U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**

Branch: Biotechnology **Duration: 3 hrs.**

Course Code: 23BT6PCBPT/22BT6PCBPT/19BT6DCBPT **Max Marks: 100**

Course: Bioprocess Technology

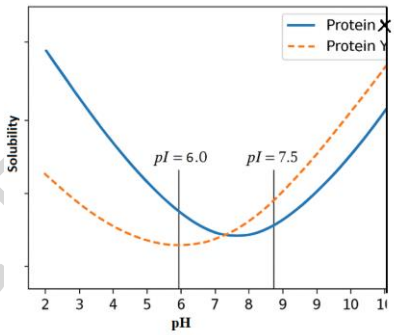
Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	CO	PO	Marks
1	a)	Differentiate feedback inhibition from feedback repression with an illustration.	*CO1*	*PO1*	**8**
	b)	A biotechnology firm is aiming to produce a thermostable amylase enzyme for application in the starch processing industry, where enzymes must operate efficiently at high temperatures and pH levels. The R&D team is evaluating two strategies: 1. Isolate a novel thermophilic microorganism from geothermal environments (e.g., hot springs, deep-sea vents). 2. Source an industrially validated strain from a microbial culture collection known to produce amylase. As a microbial biotechnologist, critically evaluate this decision by addressing the following: i. Compare the advantages and limitations of isolating a novel thermophilic strain versus sourcing an established amylase-producing strain from a microbial culture collection. ii. Discuss the economic, regulatory, and process scale-up factors that influence the strategic choice. iii. Recommend the most suitable approach for the company and justify your recommendation with examples from industrial enzyme production practices.	*CO1*	*PO1*	**12**
		OR			
2	a)	Illustrate how do you isolate mutants that do not recognize the presence of inhibitors and repressors.	*CO1*	*PO1*	**6**
	b)	A Bioprocess Technology Engineer is optimizing a continuous fermentation system for large-scale biosurfactant production using	*CO1*	*PO1*	**14**

			either *Pseudomonas aeruginosa* or *Candida bombicola*. The following microbial characteristics are known: o *Pseudomonas aeruginosa:* μmax = 0.6 h^{-1}; Ks = 0.05 g/L ;Produces rhamnolipid extracellularly ; Can utilize a wide range of carbon sources including waste oils; Optimal growth at 35–40°C o *Candida bombicola:* μmax = 0.4 h^{-1}; Ks = 0.02 g/L; Produces sophorolipids intracellularly and partially secreted; Requires glucose and fatty acid co-substrate for high yields; Optimal growth at 25–28°C The continuous reactor is operated at a steady-state dilution rate D = 0.3 h^{-1}. Analyze the feasibility of each microorganism for large-scale enzyme production by addressing the following questions: i. Calculate the steady-state substrate concentration (**S**) for each strain using the Monod equation. ii. Discuss the ease and cost of downstream processing for product from each strain. iii. Evaluate the two microbes in terms of: • Substrate cost and availability • Operating conditions (temperature, safety) • Genetic stability and scalability • Environmental or regulatory concerns. Based on your above analysis, suggest the more suitable microorganism for continuous biosurfactant production and justify your selection.			
			UNIT - II			
	3	a)	Differentiate between inducers, precursors, and growth factors in the context of bioproduct yield.	*CO2*	*PO1,3*	**10**
		b)	A biotechnology company is scaling up its fermentation process from a 12 dm^3 laboratory fermenter (designed by Wegrich & Shurter with an L/D ratio of 1.1, P/D ratio of 0.5, and a baffle width/D ratio of 0.08) to a 250 dm^3 industrial fermenter (designed by Steel & Maxon with an L/D ratio of 0.72, P/D ratio of 0.4, and a baffle width/D ratio of 0.10). Discuss how these design changes may influence the overall process performance, including the trade-offs involved and any potential improvements or challenges the company may face in optimizing energy efficiency and process efficiency.	*CO2*	*PO1,3*	**10**
			OR			
	4	a)	Compare and contrast the different types of spargers. Discuss the advantages and disadvantages of each type in the context of different fermentation processes.	*CO2*	*PO1,3*	**10**
		b)	A researcher was culturing an organism in a reactor. During culturing she added toxic compounds to the medium to kill the organisms immediately. Increase in DO concentration upon addition of toxic compounds followed by the aid of DO analyzer and a recorder. Using the following data, calculate the Volumetric oxygen transfer coefficient (K_La) for the reactor. Saturated DO is 9mg/ml. Comment on the result.	*CO2*	*PO1,3*	**10**

