Ref. No. EX/PG/EBT/T/111/2024

M.TECH. ENVIRONMENTAL BIOTECHNOLOGY
1ST SEMESTER EXAMINATION, 2024

Modern Biology and Biochemical Engineering

Time: 3 hours **Full marks: 100**

Use separate answer scripts for each part.

Part - I (Modern Biology)
(50 marks)
Attempt all questions.

1. Write the structural formulae for i) one aromatic amino acid and ii) one polar, uncharged amino acid. What are the single letter abbreviations internationally used for Lysine and Glutamine? Use labeled figure along with text to explain how Rho protein causes termination of transcription in bacteria. (1.5+1.5+2+ 5)

2. How did Avery and co-scientists demonstrate that DNA is the genetic material in bacteria. Your answer should contain the steps of the experiment. What are the different kinds of cofactors used by enzymes? Write the structural formula for the monosaccharide present in DNA (5+4+1)

3. A protein has MW of 142 kDa. Calculate the approximate number of amino acid residues present in this protein. Fill in the blanks – *the ring of a purine has.... atoms and out of these ..... are Nitrogens.* You are asked to produce lots of DNA containing the gene for Insulin. Briefly describe how you would set up a successful PCR reaction for this purpose (2+2+6)

4. Write down the properties of the Genetic code? What are the main features of any one of the following - i) bacterial promoter OR ii) Beta-sheet ? What is the relation between the structure of L-Glyceraldehyde and L-Valine? Name the famous Indian-origin scientist who won the Nobel for his discoveries about translation. (5+3+1+1)

OR

Write short notes explaining – i) Transcription Bubble, ii) Shine-Dalgarno sequence, iii) use of UV light to monitor concentration and purity of DNA. Explain, using diagrams, how the Lac Repressor controls transcription of the lac operon. (2+2+2+4)

5. List ALL the chemicals, biomolecules and equipment needed to conduct a successful Sanger sequencing experiment. In a test tube, you take ribosome subunits, 20 amino acids, initiation factors, elongation factors, release factors, GTP, mRNA and incubate it at 37°C. However, no polypeptide is produced. Looking at the list, you realize a mistake happened. What is the mistake that you did? How can you correct this so that a polypeptide is produced? (4+1+5)

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Use separate answer scripts for each part.
Answer any four questions. Each question carries 12.5 marks

Part II (Biochemical Engineering)
(50 marks)

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1. Draw a diagram of a chemostat with recycle, write the material balance equation on cell (biomass) concentration around the bioreactor and the material balance equation for growth limiting substrate around the bioreactor. Hence, prove that the chemostat can be operated at dilution rates higher than the specific growth rate when cell recycle is used. Further derive the factor by which the steady state cell concentration in a chemostat is increased. (2.5+2.5+3.0+4.5=12.5 marks)

2. What is critical oxygen concentration? Discuss its application in practical operation of bioreactors? (3.5+9.0=12.5 marks)

3. *Zymomonas mobilis* cells are used for chemostat culture in a 60 m^3 bioreactor. The feed contains 12 g/l glucose; K_S for the organism is 0.2 g/l, $\mu_{\max} = 0.3\ h^{-1}$. What flow rate is required for steady state substrate concentration of 1.5 g/l? At this flow rate, what is the cell density if $Y^M_{X/S} = 0.06\ g/g$? (6+6.5=12.5)

4. *Pseudomonas sp.* has a mass doubling time of 2.4 h when grown on acetate. The saturation constant using this substrate is 1.3 g/l and the cell yield on acetate is 0.46 g cell/ g acetate. If we operate a chemostat on a feed stream containing 38 g/l acetate, find the following:
   a. Cell concentration when the dilution rate is one-half the maximum
   b. Substrate concentration when the dilution rate is 0.8 D_{max}
   c. Maximum dilution rate (6+4+2.5=12.5)

5. In a fluidized-bed biofilm reactor, cells are attached on spherical plastic particles to form biofilms of average thickness L = 0.5 mm. The bed is used to remove carbon compounds from a wastewater stream. The feed flow rate and concentration of total fermentable carbon compounds in the feed are respectively F = 2 l/h and S = 2000 mg/l. The diameter of the column is 10 cm. The kinetic constants of the microbial population are r_m = 50 mgS/cm^3.h and K_S = 25 mgS/cm^3. The specific surface area of the biofilm in the reactor is 2.5 cm^2/cm^3. Assuming an average effectiveness factor of η=0.7 throughout the column, determine the required height of the column for effluent total carbon concentration of S_{0e}=100 mg/l. (12.5 marks)

6. An industrial wastewater stream is fed to a stirred tank reactor continuously and the cells are recycled back to the reactor from the bottom of the sedimentation tank placed after the reactor. The following data are given for the system:

F = 100 l/h ; S_0 = 5000 mg/l ; μ_{max} = 0.25 h^{-1} ; K_S = 200 mg/l ; α (recycle ratio) = 0.6 ; C (cell concentration factor) = 2 ; $Y^M_{x/s}$ = 0.4. The effluent concentration is desired to be 100 mg/l. Calculate:

(a) Required reactor volume
(b) Cell concentration in the reactor and in the recycle stream

(5+7.5=12.5 marks)