Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech(BT)/SEM-1/MBT-101/2009-10

2009

ADVANCES IN BIOREACTOR DESIGN DEVELOPMENT & SCALE-UP

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.

Graph sheet(s) will be provided by the institution.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

   i) Microbial growth with two substrates is characterized by

      a) exponential growth

      b) diauxic growth

      c) growth with inhibition

      d) rapid growth.

   ii) A reactor with perfusion system is used for the cultivation of

      a) yeast b) bacteria

      c) animal cell d) protozoa.

iii) Shear rate in a CSTR depends on

a) velocity gradient

b) impeller based Reynolds number

c) RPM of the impeller

d) tip speed of the impeller.

iv) Vaccines are best produced in a reactor of the type

a) bubble column b) air-lift fermenter

c) fluidized bed d) hollow fibre reactor.

v) Froude number should be used for a reactor of the type

a) bubble column

b) fluidized bed reactor

c) CSTR with baffles

d) plug flow reactor with recycle.

vi) k **Error!** is determined from

a) the correlation of (P/V) and U_{gs}

b) P/V and N

c) combination of (a) and (b)

d) P/V and diameter ratio of the reactor system.

vii) Blood is a non-Newtonian fluid of the type

a) Bingham plastic b) Casson equation

c) Pseudo-plastic d) Thixotropic.

viii) The kinetics of monoclonal antibodies are described by the kinetics of the type

a) growth associated

b) non-growth associated

c) Monod model

d) combination of (a) & (b).

ix) The plot of power number (NP_o) *vs* impeller based Reynolds number Re_I

a) increases linearly

b) decreases

c) remains constant beyond $Re_I = 10^4$

d) increases exponentially.

x) Antibiotics are best produced in a reactor of the type

a) packed bed b) fluidized bed

c) bubble column d) air-lift fermenter.

xi) Damkö hler no. (D_a) is a measure of

a) pore diffusion

b) film diffusion

c) combination of (a) and (b)

d) reaction kinetics.

xii) Thiele parameter predicts the effect of

a) molecular diffusion

b) chemical reaction

c) pore diffusion

d) combination of (a) & (b).

GROUP – B

(Short Answer Type Questions)

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

2. A CSTR of cylindrical vessel type of $\frac{L}{D_t}$ = 1·2 and volume of 1 m^3 is agitated with an impeller $(0{\cdot}3\,D_t)$ with the rotational speed of 250 rpm. The air enters at the volumetic flow rate of 0·022 m^3 /s at 1·08 atm and 25°C.
   Calculate the impeller based Reynolds number, Re_I.

3. Describe the design and operation of a hollow fibre membrane reactor for animal cell production.

4. A stirred tank reactor is to be scaled down from 100 m^3 to 0·1 m^3. The dimensions of the large tank are D_t = 2m, D_i = 0·5m, N = 100 rmp. Calculate the stirrer speed, N of the small reactor on the basis of impeller based Reynolds no, Re_I.

5. Determine k_{La} in hr^{-1} in a reactor system to maintain a cell population of $1 \propto 10^8$ cells/ml when the oxygen consumption by the cell is $0{\cdot}1 \propto 10^{-12}$ mol O_2 /(hr) (cell). The solubility of oxygen in water is C_L^* = 7·5 mg O_2 /L.

6. At room temperature sucrose (A) is hydrolysed by the enzyme sucrase (E) as follows $A \xrightarrow{E}$ products

   The following batch data are obtained :

C_A mol/m^3	0·68	0·16	0·006
t , hr	2	6	10

   At t = 0, C_{A_0} = 1 mol/m^3, the rate model is

   $-\frac{dC_A}{dt} = \frac{V_{max} C_A}{K_M + C_A}$. Linearise the model after integration to find out V_{max} and K_M (the kinetic parameters) .

7. What do you understand by the term "Media" ? Define industrial media. Write compositions of MRS and LBS media.

8. Define culture. What do you understand by the term "Activated culture" ?

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

9. A cylindrical tank of 1 m^3 is filled up to its diameter (L/D = 1·2). The turbine diameter is 0·3 m and rotating at the speed of 120 rpm. The air enters the reactor below the impeller at the volumetric flow rate of 0·005 m^3 /s at 1·08 atm and 25°C.

The hold-up is E_G = 0·02, and

D_{32} = (Sauter mean diameter) = 3·9 mm.

Calculate the following :

a) k_{La}

b) interfacial area, a

c) Impeller based Reynolds no. Re_I .

Given :

k_{La} = 0·026 $(P_g/V)^{0·4}$ $(U_{gs})^{0·5}$ sec^{-1}

p_L = 1000 kg/m^3 , μ = 8·9 ∞ 10^{-4} kg/ms at 25°C

P_g/V in W/m^3 .

10. a) Describe the design and operation of a bubble column fermenter, considering its mass transfer aspect in terms of k_{La} .

b) In a packed bed biofilm reactor carbon compounds are to be removed. The feed flow rate and the concentration of C-compounds in the feed are F = 2l/hr and S_0 = 2000 mg/L. The diameter of the column, D = 10 cm, the kinetic constants are r_m = 50 mgS/(cm^3) (hr), k_s = 25 mg/cm^3 , L (film thickness) = 0·5 mm, the sp. surface area of the biofilm is a = 2·5 cm^2 /cm^3 .

Calculate the required height of the column if the effluent concentration, S = 100 mg/L. 7 + 8

11. a) How do you differentiate between ideal PFR and non-ideal PFR ? Give their corresponding model equations.

b) Describe a CSTR system with modifications which can be used for the production of vaccines. 7 + 8

12. In a non-ideal reactor, the following reaction takes place :

$A \longrightarrow R, -r_A = 0{\cdot}1\ C_A$ kmol/ (m^3) (min)

From the tracer concentration, the mean ($\bar{t}$) and variance (σ^2) are 15 minutes and 45 min^2 respectively.

a) Calculate conversion of A (X_A) from dispersion model.

b) Evaluate X_A from the tanks-in-series model.

13. Write short notes on any *three* of the following : 3×5

a) Perfusion systems

b) Hollow fibre membrane reactor

c) Types of non-Newtonian fluids

d) Scale-up methods for bioreactors

e) Trickling filter for waste water treatment.

14. a) *M* & *M* reaction kinetics says $V = [\ S\ V_{max}\ ] / [\ k_m + S\ ]$. If it is correct, prove that $V_{max}\ t = S_0 - S + k_m\ ln\ S_0 / S$. Also prove that $k_m = S$.

b) $S \varnothing P$. Determine k_m and V_{max} from the experimental data given below with the help of graphical plot :

[*S*] 8, 10, 12, 16, 20, 25, 30, 35, 40, 45, 46, 47, 48, 48

[*V*] 13, 16, 19, 23, 26, 30, 31, 32, 33, 35, 35, 37, 37, 37. $2 \times 7\frac{1}{2}$

15. Derive Monod Chemostat model for steady state CSTR and find wash-out condition. Show the entire result graphically. $7\frac{1}{2} + 7\frac{1}{2}$