Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.Tech(BT)/SEM-2/MBT-204/2011
2011
DOWNSTREAM PROCESSING

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)   Micro-filtration membrances have pore sizes in the range

   a)   0·1 to 10 μm   b)   1 to 20 μm

   c)   10 to 20 μm   d)   50 to 80 μm.

   ii)   In gel filtration chromatographic separation, biomolecules are separated on the following property of biomolecules

   a)   size   b)   charge

   c)   hyrophobocity   d)   ion affinity.

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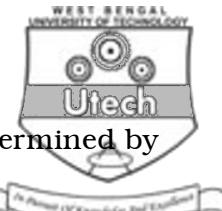
iii) Molecular weight of a protein can be determined by

  a)   size exclusion chromatography

  b)   ion exchange chromatography

  c)   affinity chromatography

  d)   electrophoresis.

iv) Non-mechanical methods of cell disruption include

  a)   French press   b)   bead mill

  c)   ball mill   d)   osmotic shock.

v) Cuprophane is a material used in the construction of membrane in the process of

  a)   dialysis   b)   hyper filtration

  c)   cross flow filtration   d)   ultra filtration.

vi) The isotherm used in the separation of protein by a solid adsorbent is the type

  a)   Langmuir adsorption isotherm

  b)   Freundlich adsorption isotherm

  c)   Tempkin adsorption isotherm

  d)   Monolayer adsorption isotherm.

vii) Medical oxygen is best prepared by a packed bed of adsorbent of the type

    a)   activated carbon   b)   sintered alumina

    c)   molecular sieve   d)   ZSM-5.

viii) Absolute alcohol from fermentation broth can be obtained by the following method

    a)   liquid-liquid extraction

    b)   adsorption

    c)   pervaporation

    d)   azeotropic distillation.

ix) Polarization factor has negligible effect on the hollow fibre permeater if the concentration difference is

    a)   less than 0·1   b)   less than 0·01

    c)   less than 1   d)   less than 10.

x) The average driving force, ΔP_M in cross flow filtrate is given by

    a) $\Delta P_M = \Delta P_{in} - \frac{1}{2} P_{av}$

    b) $\Delta P_M = \Delta P_{out} - \frac{1}{2} P_{av}$

    c) $\Delta P_M = \frac{1}{2} \Delta P_{av} - \Delta P_{out}$

    d) $\Delta P_M = \frac{1}{2} \Delta P_{av} - \Delta P_{in}$.

xi) Inhibitory fermentation product is best separated by

    a) liquid-liquid extraction

    b) aqueous for phase extraction

    c) adsorption

    d) ultrafiltration.

xii) Penicillin is more soluble in organic phase at pH

    a) 2 to 3   b) 4 to 5

    c) 6 to 7   d) 8 to 9.

GROUP – B
(Short Answer Type Questions)
Answer any *three* of the following.   3 × 5 = 15

2. Derive expressions for solvent and solute fluxes in a reverse osmosis process.

3. A 5% sucrose (Mol. wt. 342) solution in water is fed at $2l$/min to a reverse osmosis cell at 25°C to concentrate it to 80%, using a membrane which has the following characteristics on the membrane $L_P = 10^{-5}$ g/(cm^2) (s) (bar), the reflect coefficient, $\sigma = 0.074$, the permeability of the solute, $P \spadesuit O$.

If a hydrostatic pressure of 50 bar is imposed on the solution side, what is the membrane area necessary for the above flow rate ?

4. An antibiotic is to be extracted from the clarified broth by using methyl chloride as solvent. The distribution coefficient, K_D = 23. The initial concentration of the antibiotic in the feed is 150 mg/L. The recovered solvent containing 5 mg/L of cyclo hexamide is being used with the flow rate of 1 m^3/hr. The required recovery of the antibiotic is 98 percent. If 4 counter current stages are used, how much feed can be processed per hour ?

5. Ultra-filtration system was used for a protein solution at contant volume to remove low mol. wt. species. The flow channel for this system are tubes 0·1 cm in dia and 100 cm long. The protein has a diffusion coefficient of $9 \infty 10^{-7}$ cm^2/sec. The solution has a viscosity of 1.2 cp and a density of 1.1 gm/cm^3. The system is capable of operating at a bulk stream velocity of 300 cm/sec. At this velocity, determine the polarization modulus for a transmembrane flux of 45 lit./m^2.hr.   5

6. Data were obtained on the precipitation of a protein by the addition of ammonium sulfate. The initial conc. of the protein was 15 gm/lit. At ammonium sulfare conc. of 0.5 to 1.0 M, the concentrations of the protein remaining in the mother liquor at equilibrium were 13.5 and 5.0 g/lit., respectively. From this information, estimate the ammonium sulfate conc. to give 95% recovery of the protein as precipitate.

7. Determine the specific cake resistance(α), total cake resitance (rc) and medium resistance (rm) from the following data. What can be concluded regarding rc and rm from the results?

