

# B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

## September / October 2023 Semester End Main Examinations

Programme: B.E.

Branch: Biotechnology

Course Code: 22BT3DCBBM

Course: Basics of Biomolecules

Semester: III

Duration: 3 hrs.

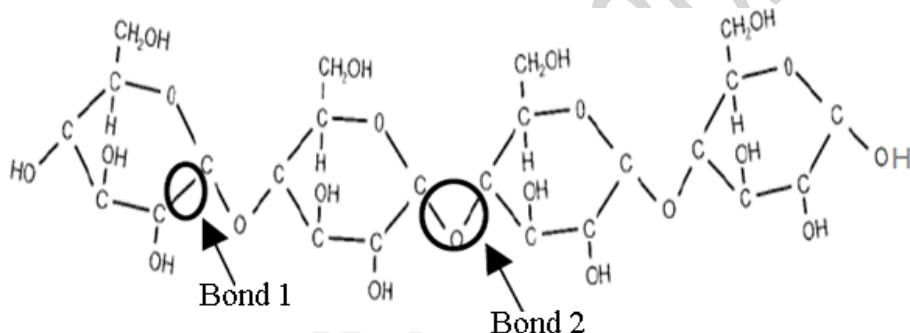
Max Marks: 100

**Instructions:** 1. Answer any FIVE full questions, choosing one full question from each unit.  
2. Missing data, if any, may be suitably assumed.

### UNIT - I

1 a)

07



- Classify this polymer as a monosaccharide, oligosaccharide or polysaccharide.
- From the following (*given in the table*), circle all the options that best characterize this polymer. Explain why you selected these options.

Hydrophobic	Polar	Hydrophilic	Nonpolar	Charged	Uncharged
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- Which of the above bonds (*choose either bond 1 or bond 2*) is an example of glycosidic bond? Explain why you selected this option.
- From the following (*given in the table*), circle the type of bond or interaction that occurs between two such polymers, when they are placed in an aqueous environment. Explain why you selected this option(s).

Ionic bond	Covalent bond	Hydrogen bonds	Van der Waals forces
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- b) A buffer contains 0.010 mol of lactic acid ( $pK_a = 3.86$ ) and 0.050 mol of sodium lactate per liter.

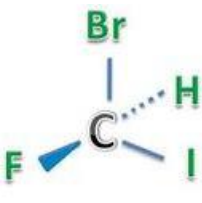
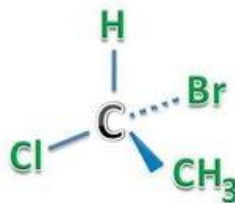
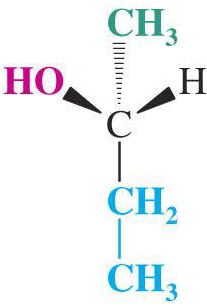
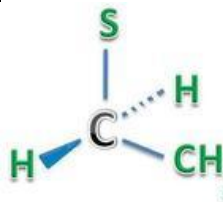
07

- Calculate the pH of the buffer.
- Calculate the change in pH when 5 ml of 0.5 M HCl is added to 1 L of the buffer.
- What pH change would you expect if you added the same quantity of HCl to 1 L of pure water?

- c) Describe one common structural feature and difference for each pair: 06
- Starch and Glycogen
  - Cellulose and Chitin
  - Trehalose and Sucrose

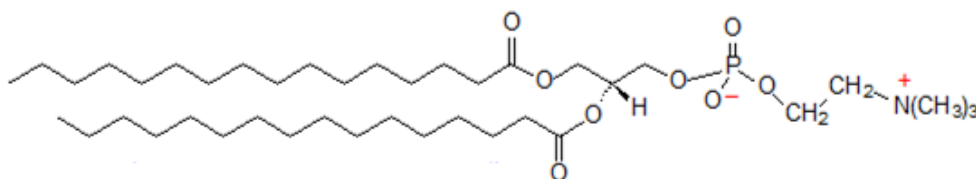
**OR**

- 2 a) (i) Gentiobiose ( $\beta$ -D-glucopyranosyl-(1 $\rightarrow$ 6)-D-glucopyranose) is a disaccharide found in some plant glycosides. Draw the structure of gentiobiose based on its systematic name. Is it a reducing sugar? Does it undergo mutarotation? 09
- (ii) Why does the specific rotation of a freshly prepared solution of the  $\alpha$ -D-glucose gradually decrease with time? Why do solutions of the  $\alpha$  and  $\beta$  forms of D-glucose reach the same specific rotation at equilibrium?
- (iii) Calculate the percentage of each of the two forms of D-glucose present at equilibrium.
- b) You have been observing an insect that defends itself from enemies by secreting a caustic liquid. Analysis of the liquid shows it to have a total concentration of formate plus formic acid ( $K_a = 1.8 \times 10^{-4}$ ) of 1.75 M; the concentration of formate ion is 0.025 M. What is the pH of the secretion? 04
- c) i. Describe R, S system of nomenclature of chiral compounds. 07
- ii. Designate the following isomers using R, S system of nomenclature.