			Time(min)	1	2	2.5	3	4	5	
			CL or DO (mg/L)	1	3	4	5	6.5	7.2	
			UNIT - III							
	5	a)	List and explain the factors that need to be considered when designing a bioseparation process.						*CO4*	*PO1,5*	**10**
		b)	Draw a flow diagram showing the steps of ethanol production to final purification, and briefly explain what happens at each stage to turn the fermentation broth into pure, fuel-grade ethanol.						*CO4*	*PO1,5*	**10**
			OR							
	6	a)	Illustrate the downstream processing workflow used in bioprocessing after upstream processing is complete. Explain the general stages involved in transforming the bioreactor output to obtain the final product in a pure and usable form, and discuss how this workflow impacts the cost and efficiency of large-scale production.						*CO4*	*PO1,5*	**10**
		b)	In a downstream bioprocess, a fermentation broth containing microbial cells is filtered under constant pressure to recover a valuable metabolite present in the clarified liquid. The pressure drop across the filtration unit is 1.5×10^5 Pa. The filtration is carried out using a filter with an area of 0.5 square meters. The viscosity of the fermentation broth is 1.2×10^{-3} Pa.s. The resistance of the clean filter medium is 2×10^{10} /m. After filtering 30 liters of broth, the resistance due to the filter cake is measured as 4×10^{10} /m. a) Calculate the average filtration rate. b) What will happen to the filtration rate if the viscosity of the broth doubles? c) Explain why the cake resistance increases as filtration progresses in a fermentation broth.						*CO4*	*PO1,5*	**10**
			UNIT - IV							
	7	a)	Explain the structural features of a globular protein in aqueous solution. Prepare a table listing each structural feature along with its role in protein precipitation. Discuss how understanding these roles is important in biotechnological applications.						*CO4*	*PO1,5*	**10**

		b)	A microfiltration unit is used to separate micron-sized particles from a liquid slurry. The transmembrane pressure applied during the filtration process is 100 kPa, and the viscosity of the permeate is 1.0×10^{-3} kg/m·s. The membrane used in the process has a resistance of 1.0×10^{11} m^{-1}. During operation, a cake layer is formed on the membrane with a volume of 0.002 m^3 over a membrane area of 1.0 m^2. The porosity of the formed cake is 0.4, and the mean diameter of the suspended particles is 2.0×10^{-6} m. Using this information, calculate: i. The specific cake resistance using the appropriate equation for micron-sized particles. ii. The cake resistance and total resistance of the system. iii. The permeate flux through the membrane. Assume steady-state conditions. Show all steps clearly and express your final answer for the permeate flux in $m^3/m^2\cdot s$ with correct units.	*CO4*	*PO1,5*	**10**
			OR			
	8	a)	Classify membranes based on their structural and morphological characteristics. Compare each type in terms of structure, transport mechanism, selectivity, and applications. Support your answer with neat and well-labeled diagrams.	*CO4*	*PO1,5*	**10**
		b)	You are given the solubility vs. pH curves for two proteins, Protein X and Protein Y, as shown in the plot below.  Using the plot: 1. Explain why the solubility of each protein reaches a minimum at its respective pI. 2. Predict the net charge on each protein at pH 7.0 and discuss how this affects their relative solubility. 3. If you want to selectively precipitate Protein X from a mixture of both proteins, at what pH would you adjust the solution? Justify your answer using the plot. 4. Discuss how this understanding can be applied in industrial protein purification processes.	*CO4*	*PO1,5*	**10**

<table>
<tr><td></td><td></td><td></td><td>UNIT - V</td><td></td><td></td><td></td></tr>
<tr><td></td><td>9</td><td>a)</td><td>Define crystallization and explain the different zones of crystallization with the help of a neat diagram.</td><td>CO4</td><td>PO1,5</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>A biotechnology laboratory is purifying an alkaloid from a plant extract using a liquid-liquid extraction process with ethyl acetate (organic phase) and water (aqueous phase). The alkaloid has a partition coefficient of 2.0 between the organic and aqueous phases. Initially, the aqueous phase has a volume of 100 mL and contains 300 mg of the alkaloid. Two successive extractions are performed using 50 mL portions of the organic solvent. Answer the following:
i. Calculate the amount of alkaloid recovered in each stage
ii. Determine the total percentage recovery after both stages,
iii. Comment on the results.
iv. Discuss the efficiency of multi-stage extraction for laboratory-scale purification and how such a method could be translated to industrial-scale operations.</td><td>CO4</td><td>PO1,5</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>10</td><td>a)</td><td>With the help of neat sketches, explain the working and applications of tray dryers and fluidized bed dryers in bioprocess industries.</td><td>CO4</td><td>PO1,5</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>In a mammalian cell culture bioreactor, cell aggregates form during cultivation. The number of aggregates per liter N with size less than or equal to (μm) is:
<table><tr><td>Aggregate size L(μm)</td><td>20</td><td>40</td><td>60</td><td>80</td><td>100</td></tr><tr><td>Number of aggregates N per liter</td><td>500</td><td>1300</td><td>2500</td><td>3800</td><td>4700</td></tr></table>i. Plot the cumulative distribution N vs L
ii. Determine the local aggregate formation rate between L=40 and 60
iii. Discuss implications for bioreactor mixing and oxygen transfer</td><td>CO4</td><td>PO1,5</td><td>10</td></tr>
</table>

****