

Time allowed: 3 Hours

Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Section.

x-x-x

1. Attempt the following:
  - a. Give a brief overview of cell-removal operation.
  - b. Define ideal stage concept.
  - c. Define aqueous two phase liquid extraction process.
  - d. Express quasi-steady state of a Fed-batch culture.
  - e. Discuss the significance of low  $K_s$  value?
  - f. Define specific cake resistance.
  - g. Differentiate between a chemostat and a turbidostat?
  - h. Justify the function of a filter aid.
  - i. Enlist various polymeric materials used for membrane separation process.
  - j. Define maintenance coefficient "m".

(10)

**SECTION-A**

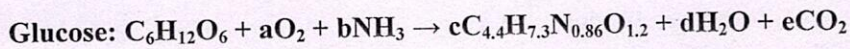
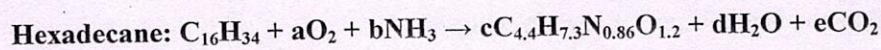
2.
    - a) Describe typical unit operations required in the recovery and purification of an intracellular protein product from a bacterial source, downstream of the bioreactor. Give your recommendations.
    - b) Enlist various membrane-driven processes used as a separation technique. Describe how do you determine the specific cake resistance and fictitious equivalent cake thickness in a constant-pressure filtration?
- (4,6)
3.
    - a) Leucine dehydrogenase is recovered from 150 litres of *Bacillus cerus* homogenate using an aqueous two-phase polyethyleneglycol-salt system. The homogenate initially contains 3.2 units of enzyme  $\text{ml}^{-1}$ . A polyethylene glycol-salt mixture is added and two phases form. The enzyme partition coefficient is 3.5. i) What volume ratio of upper and lower phase must be chosen to achieve 80% recovery of enzyme in a single extraction step? ii) If the volume of the lower phase is 100 litres, what is the concentration factor for 80% recovery?
    - b) What is a marker or a ladder? Why is this considered standard? How does size of the DNA affect its migration through the agarose gel during electrophoresis?
- (5,5)
4.
    - a) With the help of protein structure and surface chemistry, explain the following terms (i) Stern layer (ii) salting-in and salting-out.
    - b) Find the g-factor of a centrifuge with an effective radius of 10 cm and rotating at a speed of 30 rps.
    - c) Give a detailed account on the working and design of the *disc-bowl centrifuge*.
- (4,2,4)



(2)

SECTION-B

5. a) Explain how and why 'wash-out' occurs in an ideal CSTF. Show that this problem can be overcome by separating and recycling part of the cells coming out of the reactor back to the reactor vessel.
- b) List down the factors that affect specific growth rate. If there is a mathematical description of the same, show that also. (6,4)
6. Assume the experimental measurements for a certain organism have shown that cells can convert two-thirds (wt/wt) of the substrate carbon (alkane or glucose) to biomass.
- a) Calculate the stoichiometric coefficients for the following biological reactions:



- b) Determine the degree of reduction for the substrate and bacteria for both reactions.
- c) Calculate the yield coefficients  $Y_{X/S}$ ,  $Y_{X/O_2}$  and RQ for both reactions. Comment on the differences. (10)
7. a) Fermentation of *Candida utilis* exhibit substrate inhibition kinetics given by the following equation

$$\mu = \frac{\mu_{\max} \cdot S}{K_S + S + S^2/K_I}$$

Where S is the substrate concentration and  $\mu$  is the specific growth rate. For a continuous fermentation using sterile feed, derive an equation for the steady state variation of biomass concentration, substrate concentration and maximum cell productivity with dilution rate when (i)  $I=0$ (ii) I is not equal to zero.

- b) Explain different types of inhibition by toxic compounds along with the graphical representation.
- c) What is the generation time if 100 bacterial cells growing logarithmically for 5 hours produce  $1.7 \times 10^6$  cells? (5,3,2)