A	B	C	D
			

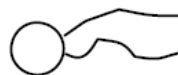
## UNIT - II

- 3 a) Membranes are made up of many components and, in some membranes, phospholipids are the major component. Below is an example of a saturated phospholipid. 08



- i. Draw a square around the portion of the molecule that is hydrophobic and a circle around the portion that is hydrophilic.

Phospholipids are also sometimes represented like this:



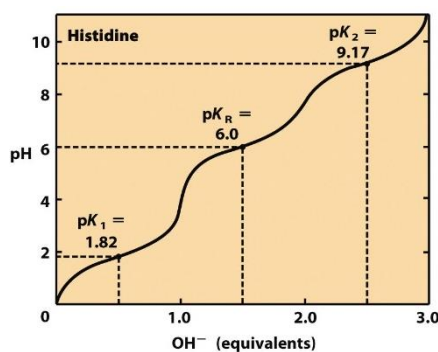
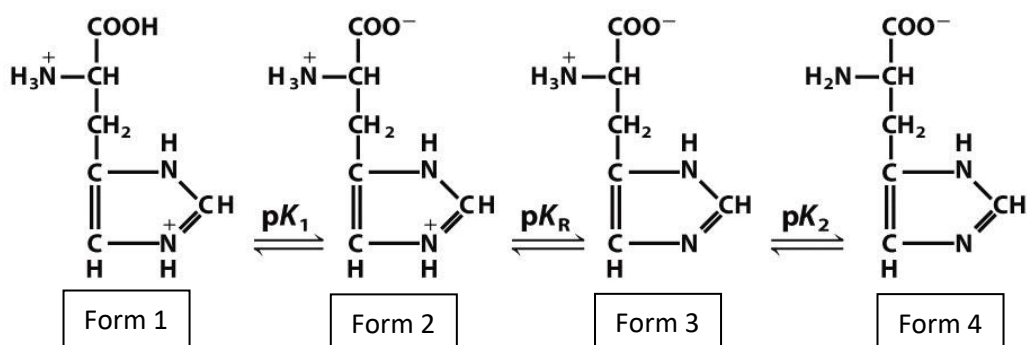
- ii. Using the simplified structure above, draw what a lipid bi-layer looks like in an aqueous environment. Explain what causes the lipids to create this formation.

In your depiction of a lipid bi-layer drawn above what type of force is acting ...

- iii. between the phosphoglycerol (hydrophilic) component and the fatty acid?
  - iv. between the phosphogroup and the surrounding aqueous environment?
  - v. between the fatty acid groups of different phospholipids molecules?
- b) In reality, membranes are composed of several different types of lipids, as well as proteins. One reason why there are multiple types of lipids is to ensure that the membrane remains fluid so that proteins, lipids and small molecules can move through and within the membrane. In particular, there is always a mixture of saturated and unsaturated phospholipids. Will you give an explanation with diagram of why a membrane containing unsaturated phospholipids would be more fluid than a membrane made exclusively of saturated phospholipids? **05**
- c) Complete hydrolysis of a glycerophospholipid yields glycerol, two fatty acids [16:1( $\Delta^9$ ) and 16:0], phosphoric acid, and serine in the molar ratio 1:1:1:1. Name the lipid and draw the structure. **04**
- d) Compositional analysis of a certain lipid shows that it has exactly one mole of fatty acid per mole of inorganic phosphate. Could this a glycerophospholipid? or a ganglioside? or a sphingomyelin? Substantiate your answer with the explanation. **03**

### UNIT - III

- 4 a) A protein is subjected to end group analysis by Edman degradation. The liberated PTH-amino acids are found to be present with a molar ratio of two parts Val, one part Ala and one part Phe. **08**
- i. What is Edman's reagent? Write its structure.
  - ii. What conclusions can be drawn about the nature of the protein?
  - iii. What is the most important difference between the Edman degradation and other methods of N-terminal residue identification?
- b) Write the symbol for the following amino acids. **05**
- i. Glutamate
  - ii. Phenylalanine
  - iii. Asparagine
  - iv. Lysine
  - v. Tyrosine
- c) Indicate whether the following statements concerning histidine are true or false. Refer to the following titration curve. **07**

