

National Exams May 2014

04-Chem-B4, Biochemical Engineering

3 hours duration

NOTES:

- 1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.**
- 2. This is a CLOSED BOOK EXAM. Any non-communicating calculator is permitted.**
- 3. FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.**
- 4. Each question is of equal value.**
- 5. Most questions require an answer in essay format. Clarity and organization of the answer are important.**

Question 1 (20 marks)

A biotechnology company has obtained lab scale and pilot scale data for a bioprocess. The lab scale bioreactor is 12 inches diameter and a tank (liquid) height of 50 cm. The bioreactor has an impeller which is a pitched blade turbine with a diameter of 4 inches and is operated at an RPM of 60. The larger bioreactor is a tank geometrically similar in terms of ratios of height/diameter of the tank and the tank to impeller diameter but is 100 times larger in volume. What is the impeller speed in the larger vessel to the smaller bioreactor assuming each of the following scale up criteria respectively: (a) equal impeller Reynolds number; (b) equal power per unit volume; (c) equal impeller pumping rate (d) equal impeller tip speed.

Question 2 (20 marks)

An enzyme is immobilized in the form of spherical beads. The immobilized enzyme beads follow a first order kinetics with a reaction rate constant of 3.6 h^{-1} . Given the radius of the beads is 6 mm and the effective diffusivity for substrate in the beads is $1 \times 10^{-6} \text{ m}^2 \cdot \text{s}^{-1}$:

- (i) Is the availability of substrate a limiting factor in this system? Justify your answer with a quantitative explanation.
- (ii) The immobilized beads in 2(i) are now replaced by rectangular shaped strips of immobilized enzyme. The volume of each strip is $1 \times 10^{-9} \text{ m}^3$ and its surface area is $6 \times 10^{-6} \text{ m}^2$. How will this affect the answer obtained for 2(i)? Provide a quantitative explanation.

Question 3 (20 marks)

- (i) Compare and contrast prokaryotes and eukaryotes (10 marks).
- (ii) Discuss and describe in detail any one of the following (1) Aerobic Respiration in cells; (2) Electron Transport Chain (3) Oxygenic Photosynthesis metabolism. (10 marks)

Question 4 (20 marks)

- (i) Prove that for a chemostat (steady state continuous bioreactor) system, where microbes are being cultivated the dilution rate is equal to the specific cell growth rate of cells until washout (10 marks).
- (ii) Compare and contrast biomass productivity in batch and continuous cultivation in bioreactors when the inlet or initial substrate concentration $S_0 \gg K_s$ where K_s is the substrate limitation constant. (10 marks).

Question 5 (20 marks)

- (i) What is meant by “primary”, “secondary”, “tertiary” and “quaternary” structures of proteins. Discuss in detail four types of protein secondary structure.
- (ii) Explain briefly: (a) mitochondria, (b) Golgi bodies, (c) endoplasmic reticulum (smooth and rough), (d) chloroplast; (e) flagella

Question 6 (20 marks)

Discuss in detail and schematic diagrams the process of high temperature and short time approach for continuous sterilization of nutrient media in bioprocess operations. Discuss both direct steam injection and indirect heating approach and compare and contrast the two approaches.