ADVANCES IN BIOREACTOR DESIGN, DEVELOPMENT AND SCALE UP (BIOT 5202)

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) Sherwood Number is given by the expression
(a) $\frac{K_L d_f}{D_{AB}}$ (b) $\frac{K_L d_b}{D_{AB}}$ (c) $\frac{K_L L_C}{D}$ (d) $\frac{K_L \rho}{D_{AB}}$.

(ii) The ratio of momentum diffusivity and thermal diffusivity is called as
(a) Prandlt number (b) Nusselt number
(c) Peclet number (d) Schmidt number.

(iii) R T D curve due to pulse input gives rise to
(a) asymptotic curve (b) hyperbolic curve
(c) bell-shaped curve (d) normal distribution curve.

(iv) Low flow rate of a gas is measured by
(a) rotameter (b) orificemeter
(c) wet gas meter (d) thermo-anemometer.

(v) Monod model is an equation of which of the following types?
(a) Linear (b) Nonlinear
(c) Hyperbolic (d) Parabolic.

(vi) Cell suspension is a non-Newtonian fluid of the type
(a) bingham plastic (b) pseudo plastic
(c) dilatants (d) bingham plastic.

(vii) The criterion for the selection of animal cell culture reactor is
(a) low shear rate (b) removal of toxic metabolites
(c) combination of (a) & (b) (d) high cell mass concentration.

(viii) Dimension of mass transfer coefficient is
(a) LT^{-1} (b) T^{-1} (c) MLT^{-1} (d) MT^{-1}.

(ix) The scale-up criterion for a CSTR to be used for animal cell culture is based on
(a) geometric similarity
(b) equal P/V
(c) equal tip velocity
(d) equal impeller based Reynolds Number (R_{eI}).

(x) Microbial fermentation is best carried out for high yield of cell mass by
(a) plug flow reactor (b) fed batch reactor
(c) back-mixed reactor (d) fluidized bed reactor.

Group – B

2. (a) A new strain of yeast being considered for biomass production. The following data were obtained using a chemostat. An influent substrate concentration of 800 mg/L and an excess of oxygen were used at a pH of 5.5 and T = 35°C. Using the following data, calculate $\mu_{\max}$, K_S, $Y^M_{X/S}$, k_d, and m_S, assuming $\mu_{net} = \frac{\mu_{max} S}{K_S + S} - k_d$.

D (h^{-1})	0.1	0.2	0.3	0.4	0.5	0.6	0.7
S (mg/L)	16.7	33.5	59.4	101	169	298	702
X (mg/L)	366	407	408	404	371	299	59

(b) A bioreactor has an oxygen mass transfer coefficient capability of 400 h^{-1}. What is the maximum concentration of *E. coli* that can be grown aerobically in this reactor? Respiration rate of *E.coli* is 0.35 g O_2 (g cell)$^{-1}$ h^{-1}. Critical oxygen concentration is 0.2 mg/L. Assume oxygen saturation with air to be 6.7 mg/L.

8 + 4 = 12

3. (a) Calculate the productivity (i.e DP) of a chemostat under the following conditions:
(i) Apply Monod kinetics. Assume negligible amount of biomass must be converted to product.
(ii) Apply Luedeking-Pirate Kinetics.
Assume steady state:
D = 0.8 $\mu_{\max}$, $\mu_{\max}$ = 1.0 h^{-1}, K_S = 10 mg/L, α = 0.4 mg P/g X, $Y^M_{X/S}$ = 0.5 g X/ g S, S_0 = 1000 mg/L, β = 0.5 h^{-1} mg P/g X.

(b) A value of k_{La} = 30 per hour has been determined for a fermenter at its maximum practical agitator rotational speed and with air being sparged at 0.5 L gas/g dry weight per hour are to be cultured. The C_{CRIT}

is 0.2 mg/L. The solubility of oxygen from air in the fermenter broth is 7.3 mg/L at 30°C.

(i) What maximum concentration of *E. coli* can be sustained in this bioreactor under aerobic condition?

(ii) What concentration could be maintained if pure oxygen was used to spurge the bioreactor?

7 + 5 = 12

Group – C

4. (a) Derive integral form of the Henri-Michaelis-Menten equation.

(b) Calculate K_i for a non-competitive inhibition if 2×10^{-4} M [I] yields 75% inhibition of enzyme-catalyzed reaction.

(c) Find the first-order rate constant for the disappearance of A in the gas reaction $2A \rightarrow R$ if, on holding the pressure constant, the volume of the reaction mixture, starting with 80% A, decreases by 20% in three minutes.

3 + 3 + 6 = 12

5. (a) We plan to replace our M F R with one having double the volume. For the same aqueous feed (10 ml A/lit.) and the same feed rate find the new conversion. The reaction kinetics is given below:
$A \rightarrow R$, $-r_A = KC_A^{1.5}$ and present conversion is 70%.

(b) An aqueous feed of A and B (400 l/min, 100 mmol B/l) is to be converted to product in a plug flow reactor. The kinetics of the reaction is represented by
$A+B \rightarrow R$, $r_A = 200C_AC_B \frac{\text{mol}}{\text{liter.min}}$.
Find the volume of reactor needed for 99% conversion od A to product.

7 + 5 = 12

Group – D

6. (a) What do you mean by immobilization of cells?

(b) Explain different immobilization techniques of cells.

(c) Compare free cells with immobilized cells for lab scale production of bioproducts.

4 + 4 + 4 = 12

7. (a) Define membrane bioreactors.

(b) Explain operating principles of membrane bioreactor with the help of a schematic diagram.

3 + 9 = 12

Group – E

8. (a) What is the basic principle of pH meter?

(b) How can we control the temperature in a bioreactor?

6 + 6 = 12

9. (a) Explain the significance of Dissolved Oxygen (DO) in bioreactor? Discuss the different type of DO probes available. Explain the operating principle of each type of DO probes.

(b) What are the different types of controller used in bioprocess?

(2 + 2 + 4) + 4 = 12