Time, secs	20	60	180	540	900	1500
Filtrate vol, ($V \propto 10^{-6}$), m^3	50	120	257	491	667	940

Also given : filter diameter = 7.5 cms, viscosity of filtrate = 1.2 m Pas and solid concentrate = 5 kg/m^3 .

GROUP – C

(Long Answer Type Questions)

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

8. An antibiotic from a fermentation broth (10L) is to be isolated by using activated carbon.

The concentration of the antibiotic (X_0) is $1 \cdot 1 \propto 10^{-6}$ g/g water. 95% of the antibiotic needs to be recovered. The adsorption isothorm is given as $Y^* = 0 \cdot 13 \, X^{0 \cdot 3}$ where Y^* is gm of solute/g. carbon at equilibrium.

a) using a simgle stage, how must adsorbent is needed ?

b) If 2 counter current stages are used, how much total adsorbent is required ? $8 + 7$

9. a) What is pressure – swing adsorption ? How do you prepare medical oxygen from air by two adsorption columns, using pressure swing adsorption ?

b) Show the concentration profiles and break through curve for adsorption in a fixed bed. Give the simplest equation of a break through curve in terms of N (overall number of transfer units) and τ (the dimension less time). $7 + 8$
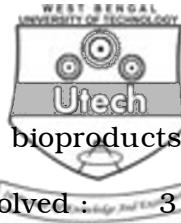
10. Discuss the process details of the following bioproducts in the form of flow sheet and unit operations involved : 3 × 5

    a) Banker's yeast

    b) Gluconic acid

    c) Streptomycin.

11. a) It is desired to scale-up a batch crystallization of an antibiotic based on experiments with a one liter crystallizer. The use of a 3 cm dia impeller at a speed of 800 rpm led to good crystallization result. For maintaining power per volume constant upon scale-up to 300 litrs, what should be the diameter and speed of the large-scale impeller ? The solvent has the same density and viscosity as of water.

    b) A non-porous wet cake of bioligcal solids that is 0·5 cm thick is to be dried by blowing dry air across the top surface. The initial moisture content is 70 wt.% water and it is desired to dry the cake in a water content of 5 wt.%. The diffusion coefficient of water in the cake has been estimated to be 7×10^{-6} cm^2 S^{-1} Estimate how long the drying will take. $7\frac{1}{2} + 7\frac{1}{2}$
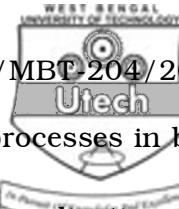
12. a) What are the advantages of membrane processes in bio-separation operations ? Discuss the applications of cross flow filtration (CFF) in downstream processing with examples. Discuss asnd explain an expression proposed for predicting fouling in UF and CFF.

b) A membrane process is being designed to recover solute A from a dilute solution where

c_1 = 2·0 ∞ 10^{-2} kg mol A/m^3 , by dialysis through a membrane, to a solution where 0·3 ∞ 10^{-2} kg mol A/m^3 . The membrane thickness is 1·59 ∞ 10^{-5} m, the disribution coefficient

K = 0·75, D_{AB} = 3·5 ∞ 10^{-11} m^2/s in the memebrane, the mass transfer coefficient in the dilute solution is k_{c1} = 3·5 ∞ 10^{-5} m/s and k_{c2} = 2·1 ∞ 10^{-5} m/s.

i) calculate the individual resistances and total % resistance of the two films.

ii) calculate the flux at steady state and the total area in m2 for a transfer of 0.01 kg mol solute/hr.

iii) Increasing the velocity of both liquid phases flowing past the membrane will increase mass transfer coefficients as k_c proportional to $v^{0.6}$, where v is velocity of fluid in m/s. If the velocities are doubled, calculate the total percent resistance of the two films and the percent increase in flux.

$$(1 + 2 + 3) + (3 + 3 + 3)$$

13. a) What are the factors that affect specific cake resistance is filtration ? How does upstream conditions affect the rate of filtration during filtration of a fermentation broth ? Explain with example.

b) It is desired to use a cross flow filtration system to desalt 1000 liters of a protein solution containing NaC1. The system is capable of operation at a transmembrane flux of 30 liters/m^2 . hr. To remove 99.99% of the salt, determine the time required and the volume of water required using a cross flow filtration unit with a membrane area of 100 m^2 .

c) It is desired to achieve complete recovery of bacterial cells from a fermentation broth with a pilot plant scale tubular centrifuge. Cells are spherical with a radius of 0.5 μm and have a density of 1.10 g/cm^3 . The speed of the centrifuge is 5000 rpm, the bowl dia is 10 cm, the bowl length is 100 cm and the outlet opening of the bowl has a diameter of 4 cm. Estimate the maximum flow rate of the fermentation broth that may be attained.(1 + 2) + 5 + 7

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