1 and X_2 with time t for the cases:

$\alpha_1 = \alpha_2$; and $\alpha_1 > \alpha_2$

B) An enzyme is used to produce a compound that is further used to manufacture sunscreen lotion. V_{max} for enzyme 2.5 m mol/m^3-s, K_m = 8.9 mM. The initial concentration of substrate is 12 mM. If the reaction is being carried out under isothermal conditions, what batch reaction time is required for 90% substrate conversion and if the enzyme used in deactivates with half life of 4.4 hr, what is the batch reaction time required to achieve 90% substrate conversion? *(4, 6)*

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 $\mathbf{t_{max}}$ at which the concentration of intermediate (gluconolactone) is maximized and also derive the maximum concentration ($\mathbf{C_{Lmax}}$) gluconolactone. Provided that the initial concentration of glucose at zero time G_0.

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)

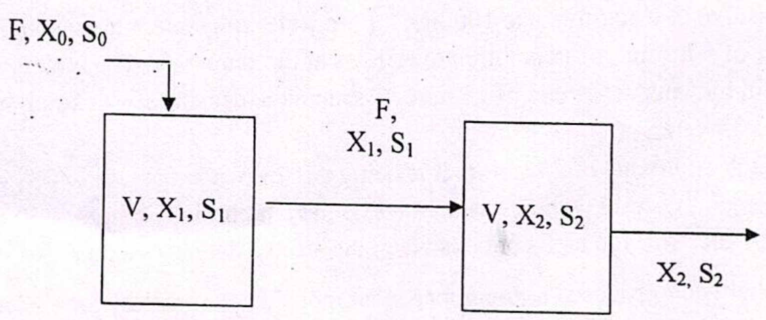
SECTION-B

5) Discuss the balance equations for each component as given two chemostat model (Fig.1) arranged in series. Consider an organism which follows the Monod equation where $\mu_m = 0.5h^{-1}$ 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 of the same size, what is concentration of cell biomass and substrate concentration in first and second vessels?

(10)



6) 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:

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

(10)

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:

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

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