CHEMISTRY OF BIOMOLECULES
(BIOT 2101)

Time Allotted : 2½ hrs   **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
<u>any 4 (four)</u> from Group B to E, taking <u>one</u> from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Which system cannot act as a physiological buffer?
(a) Biphosphate-monophosphate buffer   (b) Acetic acid-sodium acetate buffer
(c) Carbonic acid-bicarbonate buffer   (d) All of these.

(ii) Apart from phospholipid, which lipid is found in the membrane?
(a) Cholesterol   (b) Palmitic acid
(c) Retenoic acid   (d) All of these.

(iii) Example of a protein containing entirely alpha-helical structure is
(a) Collagen   (b) Keratin   (c) Fibroin   (d) Hemoglobin.

(iv) Which description is correct for the amino acid isoleucine?
(a) Isoleucine is an aromatic and non-polar amino acid residue
(b) Isoleucine is an aromatic and polar amino acid residue
(c) Isoleucine is an aliphatic and non-polar amino acid residue
(d) Isoleucine is a basic amino acid residue.

(v) The absorbance of a solution of tryptophan measured at 280 nm in a cuvette of 2.0 cm path length is 0.56 at pH 7. The molar extinction coefficient (ε) for tryptophan at 280 nm is 5600 M^{-1} cm^{-1} at pH 7. The concentration of tryptophan in the solution is
(a) 25 μM   (b) 0.5 μM   (c) 50 μM   (d) 500 μM.

(vi) Which of the following conformation of dsDNA is not right-handed?
(a) A-DNA   (b) B-DNA   (c) Z-DNA   (d) C-DNA.

(vii) Which statement is correct for starch?
(a) Starch contains glucose and galactose as the monomeric units
(b) Starch gives black colouration with iodine
(c) Starch has α (1-4) and α (1-6) glycosidic linkages
(d) Starch can be extracted by chloroform and methanol mixture.

(viii) Match the names techniques (**Group-I**) for estimation of different biomolecules (**Group-II**)

Group-I	Group-II
(P) CHOD-POD method	(1) dsDNA
(Q) UV absorption at A_{280}	(2) Reducing sugar
(R) DNSA method	(3) Protein
(S) UV absorption at A_{260}	(4) Cholesterol

Select the correct match between group-I and group-II

(a) (P)-1; (Q)-2 ; (R)-3; (S)-4   (b) (P)-2; (Q)-3 ; (R)-1; (S)-2

(c) (P)-4; (Q)-2; (R)-3; (S)-1   (d) (P)-4; (Q)-3; (R)-2; (S)-1.

(ix)   Which one of the following techniques can be used to determine the structure of a 15 kDa globular protein at atomic resolution?
(a) Raman spectroscopy   (b) IR spectroscopy
(c) UV spectroscopy   (d) NMR spectroscopy.

(x)   The spectroscopic method for detection of functional groups is
(a) CD spectroscopy   (b) FTIR spectroscopy
(c) ESR spectroscopy   (d) UV-VIS these.

Fill in the blanks with the correct word

(xi)   An example of non-reducing sugar is _____.

(xii) Enantiomers have _____ relationship.

(xiii) Fibroin contains three amino acid residues: alanine, glycine and _____.

(xiv) DNA shows absorption maxima at 260 nm due to presence of _____ inside it.

(xv)   The T_m value of the DNA with sequence ATTGGCCAAATTGATC is _____.

Group - B

2. (a)   Describe the nature of interaction between the following pairs. (i) ethyl alcohol and water, (ii) sodium chloride and water.   *[(CO1)(Describe/IOCQ)]*

   (b)   (i)Calculate the pH of a 0.500 L buffer solution composed of 0.700 M formic acid (HCOOH, $K_a = 1.77 \times 10^{-4}$) and 0.500 M sodium formate (HCOONa). (ii) Calculate the pH after adding 50.0 mL of a 1.00 M NaOH solution.   *[(CO1)(Solve/HOCQ)]*

   (c)   Do D-glyceraldehyde and L-glyceraldehyde bear the relation of enantiomers? Justify your answer.   *[(CO1)(Justify/IOCQ)]*

   3 + (2 + 2) + 5 = 12

3. (a)   Examine the following structure and answer the questions.

   (i)   Mark the asymmetric carbon atoms in the figure.
   (ii) State whether the compound has D or L configuration.
   (iii) Draw its enantiomer.   *[(CO1)(Examine/HOCQ)]*
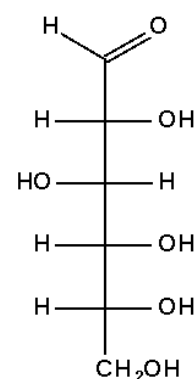
(b) Name the sugar found in nucleic acids. Draw its structure. According to the number of carbon of carbon atoms, which group the sugar belongs to?

[(CO1)(Remember/LOCQ)]

(c) Define iodine number. State their importance in characterization of lipids.

