Register Number:……………..

KUMARAGURU college of technology
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B.TECH DEGREE EXAMINATIONS: NOV/DEC 2023

(Regulation 2018)

Fifth Semester

BIOTECHNOLOGY

U18BTI5202: Bioprocess Engineering

COURSE OUTCOMES

CO1: Apply the knowledge of various optimization methods to design the media for fermentation broth
CO2: Evaluate the sterilization kinetics of media and able to design the holding time for batch. sterilization
CO3: Develop a suitable mathematical model for batch, fed-batch and continuous fermentation and able to simulate and evaluate the constants for microbial growth
CO4: Understand and analyse the application of various bioreactors and importance of mass transfer. effect in bioprocess engineering
CO5: Apply the various scale-up criteria to design the bioreactors
CO6: Identify and provide the solution for non- ideal performance of bioreactor

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 2 = 20 Marks)

(Answer not more than 40 words)

1. In what scenarios or under what conditions, is it more advantageous to use a defined growth medium instead of a complex growth medium for microbial fermentation? CO1 [K_3]
2. How do you measure the biomass concentration using ATP in a fermentation broth ? CO1 [K_2]
3. An industrial fermenter containing 10,000 L of the medium needs to be sterilized. The initial spore concentration in the medium is 10^6 spores per mL. The desired probability of contamination after sterilization is 10^{-3}. The death rate of spores at 121°C is 4 min^{-1}. Assume that there is no cell death during heating and cooling phases. Calculate the holding time of the sterilization process. CO2 [K_4]
4. Illustrate the setup of batch and continuous sterilization process. According to you, which one is superior? Substantiate your opinion. CO2 [K_2]
5. 15g of *Bacillus subtilis* biomass is produced from 40 grams of glucose. No by-product is formed was observed, calculate the yield coefficient. CO3 [K_3]
6. When does cell washout occur in a continuous fermentation? CO3 [K2]
7. Oxygen transfer was measured in a stirred tank bioreactor using dynamic gas method. The CO4 [K_3]

dissolved oxygen tension was found to be 80% air saturation under steady-state conditions. The measured oxygen tension at 7 sec and 17 sec were 55 and 68 % air saturation, respectively. Calculate the volumetric mass transfer coefficient K_La in seconds.

8. Enlist the assumptions of O_2-balance method in measurement of K_La. CO4 [K_2]

9. The dimensions and operating condition of a lab-scale fermenter are as follows: Volume = 1L, Diameter =20cm, Agitator speed=600rpm, Ratio of the impeller diameter to fermenter diameter =0.3. This fermenter needs to be scaled up to 8000L for a large-scale industrial application. If the scale-up is based on constant impeller tip speed, Calculate the speed of the agitator in the larger reactor in rpm. Assume that the scale-up factor is cube-root of the ratio of fermenter volumes. CO5 [K_3]

10. Enlist any two reasons of existing of non-ideality in bioreactors. CO6 [K_2]

Answer any FIVE Questions:-
PART B (5 x 16 = 80 Marks)
(Answer not more than 400 words)

11. a) Describe the concept of medium optimization using simplex search method 6 CO1 [K_2]

b) Given the Plackett-Burmann Design for media containing seven variables. Identify the key variable affecting the optimization of media. Consider the dummy variable at least two as per your choice. Comment on your prediction. 10 CO1 [K_4]

Trial	Variables A	B	C	D	E	F	G	Yield
1	H	H	H	L	H	L	H	1.1
2	L	H	H	H	L	H	L	6.3
3	L	L	H	H	H	L	H	1.2
4	H	L	L	H	H	H	L	0.8
5	L	H	L	L	H	H	H	6.0
6	H	L	H	L	L	H	H	0.9
7	H	H	L	H	L	L	H	1.1
8	L	L	L	L	L	L	L	1.4

H, denotes a high level value; L, denotes a low level value.

12. a) Steam sterilizer is used to sterilize liquid medium for fermentation. The initial concentration of contaminating organisms is 10^8 per litre. For design purposes, the final acceptable level of contamination is usually taken to be 10^{-3} cells; this corresponds to a risk that one batch is a thousand will remain contaminated even after the sterilization process is complete. For how long should 1 m^3 be treated if 16 CO2 [K_4]

		the temperature is A) 80°C B) 121°C and C) 140°C. (Use R as 8.3144x 10^{-3} kJ K^{-1} $gmol^{-1}$, Activation energy as 283 kJ $gmol^{-1}$ and Arrhenius constant as $10^{36.2}s^{-1}$)			
13.	a)	A 200-litre stirred fermenter contains a batch culture of *Bacillus subtilis* bacteria at 28°C. Air at 20°C is pumped into the vessel at the rate of 1vvm. The average pressure in the fermenter is 1atm. The volumetric flow rate of off-gas from the fermenter is measured as 189 $L.min^{-1}$. The exit gas stream is analyzed for oxygen and is found to contain 20.1 % O_2. The dissolved oxygen concentration in the broth is measured using an oxygen electrode as 52% air saturation. The solubility of oxygen in the fermentation broth at 28°C and 1 atm air pressure is 7.8 x 10^{-3} kg m^{-3}. (Use gas constant R as 8.205 x 10^{-5} $m^3.atm.K^{-1}.gmol^{-1}$) A) Calculate the oxygen transfer rate. B) Determine the K_La for the system.	10	CO4	[K_4]
	b)	Explain the various resistances involved in the transfer of oxygen from gas bubble to microbial cell with a neat diagram.	6	CO4	[K_2]
14.	a)	With a neat sketch, explain the production of single-cell production using photobioreactor? Emphasis on the cell harvest process.	16	CO3	[K_3]
15.	a)	Discuss – “Why would the performance of the biomass differs at 10, 000L and at 10L ?”.	6	CO5	[K_4]
	b)	Explain how heterogeneity is attained in a small fermenter. Emphasis on the scale-down approaches in debottlenecking a fermenter operation using a case study.	10	CO5	[K_4]
16.	a)	Discuss in detail the various methods employed in determining the RTD in a non-ideal fermenter.	16	CO6	[K_2]

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