CHEMISTRY OF BIOMOLECULES
(BTC2101)

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

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one 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) An acidic solution having pH 6 will have proton concentration of
(a) 10^{-6} M (b) 10^{6} M
(c) 6 M (d) 0.6M

(ii) Of the 20 standard amino acids, only histidine can act as a buffer at the physiological pH. The reason behind this is
(a) Deprotonated side chain of histidine is more stable than the protonated form due to resonating structures
(b) Protonated side chain of histidine is more stable than the deprotonated form due to resonating structures
(c) The alpha-amino group undergoes resonance due to release of protons
(d) The pI value of Histidine is 7.4

(iii) Lipids present in cell membrane are
(a) Cholesterol and fatty acids (b) Cholesterol and triglycerides
(c) Phospholipids and cholesterol (d) Phospholipids and triglycerides

(iv) The two amino acids that have negative charges on their R groups at pH 7.0 are
(a) Arginine and Glutamic acid (b) Arginine and Lysine
(c) Aspartic acid and Glutamic acid (d) Arginine and Aspartic acid

(v) For a neutral amino acid, if pK1 is 2.34 and pK2 is 9.6, what will be the pI?
(a) 5.97 (b) 5.87
(c) 3.87 (d) 2.34

(vi) Which statement is NOT correct for denaturation?
(a) A protein loses its tertiary structure but retains its primary structure
(b) A protein loses its biological activity
(c) A protein loses its tertiary structure as well as its primary structure
(d) Denaturation may be caused by heat

(vii) A sample of normal double-stranded DNA was found to have a guanine content of 18%. What is the expected proportion of adenine?
(a) 9% (b) 32%
(c) 36% (d) 82%

(viii) A sample of double stranded DNA contains 17% adenine residues. Calculate the number of guanine residues.
(a) 34 (b) 33
(c) 66 (d) 17

(ix) 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

(x) EMR interact with the matter and different molecular process occurs. Match the names EMR interact (**Group-I**) and the molecular process (**Group-II**)

Group-I	**Group-II**
(P) X-ray	(1) Molecular rotation
(Q) UV-Vis	(2) Molecular vibration
(R) IR	(3) Electronic transition
(S) Microwave	(4) Bond breaking and ionization

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

Fill in the blanks with the correct word

(xi) Optical isomers that do not have object-image relation are called _____ .

(xii) Lipid can be best extracted with _____ .

(xiii) The amino acid sequence of protein is called the _____ structure

(xiv) T_m of the following DNA (5'-ATTTAAGGCCATATATGGCCA-3') is _____.

(xv) In X-ray diffraction of a biomolecule, assume n = 1, angle of reflection is 45.0 degree and wavelength of X-ray used in the experiment is 1.54 Å, then the distance between the atomic plane is _____ .

Group - B

2. (a) Explain why benzene is insoluble in water. Name the force that keeps benzene separated from water. *[(CO3)(Explain/IOCQ)]*

(b) State which of the following pairs can act as a buffer. Justify your answer. i) HCl and H2SO4, ii) CH3COOH and CH3COOK and iii) HCl and NaCl. *[(CO4)(Reasoning/HOCQ)]*

(c) Calculate the ratio of lactic acid and lactate required to make a buffer at pH 4.5. The pKa value of lactic acid is 3.86. *[(CO2)(Understand/IOCQ)]*

(d) Describe solvation. *[(CO2)(Understand/IOCQ)]*

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

3. (a) What are stereochemical isomers? *[(CO3)(Remember/LOCQ)]*

(b) State the relation between the following pairs in terms of stereoisomers: i) D-glyceraldehyde and L-glyceraldehyde, ii) D-tartaric acid and meso-tartaric acid, iii) cis-but-2-ene and trans-but-2-ene. Give the logic behind each answer. *[(CO4)(Understand/IOCQ)]*

(c) What is mutarotation? Explain the phenomenon. *[(CO2)(Understand/IOCQ)]*

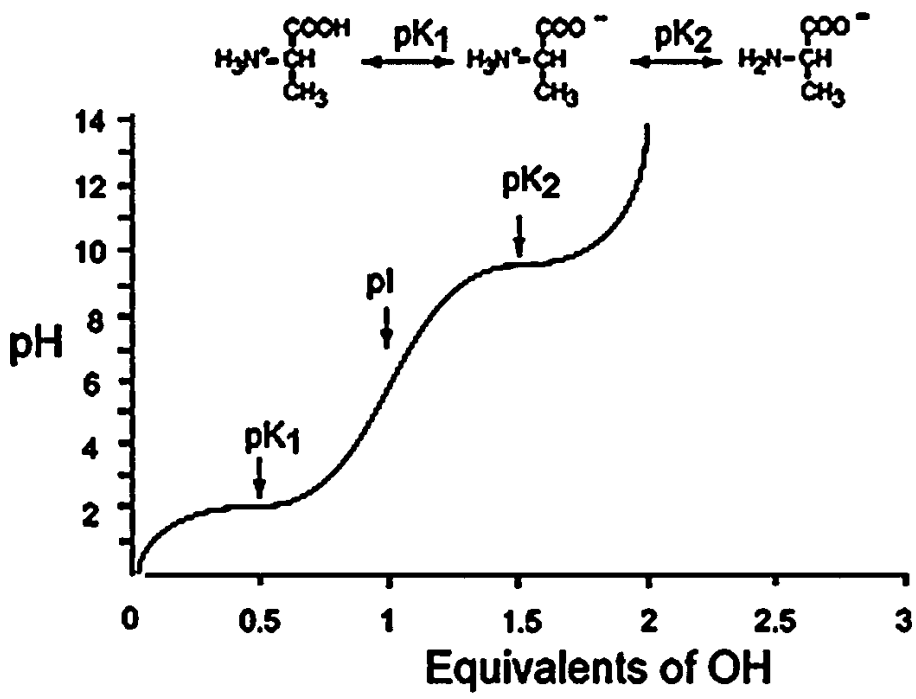
(d) Define with example: deoxy sugar. *[(CO2)(Remember/LOCQ)]*