[(CO1)(Remember/LOCQ)]

(2 + 1 + 2) + (1 + 1 + 1) + (2 + 2) = 12

Group - C

4. (a) The titration curve of alanine is given below. Answer the following on the basis of this figure.
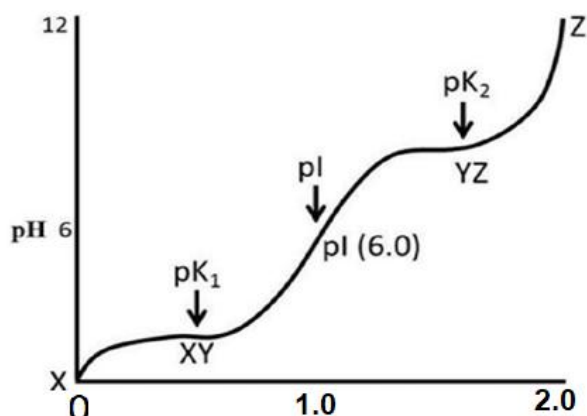
    (i) Write the chemical equations for the process starting from pH 1 to 12.
    (ii) Define pK1, pK2 and pI of alanine.   *[(CO1)(Understand/IOCQ)]*

(b) Define non polar amino acid with an example.   *[(CO1)(Remember/LOCQ)]*

(4 + 6) + 2 = 12

5. (a) Draw and describe β-α-β motif and β-barrel structures.   *[(CO2)(Describe/IOCQ)]*
(b) What is gluten? Why do we get softer bread made of natural wheat than of gulten-free wheat?   *[(CO2)(Reasoning/HOCQ)]*
(c) Correlate protein denaturation with curdling of milk by application of lemon juice.   *[(CO2)(Correlate/HOCQ)]*

(2 + 2) + (1 + 4) + 3 = 12

Group - D

6. (a) What is T_m of a DNA molecule and what is melting curve of a DNA? Write the names of factors on which the T_m of a dsDNA molecules depends and how these factors control T_m.   *[(CO3)(Remember-Analyse/IOCQ)]*
(b) What is supercoiling of DNA? A closed circular B-DNA of 4000 base pairs is negatively supercoiled by introduction of 4 writhes. Calculate the super helical density of the resultant DNA molecule.   *[(CO3)(Remember-Analyse/IOCQ)]*
(c) Derive the equation for renaturation kinetics of two complementary ssDNA molecules into dsDNA.   *[(CO3)(Derive/IOCQ)]*

(1 + 1 + 2) + (1 + 3) + 4 = 12

7. (a) Reassociation of two complementary ssDNA molecules follows second order kinetics. Based on that, derive the relation between initial concentration of ssDNA with the fraction of ssDNA will remain in the reassociation process after time t.   *[(CO3)(Remember)/LOCQ)]*

(b) The Tm value of a DNA is 75.0^0C. Calculate % of A, T, G and C in the DNA sample.
[(CO3)(Analyse)/HOCQ]

(c) In an experiment, the A_{260} value of the following aqueous solutions of three different DNA (all samples DNA length is same in base pairs) was measured separately at different temperature from 10^0C to 100^0C.
   (i) poly dAdT, (ii) poly dGdC, and (iii) poly dAdTdGdC.
   You draw the expected nature of A_{260} vs. Temperature denaturation curve of the above experiments and explain the result.
[(CO3)(Remember/explain)/IOCQ]

(d) There is circular DNA of size 3000 bp with 150 negative supercoil. Calculate the number of twist, writhe and linking number of the DNA. If we add 75 positive supercoil to that DNA then calculate the vale of σ. Explain all the logic.
[(CO3)(Analyse/HOCQ]

3 + 2 + 3 + (2 + 2) = 12

Group - E

8. (a) Derive the mathematical form of Lambert & Bears law. What are its limitations of this law?
[(CO4)(Analyse/HOCQ]

(b) Monochromatic light is passed through a 1 mm path length cell containing 0.006 moles/dm^3 solution. The light intensity reduced to 18% of its value. Calculate molar extinction coefficient of the sample. What will be the transmittance if the cell path length is 2 mm?
[(CO6)(Remember/LOCQ]

(c) Describe principle for the indirect estimation of DNA in a solution.
[(CO4)(Apply/IOCQ]

(3 + 1) + 4 + 4 = 12

9. (a) Explain application of fluorescence spectroscopy in structure determination of protein. Explain fluorophore with an appropriate example existing as biomolecules.
[(CO5)(Explain/IOCQ]

(b) Draw and explain the graphical pattern of the following:
   (i) Changes of absorbance value with the concentration of absorbing species.
   (ii) Changes of transmittance value with the concentration of absorbing species.
[(CO5)(Explain/IOCQ]

(c) Explain how we can differentiate the secondary structures of protein (α-helix, and β-sheet) by CD spectroscopy with a diagram.
[(CO5)(Explain/IOCQ]

(2 + 2) + (2 + 2) + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.67	55.21	28.12

Course Outcome (CO):

After the completion of the course students will be able to
1. Calculate the pH of a buffer system, identify different stereoisomer's of carbohydrate and lipids and understood the chemistry of carbohydrate and lipids.
2. Explain the different structural components and physiochemical properties of amino acids, proteins.
3. Analyses and explain the different structural components and physiochemical properties of DNA and RNA.
4. Select and apply suitable spectroscopic techniques for estimation biomolecules.
5. Select and apply suitable techniques for and structure determination of of biomolecules.
6. Able to solve mathematical problems related to estimation and structural features of biomolecules.

LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.