Printed Page:- 04 **Subject Code:- ABT0611**

Roll. No:

NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech

SEM: VI - THEORY EXAMINATION (2023 - 2024)

Subject: Bioreactor Analysis and Design

Time: 3 Hours **Max. Marks: 100**

General Instructions:

IMP: *Verify that you have received the question paper with the correct course, code, branch etc.*

1. *This Question paper comprises of* **three Sections -A, B, & C.** *It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.*

2. *Maximum marks for each question are indicated on right -hand side of each question.*

3. *Illustrate your answers with neat sketches wherever necessary.*

4. *Assume suitable data if necessary.*

5. *Preferably, write the answers in sequential order.*

6. *No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.*

SECTION A **20**

1. Attempt all parts:-

1-a. In batch sterilization, the sterilization process occurs in: (CO1) 1

(a) Sequential and continuous steps

(b) Continuous flow without interruption

(c) Discrete and separate batches

(d) Simultaneous and overlapping stages

1-b. In continuous sterilization, the sterilization process occurs. (CO1) 1

(a) In separate and discrete batches

(b) In a single, uninterrupted flow

(c) With intermittent pauses

(d) In a series of cyclic steps

1-c. The oxygen demand of the growing cells is fulfilled by _____ (CO2) 1

(a) aerating and agitating the fermentation broth

(b) aerating the fermentation broth

(c) Agitating the fermentation broth

(d) None of the above

1-d. Power number is independent of _____ in turbulent regime (CO2) 1

(a) Reynolds number

(b) Froude number

(c) bulk modulus

(d) Avogadro's number

1-e. The dished bottom vessel is better than the flat one because (CO3) 1

(a) requires less power

(b) less mass transfer limitations

(c) less Diffusional limitations

(d) All of the above

1-f. Impeller should be placed (CO3) 1

(a) at 1/6 the liquid off the bottom

(b) at 1/3 the liquid off the bottom

(c) at 1/2 the liquid off the bottom

(d) None of the above

1-g. The fermenter can be sterilized by (CO4) 1

(a) keeping it in the oven

(b) boiling

(c) steam under pressure

(d) all of these

1-h. The objective of Response surface methodology is to _____ (CO4) 1

(a) Maximize the response

(b) Minimize the response

(c) Optimize the response

(d) Neglect the response

1-i. What is the most common method for measuring dissolved oxygen in water? (CO5) 1

(a) Titration

(b) Colorimetry

(c) Polarography

(d) Gravimetry

1-j. What is the ideal dissolved oxygen level for most aquatic organisms? (CO5) 1

(a) 0 mg/L

(b) 2-4 mg/L

(c) 6-8 mg/L

(d) 10-12 mg/L

2. Attempt all parts:-

2.a.	Write some of the differences between disinfection and sterilization? (CO1)	2
2.b.	Define the two major flow patterns that are observed in a bioreactor? (CO2)	2
2.c.	What are feed ports? For what purpose they are being used? (CO3)	2
2.d.	What do you understand by geometric similarity of the bioreactor? (CO4)	2
2.e.	How can pH affect microbial growth and metabolism? (CO5)	2

SECTION B **30**

3. Answer any <u>five</u> of the following:-

3-a.	How bioreactor operation involves mass and energy balance calculations? (CO1)	6
3-b.	Design a flow chart for a typical bioprocess listing the steps for both upstream and downstream processing? (CO1)	6
3-c.	Distinguish between gassed and non-gassed systems in terms of power consumption? (CO2)	6
3-d.	State the conditions under which maximum cell growth can be achieved. (CO2)	6
3.e.	Discuss about the different types of stirrer glands and bearings used in a bioreactor? (CO3)	6
3.f.	How scale-up of bioreactors accomplished using geometric similarity principles? (CO4)	6
3.g.	How can dissolved oxygen levels be controlled in waste-water treatment plant? What are the challenges associated with it? (CO5)	6

SECTION C **50**

4. Answer any <u>one</u> of the following:-

4-a.	Derive an expression for the trend observed during the sterilization of sporulating organisms? (CO1)	10
4-b.	A 20 L stirred fermenter containing a *Bacillus thuringiensis* culture at 30°C is used for production of microbial insecticide, kLa is determined using the dynamic method. Air flow is shut off for a few minutes and the dissolved-oxygen level drops; the air supply is then re-connected. When steady state is established, the dissolved-oxygen tension is 78% air saturation. Oxygen tension at 5s and 15s were determined to be 50% and 66% respectively.	10

(a) Estimate kLa.

(b) An error is made determining the steady-state oxygen level, which instead of 78%, is taken as 70%. What is the percentage error in kLa resulting from this 10% error in CAL? (CO1)

5. Answer any <u>one</u> of the following:-

5-a. A strain of *Azotobacter vinelandii* is cultured in a 15 m^3 stirred fermenter for alginate production. Under current operating conditions kLa is 0.17 s^{-1}. Oxygen solubility in the broth is approximately 8 x 10^{-3} kg m^{-3}. 10

(a) The specific rate of oxygen uptake is 12.5 mmol g^{-1} h^{-1}. What is the maximum possible cell concentration?

(b) The bacteria suffer growth inhibition after copper sulfate is accidently added to the fermentation broth. This causes a reduction in oxygen uptake rate to 3 mmol g^{-1} h^{-1}. What maximum cell concentration can now be supported by the fermenter? (CO2)

5-b. Derive an expression for mass transfer coefficient determination by oxygen balance method? (CO2) 10

6. Answer any <u>one</u> of the following:-

6-a. Discuss the considerations for designing a bioreactor for animal cell culture and the unique challenges associated with mammalian cell cultivation? (CO3) 10

6-b. Discuss in detail about the different types of bioreactors commonly used in industrial applications with their advantages and disadvantages? (CO3) 10

7. Answer any <u>one</u> of the following:-

7-a. Assume you have a small bioreactor (B1) with a volume of 50 L and a height of 0.5 m and a diameter of 0.4 m. You want to scale up to a larger bioreactor (B2) with a volume of 500 L, diameter of 1 m and height of the tank as 1.5 m. Calculate the power consumption in B2 bioreactor if 2 Rushton turbine impellers are used in both the bioreactors at constant constant P/V. Assuming the power input in B1 is 1 kW and Di/Dt=0.6 in both the bioreactors? (CO4) 10

7-b. Give a brief overview on the concept of hydrodynamic similarity in scale up process? Also discuss about the importance of hydrodynamic parameters which are employed for achieving hydrodynamic similarity? (CO4) 10

8. Answer any <u>one</u> of the following:-

8-a. Describe the concept of pH control in a bioreactor? Also explain the working principle of pH control system, including feedback control loops and dosing mechanism for acid or base addition? (CO5) 10

8-b. Give details of certain challenges associated with pH control in large-scale bioprocesses? How integrating pH control with other process control parameters such as DO and temperature is important for achieving optimal bioprocess performance? (CO5) 10