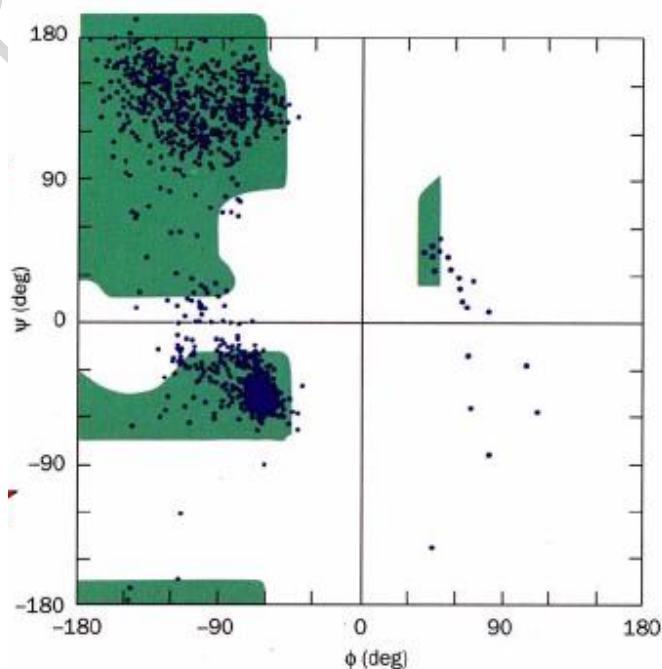


- At pH 1.82 there are equal amounts of form 1 and form 2.
- The  $\alpha$ -carboxyl group is half dissociated at pH 9.17.
- Histidine would be a good buffer at pH values near 1.8 and 9.2.
- Histidine has biological importance because the  $pK_a$  of its side chain is close to physiological pH.
- Histidine's pI is between pH 1.82 and 6.0.
- The average net charge on the Histidine at pH 9.17 is  $-1.0$ .
- Histidine will migrate towards anode at pH 7.6 when placed in an electric field.

#### UNIT - IV

- 5 a) Refer the Ramachandran plot given below to answer the following questions.

07



- i. What does the Ramachandran plot represent?
  - ii. What are the parameters shown on the Ramachandran plot and what do they characterize?
  - iii. Why is the lower right quadrant a “forbidden” region in the Ramachandran plot?
  - iv. What makes Glycine a special amino acid when it comes to Ramachandran plots?
- b) Lysozyme consists of 129 amino acids. The order of 12 amino acids numbered 4 through 15 in lysozyme is as follows. Gly–Arg–Cys–Glu–Leu–Ala–Ala–Ala–Met–Lys–Arg–His

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- i. What level of protein structure does this represent?
- ii. How do you classify these amino acids into different groups based on the side chain (R) group?

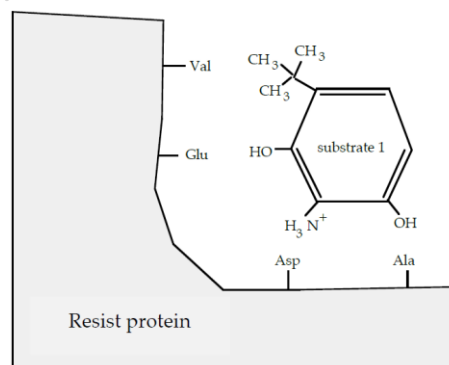
These 12 amino acids also make up an  $\alpha$ -helix in lysozyme.

- iii. What level of protein structure does  $\alpha$ -helix represent?
- iv. Do the side chains of the amino acids in a helix point into or out of the helix?
- v. What type of bond is primarily responsible for maintaining this helical structure?
- vi. What part of the amino acid participates in this bond (side chain or backbone)?
- vii. How many full turns are in this  $\alpha$ -helix?
- viii. What is the length of the helix (in Angströms) in the direction of the helix axis?

OR

- 6 a) In analyzing differences between drug resistant fungi and drug sensitive fungi, you have discovered a protein that exists only in the drug resistant fungi. You named this the Resist protein and design substrates that you hope will bind to it.

