

M.E. / M.TECH. DEGREE EXAMINATIONS, DEC 2020 (Held during April, 2021)

First Semester

BY18101- Bioprocess Technology

(Biotechnology)

(Regulation 2018)

Time: Three hours

Maximum : 80 Marks

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. A yeast ($\text{CH}_{1.66} \text{N}_{0.13} \text{O}_{0.40}$) is growing aerobically on arabinose ($\text{C}_5\text{H}_{10}\text{O}_5$) and ammonium hydroxide (NH_4OH) with a respiratory quotient of 1.4. Estimate the stoichiometric coefficient of the equation:



- a) $a = 0.2823, b = 0.2938, c = 0.13, d = 0.4113, e = 0.9065$
 b) $a = 0.2893, b = 0.3638, c = 0.13, d = 0.4321, e = 0.9478$
 c) $a = 0.2843, b = 0.2590, c = 0.13, d = 0.4321, e = 0.9576$
 d) $a = 0.2823, b = 0.2130, c = 0.13, d = 0.4113, e = 0.8743$
2. Microbial cell growth model can be represented by
- I. Moser equation
 - II. Monod equation
 - III. Michaelis-Menten equation
 - IV. Contois equation
- a) I, II and III
 b) II, III and IV
 c) I, II and IV
 d) Only II
3. During the operation of a bioreactor, a proteinaceous material was released into the medium by the cells forming froth. Following this, few parameters of the medium got altered. The set value in the bio controller is now as follows: set value : 25 C, pH = 5.8 , actual value : 37 C, pH= 7 . Determine which of the following parts of this bioreactor can get activated
- a) Heating finger
 - b) Alkali Pump
 - c) Acid Pump
 - d) Antifoam Pump
4. Which of the following statement is false?

- a) During growth, the cells derive energy from anabolic reactions to drive catabolic reactions.
 - b) Batch sterilization cycle consists of heating and cooling phases.
 - c) Heat generated in bioreactor is majorly due to mixing and metabolic activity of cells.
 - d) All the above
5. The process of penicillin production by the *Penicillium chrysogenum* filamentous fungus, The choice of substrate, usually a carbohydrate and process takes place at controlled conditions. How will you determine the amount of biomass and product formation take place in this process?
6. A bioprocess engineer carried out ethanol production using *Saccharaomyces cerevisiae*. He optimized the process parameters in order to get maximum product yield. Brief the possible type of errors he would experience during the interpretation of results.
7. *Lactobacillus species* are used in the fermentation of milk to curd. The viscosity of the broth increases with increase in cell concentration due to the bacterial growth. Comment on the rheological properties of the medium.
8. Rate of oxygen consumption by the cells determines the rate of oxygen transfer from gas to broth. List out the factors which influence the oxygen demand.

PART B - (4 X16 = 64 marks)

09. (a) (i) The chemical reaction equation for respiration of glucose is **(8)**
- $$\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$$
- Candida utilis* cells convert glucose to CO₂ and H₂O during growth. The cell composition is CH_{1.84} O_{0.55} N_{0.2} plus 5% ash. Yield of biomass from substrate is 0.8 gg⁻¹. Ammonia is used as nitrogen source. What is the oxygen demand with growth compared to that without?
- (ii) *C. utilis* is also able to grow with ethanol as substrate, producing cells of **(8)** the same composition above. On a mass basis, how does the maximum possible biomass yield from ethanol compare with the maximum possible yield from glucose?

(OR)

- (b) (i) Production of recombinant protein by a genetically-engineered strain of **(12)**
Escherichia coli is proportional to cell growth. Ammonia is used as
nitrogen source for aerobic respiration of glucose. The recombinant
protein has an overall formula $\text{CH}_{1.55}\text{O}_{0.31}\text{N}_{0.25}$. The yield of biomass
from glucose is measured at 0.48g g^{-1} ; the yield of recombinant protein
from glucose is about 20% that for cells
- (a) How much ammonia is required?
(b) What is the oxygen demand?
- (ii) If the biomass yield remains at 0.48g g^{-1} , how much difference are the **(4)**
ammonia and oxygen requirements for wild-type E. coli unable to
synthesize recombinant protein?
10. (a) (i) Explain the model which attempts to include the cell growth and **(8)**
metabolism in which the cell mass into various compartments based on
the basis of the function of parts of the cell's internal machinery.
- (ii) Consider that plasmid replication, resulting in a doubling of plasmid **(8)**
number within the cell, is governed by two separable factors: the host
cell and plasmid itself. Generate a model equation for the above reaction
process.
- (OR)**
- (b) (i) In a fermentation process Rapamycin was produced through aerobic **(8)**
process. The experiment was carried out at pH - 6.8 and 30°C in order
to get high yield. Summarize the method which is used to screen the
variables which has high impact on rapamycin production.
- (ii) Once the screening of the parameters done, how will you validate the **(8)**
predicted model with the theoretical results obtained from the aerobic
reactor and how you confirm the usefulness of medium when it is
transferred to large scale?
11. (a) (i) Consider a bioreactor in which the nutrients are added at the beginning **(8)**
and the products are withdrawn at the end. In this microorganism follow
a series of growth, derive the kinetic equations for each phase.

- (ii) Derive the design equation for the above reactor for the calculation of maximum specific growth rate. (8)

(OR)

- (b) *Methylophilus methylotrophus* is used to produce single cell protein from methanol using a 1000 m³ bioreactor. The biomass yield from substrate is 0.42 g/g and maximum specific growth rate is 0.45 h⁻¹. The medium contains 50 g/L methanol and a substrate conversion of 99% is desirable in the process. For batch mode of operation, the initial cell concentration is 0.2 g/L and the downtime between batches is 10 hours. (16)
- Calculate the batch culture in terms of hours
 - Calculate the total mass of cells produced during the batch culture in tons
 - Calculate the total number of batches in a year
 - If the desired annual biomass production is to be 10000 tons/ year, what should be the volume of the reactor

12. (a) (i) In the food industry, it is important to reduce the amount of microbes in products to ensure proper food safety. This is usually done by thermal processing and finding ways to reduce the number of bacteria in the product. How the bacterial reduction is determined, meaning how long it would take to reduce the bacterial population by 90% or one log₁₀ at a given state of the killing agent? (10)
- (ii) Derive the equation in order to estimate the probability of achieving successful sterilization. (6)

(OR)

- (b) (i) Assume the process is aerobic, oxygen transfer from gas bulk to the surface of cells is considered as prime factor. Design of fermentor for the operation to occur requires certain factors to achieve optimum mass transfer conditions. Summarize the series of transport resistances faced by the oxygen molecule before it is utilized by the cells. (8)
- (ii) Power consumption by agitation is a function of physical properties, operating conditions and the vessel impeller geometry. Justify the above statement using dimensionless parameters. (8)

