Instructions: For all numerical problems, the answer must show the base equations, the condition validation (if needed), unit for each value in the steps, and the final answer derived from the correct steps and calculations. Marks will not be awarded, even when the answer is correct, if the above conditions are not fulfilled. Each of the questions carries equal marks. Total marks: 30

1. (a) State two approaches through which you can alter the standard chemical potential of the solute in the lighter phase to improve the extraction from a heavier phase. (b) Depict graphically, how the extractability of the solute increases under these altered conditions and cite the base equation to endorse the approach.

2. A dilute buffer solution containing 12 mg/liter of cholesterol was extracted with ethyl acetate. The ratio of buffer solution to the solvent was 50 and the equilibrium constant for the cholesterol was 200. Calculate the concentration of the cholesterol in ethyl acetate after extraction. What fraction of the cholesterol has been removed?

3. (a) Erythromycin adsorbed on activated carbon follows Freundlich adsorption isotherm. A 10 cm^3 of fresh carbon was mixed with 5 liter of the fermentation beer containing 50 mg/liter of the antibiotic. The graphical solution obtained by using the equilibrium and operating lines offers the values of q 14 mg/cm^3 and y 0.10 mg/L. Deduce the operating line for the extraction. What percent recovery of the erythromycin can be expected? Solute concentrations: q is in mg/cm^3 carbon and y is in mg/liter. (b) Compare the extraction and adsorption methods utilized in the bioseparation on the following parameters: Selectivity, nature of equilibrium.

4. A disc bowl centrifuge containing 80 discs with an angle of 40°, outer radius of 15.7 cm and inner radius of 6 cm was operated at 6000r/min to separate bacterial cells from an aerobic culture broth. The settling velocity for the cells was 1.07×10^{-4} cm/s. Estimate the volumetric capacity for this centrifuge.

5. 250 cm^3 slurry containing a steroid at 0.016 g/cm^3 can be filtered in 32 min. The filter has a surface area of 8.3 cm^2, a pressure drop of 1 atm, and a filter medium of negligible resistance. The solids in the cake have a density of 1.09 g solids/cm^3 cake, and the slurry density is that of water. We want to use this experiment to estimate the time to filter 1600 liters of this slurry through a centrifugal filter. The filter has a basket of 51 cm radius and 45 cm height. It rotates at 530 r/min. When it is spinning, the liquid and cake together are 5.5 cm thick. How long will this filtration take? Given that the thickness of the cake 49.3 cm. [Factor 1.01×10^6 $g/cm.sec^2$ may be used for replacing 1 atm].

6. A partially hydrolyzed sugar believed to be mono-acidic is extracted from water into 1-hexanol. The intrinsic partition co-efficient (K_i) is 10 and the association constant (K_a) is 5×10^{-5} mol/liter. What is the value of partition co-efficient (K) at pH 7.0?

7. (a) Depict graphically the qualitative behavior of continuous stirred tank reactor (CSTR) for no adsorption, typical adsorption and rapid adsorption. (b) State the limiting mechanisms that control the rate of adsorption of solute on the adsorbent in the CSTR and define the rates for each of the cases.

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8. Mention the feed characteristics that prompt you to select centrifugation instead of filtration in the initial stage of insoluble removal from the feeds. (b) Draw the diagrams of the Tubular bowl centrifuge and Basket centrifuge and mention their differences in terms of separated solid characteristics.

9. (a) Why fermentation beers are generally hard to filter? (b) State three different types of pretreatment applied to such biological fluid to facilitate the filtrations. Give examples of materials used for at least two types of pretreatments.

10. We want to separate fungal biomass from a broth by filtration to collect filtrate containing an antibiotic. The medium resistance of the broth is void. The filter leaf has a total surface area of 0.1 ft^2, and the filtrate has a viscosity of 1.1cP. The pressure drop is 20 in of mercury, and the feed contains 0.015 kg dry cake per liter. The slope of the plot (At/V) vs (V/A) discerned from the filtration data was 29s/cm^2. Determine the specific resistance of the cake accumulated following the filtration.

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