Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech/BT(O)/SEM-5/BT-502/2012-13

2012

BIOREACTOR DESIGN AND ANALYSIS

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

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

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) Which of the following influences the rate of a chemical reaction performed in solution ?

      a) Temperature

      b) Activation energy

      c) Concentrations of reactants

      d) All of the above influence the rate.

   ii) A student determined the value of the rate constant, k, for a chemical reaction at several different temperatures. Which of the following graphs of the student's data would give a straight line ?

      a) k versus T b) $ln\ k$ versus $(1/T)$

      c) $ln\ k$ versus T d) $ln\ k$ versus E_a.

iii) 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.

iv) The rate law for certain reaction has a specific rate constant k, with unit of s^{-1}. What is the order of the reactions ?

a) 0 b) 1

c) 2 d) cannot be determined.

v) The unit of 2nd order reaction constant when partial pressure will be used in place of concentration is

a) atm-2 b) time-1 atm-2

c) time-1 atm-1 d) atm-1.

vi) Batch reactor is a

a) ideal reactor b) non-ideal reactor

c) steady d) both (a) and (b).

vii) A CSTR can be used for animal cell culture if the reactor is modified as

a) without stirers

b) removing buffels

c) agitating with low rpm

d) using micro-carriers.

viii) The $k_L a$ value is related to

a) O_2 transfer rate

b) Mass transfer unit

c) Enzyme immobilization constant rate

d) Rate of diffusion.

ix) Antibiotics formation is described by the kinetics of the type

a) Growth associated

b) Non-growth associated

c) Growth and Non-growth associated

d) Mass transfer controlling.

x) A packed bed reactor with immobilized cells is modelled as a

a) Plug flow reactor

b) Stirred tank reactor

c) Dispersion model

d) Plug flow with axial dispersion.

xi) Perfusion reactor is used for

a) Vaccine formation

b) Animal cell culture

c) Alcohol production

d) Biomass production.

xii) 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

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Experimental studies of a specific decomposition of A in a batch reactor using pressure units show exactly the same rate at two different temperatures :

   at 400 K, $-r_A = 2 \cdot 3\, P_A^2$

   Where $\begin{cases} -r_A = [\text{mol} / \text{m}^3 . \text{sec}] \\ P_A = [atm] \end{cases}$

   At 500 K, $-r_a = 2 \cdot 3 P_A^2$

   Transform the rate expressions into concentration units and then evaluate the activation energy.

   The pressure is not excessive, so the ideal gas law can be used.

3. For the decomposition $A \longrightarrow R$, $C_{A0} = 1$ mol/litre, in a batch reactor conversion is 75% after 1 hour, and is just completed after 2 hours. Find a rate equation to represent these kinetics.

4. An aqueous feed of A and B (400 litre/min, 100 mmol A/litre, 200 mmol B/litre) is to be converted to product in a plug flow reactor. The kinetics of the reaction is represented by $A + B \longrightarrow R$, $-r_A = 200\, C_A C_B$ mol/lit.min. Find the volume of reactor needed for 99·9% conversion of A to product.

5. What are the different thump rules for scale up of reactors ? What are their limitations and failures ?

6. Write a short note on trickle bed and membrane reactor.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) In a number of separate runs different concentrations of substrate and enzyme are introduced into a batch reactor and allowed to react. After a certain time the reaction is quenched and the vessel contents analyzed. From the results found below find a rate equation to represent the action of enzyme on substrate :

Run	$C_{E0}(\text{mol}/\text{m}^3)$	$C_{A0}(\text{mol}/\text{m}^3)$	$C_A(\text{mol}/\text{m}^3)$	t (hr)
1	3	400	10	1
2	2	200	5	1
3	1	20	1	1

b) Liquid A decomposes by first-order kinetics, and in a batch reactor 50% of *A* is converted in a 5-minute run. How much longer would it take to reach 75% conversion ? 10 + 5

8. a) The specific growth rate for inhibited growth in a chemostat is given by the following equation :

$\mu_g = \mu_m S/(K_s + S + IK_s/K_I)$

Where

$S_0 = 10\text{g}/l \quad K_s = 1\text{ g}/l \quad I = 0{\cdot}5\text{ g}/l$

$Y_{X/S}^{M} = 0{\cdot}1$ g cells /g subs

$X_0 = 0 \quad K_I = 0 \cdot 01\text{ g}/l \quad \mu_m = 0 \cdot 5\ h^{-1} \quad k_d = 0$

(i) Determine *X* and *S* as a function of *D* when $I = 0$

(ii) With inhibitor added to a chemostat, determine the effluent substrate concentration and *X* as a function of *D*.

(iii) Determine the cell productivity. *DX* as a function of dilution rate.

b) One litre per minute of liquid containing A and B (C_{A0}=0·1 mol/litre, $C_{B0} = 0 \cdot 01$ mol/litre) flow into a mixed reactor of volume V = 1 litre. The materials react in a complex manner for which the stoichiometry is unknown. The outlet stream from the reactor contains A, B and C ($C_{Af} = 0 \cdot 02$ mol/litre, $C_{Bf} = 0 \cdot 03$ mol/litre, $C_{Cf} = 0 \cdot 04$mol/litre). Find the rate of reaction of A, B and C for the conditions within the reactor . 10 + 5

9. A reactor with a number of dividing baffles is to be used to run the reaction $A \longrightarrow R$ with $-r_A = 0 \cdot 05\, C_A$ mol/litre. min

A pulse tracer test gives the following output curve.

Time (min)	0	10	20	30	40	50	60	70
Concentration reading	35	38	40	40	39	37	36	35

a) Calculate X_A from the dispersion model assuming small deviation from plug flow

b) Calculate X_A directly from the data. 8 + 7

10. a) What all points should be considered to design a bioreactor for animal cell culture. Describe the operation of hollow fiber reactor for the production of monoclonal antibody from hybridoma cells and indicate the design.

b) What is the importance of plant cell culture ? What are the differences between plant cells and microbes and implication for bioreactor design ? 9 + 6

11. Attempt any *three* of the following : 3×5

a) What is space time and holding time for flow reactor ? What is the relation between space time and holding time for constant density and changing density system ? Explain with example.

b) What are the advantages and disadvantages of bubble column reactor for aerobic microbial fermentation ?

c) Describe the method of determining $k_L a$ by the steady state method where the oxygen uptake rate (OUR) is $q_{o2} X$.

d) Write a short note on bioreactor consideration in immobilized cell system.