BIOPROCESS ENGINEERING
(CHEN 3233)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The plot of rate versus substrate concentration of an enzymatic reaction following Michaelis Menten equation gives
(a) a section of rectangular hyperbola
(b) a linear plot
(c) an irregular plot
(d) none of the above

(ii) The rate constant (k_3) in Michaelis- Menten equation
(a) is an intrinsic kinetic parameter (b) is an extensive kinetic parameter
(c) depends on temperature (d) both (a) and (c)

(iii) The Intercept on abscissa of Lineweaver and Burk plot is equal to
(a) 1/Vm (b) -1/ Km
(c) - Km (d) Km/ Vm

(iv) Chemostat bioreactor is
(a) an unsteady state reactor (b) a steady state reactor
(c) an isothermal reactor (d) none of the above

(v) The yield coefficient of cell growth (YA/C) is
(a) constant during exponential phase of growth
(b) constant during stationary phase of growth
(c) the slope of Cc versus CA line
(d) none of the above

(vi) The best combination of reactors to achieve the substrate concentration at the maximum cell growth rate is
(a) MFR followed by PFR (b) PFR followed by MFR
(c) Two MFRs in series (d) Two PFRs in series

(vii) The yield coefficient of cell growth ($Y_{C/A}$) is
(a) constant during exponential phase of growth
(b) constant during stationary phase of growth
(c) the slope of Cc versus C_A line
(d) the slope of C_A versus C_C line

(viii) The net effect of non competitive inhibition
(a) is an increase in the maximum velocity
(b) is a decrease in the maximum velocity
(c) is an increase in the apparent Michaelis- Menten constant
(d) is a decrease in the apparent Michaelis- Menten constant

(ix) Freundlich adsorption isotherm is expressed as
(a) $C_a = \frac{C_0 S}{K + S}$ (b) $C_a = KS^n$
(c) $C_a = KS$ (d) $C_a = K + S$

(x) A high pressure homogenizer consists of a
(a) A high pressure centrifugal pump
(b) A pressure positive displacement pump
(c) A combination of a high pressure centrifugal pump and a pressure positive displacement pump
(d) None of the above

Group – B

2. (a) Explain by deducing the initial slope of Michaelis-Menten equation how this can be used to determine the Michaelis-Menten constant (K_m) from rate versus substrate concentration plot.

(b) Sucrose is hydrolyzed in a batch bioreactor in presence of the enzyme sucrase (E) as follows:

Sucrose (A)$\rightarrow$ product

With initial concentrations of 1 mM sucrose and 0.01 mM enzyme, the following data are obtained.

C_A, mM	0.84	0.68	0.53	0.38	0.27	0.16	0.09	0.04
$(-r_A)$,mM/hr	0.160	0.154	0.152	0.127	0.110	0.0882	0.0625	0.0400

Using Hanse-Woolf method, find the intrinsic kinetic parameters of Michaelis-Menten equation.

5 + 7 = 12

3. Reactant A decomposes in the presence of an enzyme E. To study the action of this enzyme, A and E (C_{E0} = 10 mol/m^3) are introduced into a batch reactor and the concentration of A is measured at various times. The data are given below

Time (t), hr	0	1	4	5
Concentration of A (C_A), mol/m^3	1200	840	100	30

(i) Find a rate equation for this enzymatic reaction

(ii) Deduce the equation used for determining the rate.

(7 + 5) = 12

Group – C

4. The rate of reaction of an enzyme catalyzed reaction was determined in the presence of an inhibitor B. The data in the presence and absence of the inhibitor are shown in the table below. Determine the nature of inhibition and the rate expression of the reaction.

Substrate concentration (mmol/liter)	0.2	0.33	0.5	1.0	2.5	4.0	5.0
Rate with no inhibitor, (mmol/liter.min)	8.34	12.48	16.67	25.0	36.2	40.0	42.6
Rate with C_{B0} = 5 μmol/liter (mmol/liter.min)	3.15	5.06	7.12	13.30	26.2	28.9	31.8

12

5. (a) A specific bacterium lives and grows on lactose. In order to study the kinetic of this reaction, the following experimental data (in consistent units) were obtained from a batch reactor.

Time (t)	0	0.54	0.90	1.23	1.58	1.95	2.33	2.70
Concentration of substrate (C_A)	147	125	104	70	38	18	3	1
Concentration of cell (C_C)	15.5	23	30	38.8	48.5	58.3	61.3	62.5

(b) Find the yield of the cell ($Y_{C/A}$) with respect to the substrate consumption. Assume that experimental measurements for a certain organism have shown that cells can convert two-third (wt/wt) of the substrate carbon to biomass. Calculate the stoichiometric coefficients for the following biological reaction:

$$C_6H_{12}O_6 + aO_2 + b\ NH_3 \rightarrow c(C_{4.4}H_{7.3}N_{0.86}O_{1.2}) + d\ H_2O + e\ CO_2$$

7 + 5 = 12

Group – D

6. (a) E.coli lives and grows on mannitol with the following kinetics:

$r_C = 1.2\ C_A\ C_C\ /(\ C_A + 2)$ gm cell formed /hr. m^3 with $Y_{C/A}$ = 0.1 gm cell/gm mannitol. It is desired to produce 1 Kg cell / day in a batch fermenter. We start with 1000 gm mannitol / m^3 and 0.1 gm /m^3 cells and continue the fermentation until the substrate drops to 10 gm / m^3. The plant operates day and night and the times for filling cleaning and emptying the reactor are 0.23 hours, find the volume of the fermenter needed. C_A and C_C are the concentrations of substrate and cells in gm / m^3 respectively.

(b) Derive the performance equation of a Chemostat in terms of cell concentration and residence time used for carrying out a microbial fermentation reaction following substrate uninhibited Monod equation.

7 + 5 = 12

7. (a) Show that the optimum residence time (τ_m) in chemostat with $C_{C_0} = 0$ is given by $k\tau_m = \frac{N}{N-1}$ where $N^2 = \frac{K_S + C_{A_0}}{K_S}$. The system follows the Monods equation.

(b) Consider the scale up of fermentation from a 10 liter to 10,000 liter vessel. The small fermenter has a height to diameter ratio of 3. The impeller diameter is 30% of the tank diameter. Agitator speed is 500 rpm and three Rushton impellers are used. Determine the dimensions of the large fermenter for constant impeller tip speed.

6 + 6 = 12

Group – E

8. (a) A bio product (C) in a water(A) solution containing 1% C is to be extracted with a solvent (B) at 20^0C. A and B are essentially insoluble. Determine the percentage extraction of C if 100 kg of feed solution is extracted three times in cross current manner with 50 kg solvent in each stage.
Equilibrium data:

$\frac{kgC}{kgA}$	0	0.001011	0.00246	0.00502	0.00751	0.00998	0.0204
$\frac{kgC}{kgB}$	0	0.000807	0.001961	0.00456	0.00686	0.00913	0.01870

(b) Write short notes on concentration polarization in membrane separation processes

8 + 4 =12

9. (a) The lab scale experimental data for the adsorption an antibiotic on activated carbon are as follows;

Solute concentration in feed (mg/cm^3)	0.3	0.12	0.04	0.018	0.006	0.001
Solute adsorbed on activated carbon (mg/g)	0.15	0.12	0.095	0.08	0.06	0.045

Find out to which adsorption isotherm the data fit.

(b) Explain the working principle of tubular bowl centrifuge used for bioseparation.

8 + 4 = 12

Department & Section	Submission Link
CHE	https://classroom.google.com/c/MzY4NzMwNzg0NjUw/a/MzY4NzMwNzg0NjYz/details