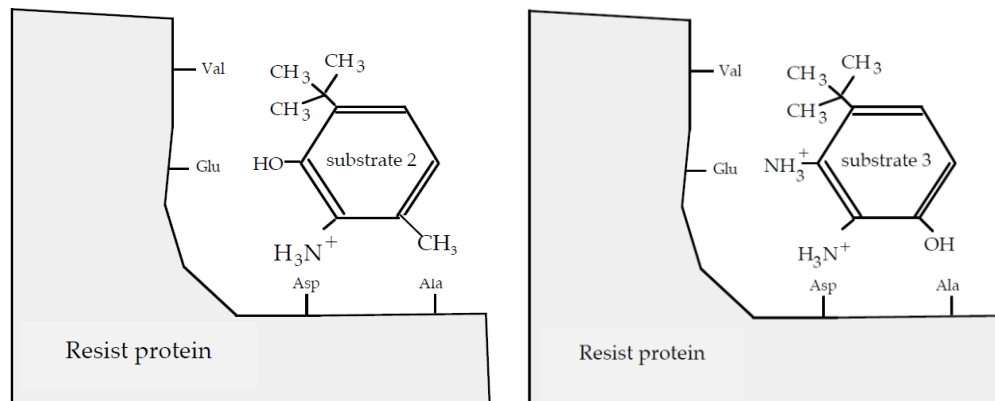
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- i. Give the name for the strongest intermolecular interaction between substrate 1 as shown and the side chains of following amino acids on the Resist protein. Choose from ionic bond, covalent bond, hydrogen bond, and van der Waals forces.

Amino acid	Strongest interaction
Val	
Glu	
Asp	
Ala	

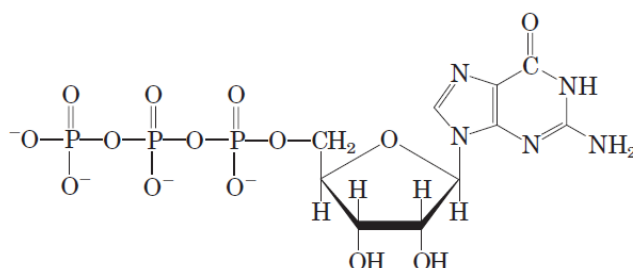
You make the following additional substrates.



- ii. What is the strongest interaction that now exists between the Ala of the Resist protein and substrate 2?
  - iii. What is the strongest interaction that now exists between the Glu of the Resist protein and substrate 3?
  - iv. Which substrate (Substrate 1/Substrate 2/Substrate 3) would you expect to bind the most tightly to the Resist protein? Explain why you made this choice.
- b) You are studying a tri-peptide with the sequence Ala-Arg-Glu. Draw the structure of this tri-peptide at pH 7. Indicate which parts of the molecule are planar and explain why. On the drawing, indicate the  $\Phi$  and  $\psi$  angles. **07**
- c) Protein A has a binding site for ligand X with a  $K_d$  of  $10^{-6}$  M. Protein B has a binding site for ligand X with a  $K_d$  of  $10^{-9}$  M. Which protein has a higher affinity for ligand X? Explain your reasoning. Convert the  $K_d$  to  $K_a$  for both proteins. **05**

## UNIT – V

- 7 a) The following diagram represents a nucleotide that serves as a monomer for ribonucleic acid (RNA). **10**



- i. Classify this nucleotide as purine or pyrimidine nucleotide.
- ii. Besides serving as a monomer of RNA, what is the other major role of this nucleotide within a cell?
- iii. Box the group or atom that you would remove, so that the nucleotide

drawn above can serve as a monomer for DNA.

- iv. What type of bonds would hold two such adjacent nucleotides together in a growing nucleic acid chain? Circle the group(s) that would participate in the formation of this bond if the nucleotide shown above, was added to the growing nucleic acid chain.
- v. Name the type of bonds that the above nucleotide will form with its complementary nucleotide. How many of these bonds would you expect between this nucleotide pair?

The nucleotide (N) shown above is a part of the following DNA sequence in its deoxygenated form.

5'GGCCANACCA3'

For the nucleic acid sequence that is given above...

- vi. Which nucleotide (G/C/A/N) has a free phosphate group?
- vii. Which nucleotide (G/C/A/N) has a free hydroxyl group?
- viii. If adenine nucleotide is added to the above nucleic acid sequence in a cell, would it be added to the 5' end or the 3' end?

- b) In samples of DNA isolated from two unidentified species of bacteria, X and Y, adenine makes up 32% and 17% respectively, of the total bases. **10**

- i. What relative proportions of adenine, guanine, thymine, and cytosine would you expect to find in the two DNA samples?
- ii. What assumptions have you made?

One of these species was isolated from a hot spring (64 °C).

- iii. Suggest which species is the thermophilic bacterium.
- iv. What is the basis for your answer?
- v. Why the absorption of UV light by double-stranded DNA increases when the DNA is denatured?

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