Instructions: *Answer all questions. For all numerical problems, the answer must show the base equations, the unit for each value in the steps, and the final answer derived from the correct steps and calculations. Marks will not be awarded if the above conditions are not fulfilled, even if the answer is correct. Each of the questions carries equal marks.* **Total Marks: 40**

1. (a) State the common stages involved in downstream processing and identify the unit operation typically used in each of the stages. (b) Mention the characteristics of the feed that prompted you to select centrifugation instead of filtration in the initial stage of insoluble removal from the feeds.

2. (a) State two routes through which you can alter the standard chemical potential of the solute in the lighter phase to improve the extraction ? (b) Depict graphically, how the extractability of the solute increases under these altered conditions. (c) Draw the diagrams of Tubular bowl centrifuge and Basket centrifuge and mention their differences in terms of functions.

3. State differences in principle involved in the following techniques used to disintegrate cells for processing bioseparation: (a) Solubilization versus Lipid dissolution. (b) Grinding versus Homogenization.

4. (a) Why the cake formation in microfiltration is negligible? (b) Distinguish the microfiltration from the conventional filtration on the basis of Darcy's law of permeability. (c) State the three design of the filter commonly used in microfiltration and identify the one that does not often plug and easy to clean.

5. (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.

6. Cholesterol containing 12 mg/liter was extracted with ethyl acetate from a dilute buffer solution. 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?

7. Erythromycin adsorbed on activated carbon following 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?

8. 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 cyanobacteria cells from a pond-grown aerobic culture. Estimate the volumetric capacity for this centrifuge.

9. We can filter 250 cm^3 of a slurry containing 0.016 g/cm^3 progesterone in 32 min. Our 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 $R_c = 49.3$ cm. [Factor $1.01 \times 10^6 \text{ g/cm.sec}^2$ may be used for replacing 1 atm].

10. Compare the extraction and adsorption methods utilized in the bioseparation with respect to the following parameters: Capacity, Selectivity, nature of equilibrium, and problems.

END