

- (v) Immobilized cell reactors for wastewater treatment have the advantage of having/being
- higher cell concentration
 - more stable prevents washout
 - higher dilution rate before the cells washout
 - all of the above.
- (vi) The oxygen transfer rate in a bioreactor will increase if
- oil is added
 - antifoam is added
 - detergent like molecules are added
 - the reactor temperature is increased.
- (vii) The kinetics of monoclonal antibodies are described by the kinetics of the type
- growth associated
 - non-growth associated
 - Monod model
 - combination of (a) & (b).
- (viii) A fluid in which the viscosity decreases with increasing stirrer speed and mixing time, can be represented as
- newtonian fluid
 - pseudoplastic, thixotropic fluid
 - dilatant, rheopectic fluid
 - dilatant, pseudoplastic fluid.
- (ix) Damkohler No. (Da) is a measure of
- pore diffusion
 - film diffusion
 - combination of (a) & (b)
 - reaction kinetics.
- (x) Thiele parameter predicts the effect of
- molecular diffusion
 - chemical reaction
 - pore diffusion
 - combination of (a) & (b).

Group – B

2. (a) What is volumetric mass transfer coefficient? What are the factors that affect volumetric mass transfer coefficient? Draw the concentration profile at air-bubble – medium interface.

Run	1	2	3	4
v_0 liter/hr	30.0	9.0	3.6	1.5
C_{Af} millimol/liter	85.7	66.7	50	33.4

- (b) A 10 litre ($H/D = 1.4$) reactor having its stirrer rotating at 500 rpm is fed with air at a rate of 1 v u m is to be scaled up to 10,000 litre on similar geometry for equal aeration. Compute the speed of agitation in the scaled up vessel.

6 + 6 = 12

B.TECH/BT/6TH SEM/BIOT 3203/2017
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 the reaction rate doubles as the concentration of the reactant A increases by a factor of 2, what is the order of the reaction with respect to A?
- (a) First order (b) Zero order
(c) Pseudo first order (d) None of these.
- (ii) Swirling and vortex formation can be prevented by
- (a) using baffles (b) using diffusion ring with turbines
(c) both (a) and (b) (d) none of these.
- (iii) Yield coefficient represents
- (a) total biomass or product produced
(b) conversion efficiency of a substrate into product
(c) conversion rate of a substrate into biomass or product
(d) production time of biomass or product.
- (iv) The rate limiting step in the movement of oxygen from the gas phase in a bubble to the medium is the movement of oxygen molecules through
- (a) gas-liquid interface (b) bulk liquid
(c) gas phase (d) none of these.

- (b) A bioreactor has an oxygen mass transfer coefficient capabilities of 400 h^{-1} . What is the maximum cell concentration of E. coli that can be grown aerobically in this reactor? Respiration rate of E. Coli is $0.35 \text{ g O}_2 (\text{g cell})^{-1} \text{ h}^{-1}$. Critical oxygen concentration is 0.2 mg/L . Assume oxygen saturation with air to be 6.7 mg/L .

$$(2 + 2 + 2) + 6 = 12$$

3. (a) Derive washout condition from Monod chemostat model.

- (b) An aerobic batch fermentation is carried out using methanol as substrate. Calculate the following μ_{\max} , $Y_{X/S}$, K_S , t (doubling time) and S_p . Growth rate at 10 hrs. from given experimental data.

Time (hr.)	0	2	4	8	10	12	14	16	18
x(gm/lit.)	0.2	0.211	0.305	0.98	1.77	3.2	5.6	6.15	6.2
S(gm/lit.)	9.23	9.21	9.07	8.03	6.8	4.6	0.92	0.077	0.0

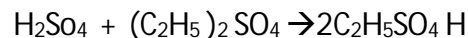
$$4 + 8 = 12$$

Group – C

4. (a) Explain how concentration, temperature and pressure affect reaction rate.
- (b) A mixed flow reactor (2 m^3) processes an aqueous feed (100 lit./min) containing reactant A ($C_{A0} = 100 \text{ mol/lit}$). The reaction is reversible and represented by $A \leftrightarrow R$, $-r_A = 0.04 C_A - 0.01 C_R$. What is the equilibrium conversion and the actual conversion in the reactor?

$$6 + 6 = 12$$

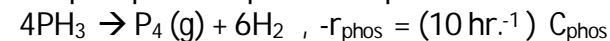
5. (a) The reaction of sulphuric acid with diethylsulfate in aqueous solution at 23°C is given below :



Initial conc. of H_2SO_4 and $(\text{C}_2\text{H}_5)_2\text{SO}_4$ are each 5.5 mol/lit . Find a rate equation for this reaction with the help of data given below:

Time (min) ---	0	41	55	96	146	194	267	368	410	infinite
$2\text{C}_2\text{H}_5\text{SO}_4\text{H}$ ---	0	1.18	1.63	2.75	3.76	4.31	4.86	5.32	5.42	5.8
(mol/lit.)										

- (b) At 650°C phosphine vapor decomposes as follows :



What size of PFR operating at 650°C and 11.4 atm is needed for 75% conversion of 10 mol/hr. of a feed containing $\frac{2}{3}$ phosphine and $\frac{1}{3}$ inert.

$$6 + 6 = 12$$

Group – D

6. (a) A sample of tracer was injected as pulse to a reactor and the effluent concentration measured as a function of time. The results are in the following table. Construct C and E curves.

T (min)	0	1	2	3	4	5	6	7	8	9	10	12	14
C (g/cum)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

- (b) Explain the relation between F and E curves.

$$8 + 4 = 12$$

7. (a) Explain axial dispersion and degree of back mixing.

- (b) Tracer data Given :-

T (min)	0	1	3	4	7	9	12	14
C (gm/m ³)	0	1	8	10	4	2.2	0.6	0.0

Determine the fraction of material leaving the reactor that has spent between 3 to 6 minutes in the vessel.

$$3 + 9 = 12$$

Group – E

8. (a) What are the different thumb rules for scale-up of reactors? What are their limitations and failures?

- (b) Briefly describe about the working principles and applications of membrane bioreactor and photo bioreactor with schematic diagram.

$$(3 + 3) + 6 = 12$$

9. (a) Pure gaseous reactant A ($C_{A0} = 100 \text{ millimol/liter}$) is fed at a steady rate into a mixed flow reactor ($V = 0.1 \text{ liter}$) where it dimerizes ($2A \rightarrow R$). For different gas rates the following data are obtained. Find a rate equation for this reaction.