Ex/PG/BPE/T/121A/2024

MASTER OF BIOPROCESS ENGINEERING EXAMINATION, 2024

[1ST year, 2nd semester]

Bioseparation Engineering

Time: 3 hours. **Full Marks: 100**

Answer q. 1 (compulsory) and any four from the rest. Questions 2 to 9 have 16 marks each.

1. Answer any nine. [9 x 4 = 36]. Be very brief.

(a) Show the force balance on a spherical particle falling under gravity in a viscous medium, leading to the settling velocity.

(b) Give expressions for Graetz-leveque and Dittus-Boelter equations for determining mass transfer coefficient in ultrafiltration.

(c) Show the relationship between intrinsic and apparent sieving coefficients in ultrafiltration

(d) Diagrammatically explain the concept of concentration polarization layer and gel layer in ultrafiltration and how resistances arising therefrom affect permeation rate.

(e) State mathematically the Van-Deemter Equation in column chromatography, explaining the individual terms.

(f) Explain the concept of theoretical plates for a chromatographic column. How is the number of plates related to the base width and to the peak width at half-height ?

(g) Show how and when Langmuir and Freundlich models in adsorption reduce to a linear model

(h) State and explain the Cohn equation in precipitation .

(i) Obtain a relation between the concentrations of solute in feed and final raffinate in multistage batch extraction.

(j) Enlist the physical and chemical methods (just state names) employed for breakage of cell.

2. 100 cc of a fermentation broth pretreated with filter-aid may be filtered in 24 min in a 5 cm dia Buchner funnel attached to an aspirator, under ordinary atmospheric pressure. Find the time required to filter 3000 L of this broth in a plate-and-frame filter press consisting of 15 frames each of area 3520 cm^3 at 25 psi pressure. (Assume negligible filter medium resistance and cake compressibility = 0.67)

3. (a). 50 litres of filtrate is collected in 30 minutes when an inorganic suspension is filtered through a sintered glass filter using a pressure drop of 50 kPa. How much filtrate will be collected in 30 minutes at a pressure drop of 100 kPa? Assume that Rm is negligible.

   (b)A laboratory bottle centrifuge consists of a number of cylindrical bottles rotated perpendicular to the axis of rotation. Such a centrifuge, operated @ 500 rpm, is used to separate yeast cells from a fermentation broth. During centrifugation, the distance between the surface of liquid in the bottles and the axis of rotation is 3 cm. whereas the distance from the bottom of the bottles to that axis is 10 cm. The yeast cells can be assumed to be spherical with dia= 8 μm and density = 1.05g / cm^3. The broth liquid may be assumed to have physical properties close to that of pure water. How long does it take to have a complete separation?

4. A plasmid solution (concentration = 0.1g / l) is being concentrated by ultrafiltration in a continuous manner using a tubular membrane module, which gives an apparent sieving coefficient of 0.02. The feed flow rate into the membrane module is 800 ml/min and the average permeate flux obtained at the operating condition is $3 * 10^{-5}$ m / s. If the membrane surface area is 0.1m^2 predict the concentration of the plasmid in the retentate stream. Assume that the permeate flux is same at all locations on the membrane and the concentration of the plasmid increases linearly within the membrane module.

5. The adsorption of a certain antibiotic from aqueous solution onto a proprietary adsorbent gives the following equilibrium data:

Y (mg/L solution)	0.01	0.02	0.03	0.06	0.10
Q (mg/cm^3 adsorbent)	5.3	7.1	8.3	11.1	13.7

   Which adsorption isotherm best fits the data? Estimate the parameters of that best-fit equation.

6. The adsorption of the enzyme phosphoglycerate kinase, isolated from yeast, onto celulose, follows Langmuir isotherm with a maximum uptake of 70 mg/ cc adsorbent. Haf of this maximum occurs when the solution contains 50 mg/L of enzyme, Given 1.5 L of feed solution containing 220 mg/L of this enzyme find how much cellulose is required to adsorb 99% of enzyme initially present.

7. 1L water is used to 'strip' a certain amino acid from 4.7 L of toluene containing 0.006M of this amino acid. The amino acid partitions between toluene and water as per the equilibrium relation $x^2 = Ky$ (K=0.001 mol/L), where x and y are solute concentrations in organic and aqueous phases respectively. Find the % of amino acid originally present in feed that is extracted.

8. 100 L. of a solution containing 10 g/L of BSA (bovine serum albumin) and 5 g/L of a second unidentified protein (X) is to be treated with ammonium sulfate, with the objective of recovering 90% of the BSA in the precipitate. Precipitation constants for the two proteins are:

Protein	B	K_s
BSA	21.6	7.65
X	20.0	7.00

where the constants have their usual meaning. Assuming that these properties are independent of the presence of the other protein, what is the purity of the precipitate obtained?

9. A chromatographic separation of a two component samples on a 50 cm column gave the retention times for the solutes A and B as 2.5 and 3.1 minutes with base widths of the two chromatographic peaks being 0.24 and 0.3 minutes respectively. Calculate the (a) number of theoretical plates, (b) plate height and (c) resolution of the two peaks.
   Using the data in question 8. above, calculate the resolution of the two peaks on an 80 cm column.