Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech (BT-OLD)/SEM-1/MBT-101/2010-11

2010-11

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.

GROUP – A

(Multiple Choice Type Questions)

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

   i) Plug flow behaviour of a reactor may be predicted if the flow is

      a) laminar b) turbulent

      c) intermediate d) viscous flow.

   ii) Volumetric mass transfer in a CSTR is given as a function

      a) P/V

      b) Ugs

      c) Re_I

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

iii) Animal cell culture is best carried out in a reactor of the type

a) CSTR

b) Bubble column

c) Airlift fermentor

d) Hollow fibre biological reactor (HFBR).

iv) Kinetics of alcohol production is based on the model of

a) Growth associated b) Non-growth associated

c) Luedeking-piret model d) Monod model.

v) High flow rates of a gas are measured by

a) Rotameter b) Orifice meter

c) Wet-gas meter d) Thermo-anemometer.

vi) The scale-up of a CSTR for animal cell culture should be based on constant

a) P/V b) impeller tip speed

c) Re_I d) mixing time.

vii) Trickle bed reactor in biotechnology is used for

a) alcohol production

b) antibiotic production

c) waste water treatment

d) animal cell culture.

viii) In a plus flow reaction $\frac{L}{D}$ ratio should be

a) $\frac{L}{D}=2$ b) $\frac{L}{D}<1$

c) $\frac{L}{D}=3$ d) $\frac{L}{D}>3$.

ix) Cheapest reactor for aerobic fermentation is

a) CSTR

b) bubble column

c) airlift framenter

d) fluidized bed.

x) Human blood is an non-Newtonian fluid of the type

a) Pseudoplastic

b) Bingham plastic

c) Dilatant

d) Cassan eguation.

xi) The design parameter of a chemostat is given by

a) specific growth rate

b) dilution rate

c) RTD

d) combination of (a) & (b)

xii) Monod model A behaves as a zero order reaction if

a) Rs << S

b) Rs >> S

c) Rs = S

d) $\mu \max = Rs$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. A clindrical tank of diameter of 1·0 m is filled with water. The tank is agitated with 0·3 m impeller diameter with flat six blade disk. The impeller rotational speed, N = 180 rpm. The air enters from the bottom at the rate of 0·005 m^3/s at 1·08 bar at 25° C. Calculate power requirement of the system.

   For $Re I_C > 10^4$, $N_P = \frac{P}{P N^3 D_I^5} = 6$. Assume that the properties of the liquid are the same as those of water. 5

3. Describe the operation of an airlift fermenter with internal loop and discuss its principal merits. 5

4. A reactor is to be scaled up from a 1·0 m^3 to 1000 m^3. The small reactor has a $\frac{L}{D} = 3·0$. The impeller diameter is 30% of the tank diameter agitator speed of the smaller tank is 500 rpm.

   Determine the dimensions of the large fermenter (L, D_t, D_I) and agitator speed for constant $\frac{P}{V}$. 5

5. Describe the dynamic method of determination of k_{La} for aerobic fermentation. 5

6. What conc. of competitive inhibitor is required to yield 75% inhibition at a substrate conc. of $1{\cdot}5\times10^{-3}$ μ if $k_m = 2{\cdot}9\times10^{-4}$ μ and $k_i = 2\times10^{-5}$ μ. 5

GROUP – C

(Long Answer Type Questions)

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

7. A CSTR of volume $1\ \text{m}^3$ $(L/D_t = 1{\cdot}5)$ and $D_I = 0{\cdot}3\,D_t$ is equipped with four baffles and is agitated at a speed of 300 rpm. The air enters from the bottom of the reactor at the rate of $0{\cdot}02\ \text{m}^3/\text{s}$ at 1·08 bar and 25° C. The sauter-mean diameter of the bubbles, $D_{32} = 4$ mm, $E_G = 0{\cdot}03$. Calculate the following :

   i) bubble rise velocity, u_b

   ii) interfacial area, a $\left(\text{m}^2/\text{m}^3\right)$

   iii) volumetric mass transfer coefficient, k_{La}

   Given :

   $k_{La} = 0{\cdot}026\left(P/V\right)^{0{\cdot}4}\left(V_{gs}\right)^{0{\cdot}5}\ \text{sec}^{-1}$ where P/V in w/m^2. 15

8. a) What are the merits and demerits of a bubble column reactor when it is used for aerobic microbial fermentations ? 7

b) An aerobic fermenter with good agitator speed in sparged with air for the growth of *E.Coli*. The oxygen uptake rate of *E.Coli* is 10 m mol/(g cell) (hr) and the estimated k_{La} value is 30 hr^{-1}. The critical dissolved oxygen concentration is 0·2 mg/L. The solubility of oxygen is 7·5 mg/L at 30° C. What can maximum concentration of *E.Coli* (X) be sustained in this fermater under aerobic condition ? 8

9. a) Derive an expression for a plug flow reactor with axial dispersion. How do you calculate conversion from such a model ? 7

b) Explain the operation of a hollow fibre membrane reactor for the production of a therapeutic protein using a perfusion system. 8

10. a) What are the different types of non-Newtonian fluids ? Draw their shear stress and strain diagram on the basis of power low model. 7

b) For a reaction of the type, $A \rightarrow R$ and $-r_A = 0 \cdot 1\ C_A$ k mol/$\left(m^3\right)$(min) in a reactor vessel whose tracer data due to pulse input gave $\delta_6^2 = 0 \cdot 15$, $\bar{t} = 12$ minutes. Calculate conversion X_A from tanks in series model. 8

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

a) Bioreactor control with instrumentation

b) Characteristic features of reactors for animal cell culture

c) Scale-up criteria for biological reactors

d) Growth recombinant cells with plasmid vectors.

12. a) Calculate V_i and the degree of inhibition caused by a competitive inhibition under the following conditions :

i) [S] = 0·00002 M and [I] = 0·00002 M

ii) [S] = 0·0004 M and [I] = 0·00003.

b) Calculate K_i for a non-competitive inhibitor if $[I] = 2 \times 10^{-4}$ M yield 75% inhibition of an enzyme catalyzed reaction.

c) Describe and compare the functioning of galvanic and polarographic oxygen electrode.

d) Explain how the rate of mass transfer affects the growth rate of microbes in an aerobic process. 15

13. a) Define chemostat and turbidostat. Derive Monod chemostat model from mass balance equation. Develop washout condition and show the final result with the help of a graphical plot.

b) With the help of schematic diagram [External Loop and Internal Loop Airlift React (ALR)]. Explain the operation of the ALR. 10 + 5