B.TECH/ BT/6TH SEM/ BIOT 3203/2018
BIOREACTOR DESIGN AND ANALYSIS
(BIOT 3203)

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) If Thiele parameter, Φ , is greater than 3 reactor will be
(a)mass transfer controlling
(b) reaction rate controlling
(c) molecular diffusion controlling
(d) intra-particle diffusion controlling.

(ii) The unit of 1st order rate constant
(a) mol/L sec (b) mol/sec (c) 1/time (d) 1/mol.

(iii) Dispersion number is given by
(a) D/UL (b) DU/L (c)DL/U (d) L/DU.

(iv) Non-ideal reactors are characterized by
(a) Dispersion number (b) Peclet number
(c) Schmidt number (d) Damkohler number.

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

(vi) 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) $\frac{K_L \rho}{D_{AB}}$.

(vii) If the rate is given as $-r_A = kC_A^{0.6}C_B^{0.4}$ then the molecularity and order of the reaction is
(a) 1 and 1 (b) 1 and 2 (c) 2 and 1 (d) 2 and 2.

(viii) Damkohler number is a measure of
(a) molecular diffusion (b) biochemical reaction
(c) pore diffusion (d) both (a) and (b).

(ix) Air-lift reactor is used for production of
(a) alcohol (b) penicillin G
(c) enzymes (d) monoclonal antibody.

(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) Derive rate equation for non-competitive inhibition (enzyme reaction) and show the result graphically.

(b) The following set of growth data is available for a new microorganism :

t, hrs	0.0	0.5	1.0	1.5	2.0
X, dry cell mass (gm/L)	0.10	0.15	0.23	0.34	0.51

The above set of data is to be fitted to the model : $dx/dt = kx(1- \beta x)$

Where, $\beta = 1/x_s$ and x_s is the cell mass concentration in the stationary phase. Evaluate the constants k and β.

3 + 9 = 12

3. (a) Show that the following numbers are dimensionless.
(i) Prandtl number
(ii) Schmidt number

(b) A value of k_{LA} = 30 per hour has been determined for a fermentor 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?

(c) 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.

2+ 6+ 4 = 12

Group – C

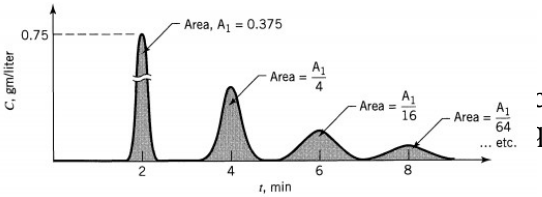
4. (a) Find the overall order of the irreversible reaction $2H_2 + 2NO \rightarrow N_2 + 2H_2O$ from the following constant-volume data using equimolar amounts of hydrogen and nitric oxide :

Total pressure, mm Hg	200	240	280	320	360
Half-life, sec	265	186	115	104	67

(b) 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.

7 + 5 = 12

5.(a) An aqueous [illegible]ch reactor where $C_{A0} = C_{B0} = ($ [illegible]quation using the following da



C_A (mol/L)	0.017	0.015	0.013	0.01	0.008	0.005	0.003
t, (sec)	260	490	790	1470	2205	4470	8330

(b) Consider a gas phase, isothermal, zeroth order reaction A → 3B. Initial concentration of A is 2 mol/L. Specific rate constant is 0.1 mol/L min. Final conversion required is 80%. In case of flow reactors, the volumetric flow rate to be used is 2 L/min. Calculate
i) time required in a constant volume batch reactor.
ii) volume required of a CSTR.
iii)volume required of a PFR.

6 + 6 = 12

Group – D

6. (a) What are the factors responsible for deviations from ideal plug flow in a tubular reactor?

(b) Define Peclet number. What are the values of Peclet number for
(i) ideal CSTR.
(ii) ideal PFR.

(c) A fluid reacts according to A→R as it flows through a vessel. Find the conversion of A for the flow pattern shown in the figure 1 with the following data:

$C_{A0} = 1$ mol/L, $-r_A = kC_A^{0.5}$, $k = 2$ mol$^{0.5}$/L$^{0.5}$.min.

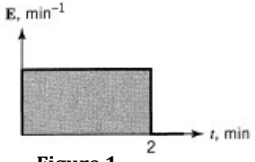


Figure 1

2+ 3 +7 = 12

7. (a) Explain the significance of (D/UL) dispersion number.

(b) A large tank (860 liters) is used as a gas-liquid contactor. Gas bubbles up moves through the vessel and goes out through the top, liquid flows in at one part and goes out at the other at 5 L/sec. To get an idea of the flow pattern of liquid in this tank a pulse of tracer (M = 150 gm) is injected at the liquid inlet and measured at the outlet, as shown below.

(i) Is this a properly done experiment ?
(ii) If so, find the liquid fraction in the vessel.
(iii) Determine the E curve for the liquid.
(iv) Qualitatively what do you think is happening in the vessel?

2 + 10 = 12

Group – E

8. (a) In a fluidized bed biofilm reactor with biofilms of average thickness L=0.5 mm carbon compound are to be removed. The feed flow rate and the conc. of carbon compound in the feed are F=2 L/hr and S_0 =2000mg/L. The diameter of the column, D=10 cm. The kinetic constants of the microbial population are R_m =50mg/cm^3(hr) and K_s = 25 mg/cm^3. The sp. Surface area of the biofilm in the reactor is a= 2.5 cm^2 /cm^3 .
Assume first order kinetics and effectiveness factor, $\eta = 0.7$
Determine the required height of the column, if the effluent carbon concentration S = 100 mg/L

(b) A stirred tank reactor is to be scaled down from 10 m^3 to 0.1 m^3. The dimension of the large tank are D_t =2 m, D_i = 0.5 m, N=100 rpm. Determine the dimension of the small tank (D_t, D_i, and H) by using geometric similarity.

8 +4 = 12

9. (a) What is a membrane bioreactor? What are the applications of membrane bioreactor? What are the major considerations of membrane bioreactor?

(b) Discuss the importance of mass transfer coefficient and heat transfer coefficient for a bubble column reactor.

(2+2+4)+4 = 12