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**Printed Page:-4** **Subject Code:- BBT0611**

**Roll. No:**

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**NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA**
**(An Autonomous Institute Affiliated to AKTU, Lucknow)**
**B.Tech**
**SEM: VI - THEORY EXAMINATION (2025 - 2026)**
**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:-

(1.1) Nonionizing radiation and ionizing radiation are sterilization methods mainly used in hospitals. Ultraviolet radiation is one example of nonionizing radiation, name the ionizing radiation? (CO1, K3) 1

(a) Infrared
(b) X-rays and gamma rays
(c) Halogens
(d) Ethylene oxide

(1.2) If the foreign microorganism invades the fermentation. Analyze, which of the following is not likely to occur? (CO1, K4) 1

(a) The medium will not allow the growth of contaminant
(b) The contaminant may outgrow the production organism
(c) The contaminant may contaminate the final product
(d) The contaminant may degrade the final product

(1.3) The effectiveness of mass transfer in an agitated vessel is primarily influenced by: (CO2, K2) 1

(a) Agitator speed
(b) Vessel geometry
(c) Temperature
(d) All of the above

(1.4) Bubble damage can be mitigated by: (CO2, K4) 1

(a) Degassing the liquid to remove trapped bubbles
(b) Using anti-foaming agents

(c) Reducing turbulence in the liquid flow

(d) All of the above

(1.5) Which grade of stainless steel is commonly used for bioreactor construction? (CO3, K2) 1

(a) SS202

(b) SS304

(c) SS316L

(d) SS430

(1.6) What type of valve allows flow in only one direction? (CO3, K2) 1

(a) Gate valve

(b) Globe valve

(c) Check valve

(d) Ball valve

(1.7) What type of bioreactor is used for suspension animal cells? (CO4, K2) 1

(a) Fixed bed

(b) Airlift

(c) Stirred tank

(d) Bubble column

(1.8) The restriction of enzyme mobility in a fixed space is known as _____ (CO4, K2) 1

(a) enzyme immobilization

(b) enzyme inhibition

(c) enzyme kinetics

(d) biosensor

(1.9) The term "kLa" in bioreactor design stands for: (CO5, K3) 1

(a) Mass transfer coefficient

(b) Oxygen transfer coefficient

(c) Volumetric mass transfer coefficient

(d) None of the above

(1.10) Maintaining constant mixing time during scale-up helps in: (CO5, K3) 1

(a) Ensuring uniform nutrient distribution

(b) Reducing shear stress

(c) Increasing oxygen solubility

(d) Decreasing foam formation

2. Attempt all parts:-

(2.1) What are the main parts of a typical bioreactor system.(CO1, K1) 2

(2.2) Name the dimensionless numbers commonly used in mixing analysis. (CO2, K1) 2

(2.3) What are the characteristics of orifice spargers? (CO3, K2) 2

(2.4) Name one bioreactor suitable for plant cell suspension culture. (CO4, K2) 2

(2.5) What is partial pressure, and why is it important in gas exchange? (CO5, K2) 2

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**SECTION-B** 30

Answer any one of the following:-

(3.1) Describe how heat transfer is managed in the design of bioreactors. Discuss why it is critical to maintain optimal temperature conditions. (CO1, K2) 6

(3.2) What are the advantages and disadvantages of continuous sterilization? (CO1, K2) 6

Answer any one of the following:-

(3.3) What are the different steps for oxygen transfer from gas bubble to individual cell? (CO2, K2) 6

(3.4) Illustrate how bioreactor geometry, including the arrangement of internal components, affects the distribution of shear forces and the overall health of cell cultures. (CO2, K2) 6

Answer any one of the following:-

(3.5) Discuss the role of valves in preventing contamination during sample collection. (CO3, K2) 6

(3.6) Explain the role of foam sensor materials in detecting and controlling foam formation. (CO3, K2) 6

Answer any one of the following:-

(3.7) Analyze the challenges in designing bioreactors for plant cell culture compared to microbial systems.(CO4, K4) 6

(3.8) "A bioprocess engineer is scaling up a CHO (Chinese Hamster Ovary) cell culture from a 5L benchtop bioreactor to a 500L production scale. To maintain cell viability, the engineer decides to use a pitched-blade impeller instead of a high-shear Rushton turbine and sets a lower tip speed**.** Apply your knowledge of fluid dynamics and cell biology to explain how these two specific choices help protect the animal cells during the scale-up process." (CO4, K3) 6

Answer any one of the following:-

(3.9) Describe the relationship between agitation speed and power requirement during scale-up. (CO5, K3) 6

(3.10) During the SIP cycle of a 15,000L stainless steel bioreactor, a technician observes that while the bulk vessel temperature has maintained 121°C for 30 minutes, a thermocouple located at a distal harvest valve 'dead leg' only reached 114°C. Analyze the potential impact of this temperature discrepancy on fermentation process and determine which physical parameters likely contributed to this sterilization failure (CO5, K4) 6

**SECTION-C** 50

4. Answer any one of the following:-

(4.1) Write a short note on methods of sterilization. Discuss in detail about the mathematical expression for thermal death kinetics of microbial cells. (CO1, K2) 10

(4.2) Describe the function of agitation in bioreactor design. Explain how the speed of agitation influences oxygen transfer and the overall performance of the bioreactor. (CO1, K2) 10

5. Answer any one of the following:-

(5.1) Evaluate the relationship between rheology of fermentation broth and mixing 10

efficiency and explain how the fluid behavior impacts the fermentation process and scale up (CO2, K3)

(5.2) Derive the equation for liquid-liquid mass transfer of two immiscible solvents? (CO2, K3) 10

6. Answer any one of the following:-

(6.1) Describe how the materials used for cooling coils impact heat exchange efficiency in bioreactors. (CO3, K3) 10

(6.2) "A facility is switching from an open pond system to a tubular photobioreactor to grow a specific strain of algae for pharmaceutical use. Using your knowledge of algal growth requirements, demonstrate how the closed nature of the photobioreactor will improve both the purity of the biomass and the efficiency of CO2 utilization compared to the previous open system."(CO3, K3) 10

7. Answer any one of the following:-

(7.1) Derive the equation for rate of microbial growth in a fed-batch operation of a mixed reactor? (CO4, K3) 10

(7.2) The maximum specific growth rate of *Zymomonas mobilis* cells is 0.3 $h^{-1}$ are used for chemostat culture in a 60 $m^3$ fermenter. The feed contains 12 g/l glucose; Ks for the organism is 0.2 g/l. Calculate flow rate required for a steady-state substrate concentration of 1.5 g/l? (CO4, K3) 10

8. Answer any one of the following:-

(8.1) Explain scale-up process of a bioreactor? Also discuss about the different parameters that must be considered during the scale-up of a bioreactor? (CO5, K3) 10

(8.2) After a batch fermentation, the system is dismantled and approximately 75% of the cell mass is suspended in the liquid phase (2 l), while 25% is attached to the reactor walls and internals in a thick film (ca. 0.3 cm). Work with radioactive tracers shows that 50% of the target product (intracellular) is associated with each cell fraction. The productivity of this reactor is 2 g product/l at the 2 l scale. What would be the productivity at 20,000 l scale if both reactors had a height-to-diameter ratio of 2 to 1? (CO5, K4) 10