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

Group - C

4. (a) Draw the structure of (i) a non-polar amino acid, (ii) an acidic amino acid. *[(CO3)(Remember/LOCQ)]*

(b) Analyze the following diagram and answer the questions related to it.



(i) The graph represents titration curve of which amino acid?

(ii) Name two more amino acids that you expect to follow this type of titration curve. Justify your answer.

(iii) The term pI stands for isoelectric point. State what do you understand by the term pI?

(iv) The pK1 and pK2 values for the above graph are 2.3 and 9.7 respectively. Calculate the pI value. *[(CO4)(Analysis/IOCQ)]*

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

5. (a) What are motifs present in a protein structure? Describe four motifs that are commonly found in proteins. *[(CO3)(Remember, Understand/LOCQ, IOCQ)]*

(b) Name the amino acids that are found in beta-sheets. *[(CO4)(Remember/LOCQ)]*

(c) A protein will always go back to its native state once the denaturing agent is removed. Do you agree with the statement? Justify your answer. *[(CO2)(Justify/HOCQ)]*

(2 + 4) + 2 + 4 = 12

Group - D

6. (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)(Derive/IOCQ)]

(b) The T_m value of a DNA is 55^0C. 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)(Expalin/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 value of σ. Explain all the logic. *[(CO3)(Apply/HOCQ)]*

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

7. (a) Which experiment confirms that RNA can be genetic material for some virus? Explain the principle and steps of that experiment with labelled diagram. *[(CO3)(Analyse/HOCQ)]*

(b) Draw the detail chemical structure of ssRNA molecule with three nitrogen bases? *[(CO3)(Remember/LOCQ)]*

(c) How you will convert B form of DNA to A form of DNA and vice versa. *[(CO3)(Explain/IOCQ)]*

(d) The genetic materials of an RNA virus, a ssDNA virus, and a wombat (a mammal) were analyzed by a very disorganized laboratory technician, who lost the identification tags to the samples. Identify the source of the nucleic acid for each sample, giving a reason for each choice.

Sample	Adenine	Cytosine	Guanine	Thymine	Uracil
X	28.0	22.0	22.0	0.0	28.0
Y	21.0	29.0	29.0	21.0	0.0
Z	27.0	24.0	26.0	23.0	0.0

[(CO6)(Analyse/HOCQ)]

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

Group - E

8. (a) A solution of DNA and a solution of protein, separately used to do wavelength scan (from 200 to 310 nm) in spectrophotometer, now you draw and explain the expected nature of the changes of absorption for DNA and protein with increasing wavelength with a labelled diagram. *[(CO5)(Explain/IOCQ)]*

(b) Explain the principle a step for structure determination of biomolecules with cryo-electron microscopy with example? *[(CO5)(Remember/LOCQ)]*

(c) Explain the optical arrangement and working principle of dual beam UV-VIS spectrophotometer with a diagram. *[(CO2)(Apply/IOCQ)]*

(d) A solute solution's transmittance is 45.0%. What will be the transmittance if you dilute 50.0 mL of that solution to 100.0 ml? *[(CO6)(Apply/HOCQ)]*

3 + 3 + 3 + 3 = 12

9. (a) Derive the relation between absorbance, transmittance and % transmittance in absorption spectroscopy. *[(CO3)(Analyse/HOCQ)]*

(b) Explain the fluorescence phenomena with Jablonski diagram. *[(CO4)(Remember/LOCQ)]*

(c) Explain the principle of CD spectroscopy. Three protein samples containing only α-helix, only β-sheet and only random coil respectively is analysed by CD spectroscopy. Explain the CD spectrum of these three protein with diagram. *[(CO2)(Apply/IOCQ)]*

(d) The absorbance value (at 260 nm) is 0.5, for a 50 times diluted sample of genomic DNA isolated from *E.coli*. Calculate the concentration of DNA solution. If the volume of the DNA sample is 250 µl, calculate the amount of DNA in the supplied sample. *[(CO2)(Apply/IOCQ)]*

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

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18	64	18