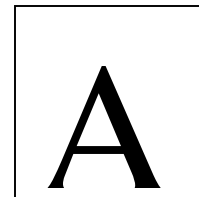


BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI, RAJ.
BIOPHYSICS, BIOC331, 1ST SEMESTER, 2007-08
COMPREHENSIVE EXAMINATION, Date: 6.12.2007, (OPEN BOOK)



(See the instructions before starting to answer)

1. For Part I, quiz answers should be written **ONLY** in the printed ANSWER SHEET provided separately by indicating your choice in the answer sheet as (A) or (B) etc. Answers once written cannot be changed in any manner. Pencil should not be used for answering.
2. Overwritten answers will be treated as unanswered. So, use answer sheet carefully.
3. Do rough work at the backside of the question paper.
4. Each correct answer will be awarded 1 marks. 1 mark will be deducted for every two wrong answers. Maximum marks for Part I is 30
5. The maximum time allowed for Part I is 60 minutes. Part II may be collected as and when Part I is submitted. Detach the answer sheet and submit only this.
6. Part II has total marks of 60.

PART I (Answer All; 1x30 = 30 Marks)

1. Which of the group of an amino acid without ionizable side chain, will be either protonated or deprotonated, as the case may be, at pH 11.
(A) COOH (B) COO⁻ (C) NH₂ (D) NH₃⁺
2. Assume that an amino acid without any ionizable groups in side chain, has isoelectric point at pH 7. How is it charged at pH 3?
(A) positively (B) negatively (C) neutral overall (D) data insufficient
3. Choose which statements are/is correct from following about the peptide bond
 1. is an amide linkage
 2. has a partial double bond character.
 3. is not ionized at physiological pH.
 4. is ionized at physiological pH(A) if 1, 2, and 3 are correct (B) if 1 and 3 are correct (C) if 2 and 4 are correct (D) if only 4 is correct
4. Which one of the following types of bonds or interactions is LEAST important in determining the three-dimensional folding of most proteins?
(A) Hydrogen bonds (B) Hydrophobic interactions (C) Disulfide bonds (D) pi bonds
5. Which sequence of atoms can be found in the backbone of polypeptides?
(A) C-N-N-C (B) C-C-C-N (C) C-C-N-C (D) N-C-C-C
6. A pair potential between two identical spherical atoms has the form

$U(r) = (4\epsilon / k_B T)[(\sigma/r)^{12} - (\sigma/r)^6]$; r is the separation between the centers of the spherical atoms and σ is the diameter, ϵ is the energy parameter and T is temperature, k_B is the Boltzmann constant. Which of the following is true?

- (A) $r \rightarrow \infty; U(r) \rightarrow 0$ and $r \rightarrow 0; U(r) \rightarrow \infty$
- (B) $r \rightarrow 0; U(r) \rightarrow 0$ and $r \rightarrow \infty; U(r) \rightarrow \infty$
- (C) $r \rightarrow \infty; U(r) \rightarrow \epsilon$ and $r \rightarrow 0; U(r) \rightarrow \epsilon/k_B$
- (D) $r \rightarrow 0; U(r) \rightarrow k_B T$ and $r \rightarrow \infty; U(r) \rightarrow \infty$

7. The packing parameter of an amphiphilic aggregate is given by the relation and dimension as follows (where 'v' is volume of hydrocarbon chain, 'a₀' is optimum area per molecule and 'l_c' is length of hydrocarbon chain):

- (A) $v/(a_0 l_c)$, dimensionless (B) $v l_c / a_0^2$, dimensionless (C) $a_0 l_c^2 / v, \text{\AA}^3$ (D) None

8. List atoms commonly found in biological molecules that are often hydrogen bond acceptors.

- (A) carbon (B) oxygen (C) nitrogen (D) Both B and C

9. Bilayers are observed to be twisted or buckled. This is due to

- (A) Due to crystallization of molecules
- (B) Due to elasticity of the bilayer and chirality of the molecules
- (C) Due to extensive gauche bending of alkyl chains
- (D) None

10. Most frequently observed Hydrogen bonds in the biological systems are

- (A) Strong (B) Weak (C) Tandem (D) None

11. Interaction arising from the process of bringing two non-polar solutes from infinity to a separation that corresponds to a final configuration within water at constant temperature and pressure is:

- (A) Hydrophobic effect (B) Hydrophobic interaction (C) Charge dipolar interaction (D) Hydrophobic hydration

12. Disulfide bonds are formed by pairs of which amino acid?

- (A) Glycine (B) Cysteine (C) Histidine (D) Proline

13. How do protein folding progresses towards the native state?

- (A) by cooperative folding (B) by progressive stabilization of intermediates (C) by random search through all possible conformational states (D) A and B

14. The following double-stranded DNA molecules (only the "top" strand is shown) are present in a dilute solution, which is heated sufficiently to denature all the DNA molecules. The solution is then rapidly cooled to room temperature. DNA from which molecule will first show the presence of double strands again after cooling?

- (A) AGGTAATTTCGCC (B) AGGTAAGCTTACCT (C) AGGTTGGGTGCTGA
(D) AAAAAAAAAAAAAA

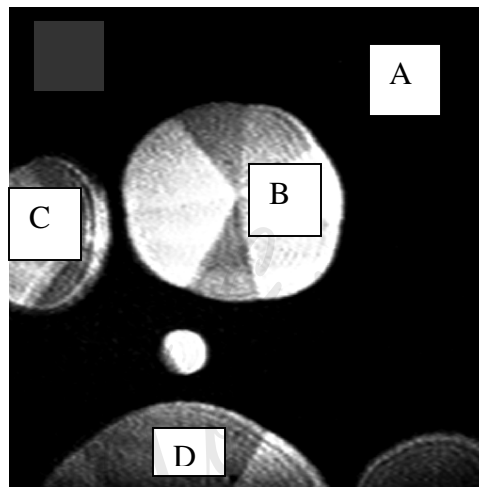
15. For alpha helix, given pitch = p , residue per turn = n , rise per residue = h which can be used to calculate pitch

- (A) $p = n / h$ (B) $p = n \times h$ (C) $p = h \tan (n)$ (D) Sufficient parameters are not given

16. Given the selected free energy contribution to the spontaneous aggregation of an amphiphilic aggregate, identify the unfavorable free energy components:

- (A) Hydrophobic, entropic (B) Hydrophobic, vander Waals interaction between chains (C) Translational-rotational, head group repulsion (D) Entropic, vander Waals interaction between chains

17. From the Brewster angle image in Fig. 1(attached), identify the region (shown as A,B,C, or D) that has most probability with amphiphile in LE phase and write that choice in the corresponding box provided in the answer sheet.



18. At high temperature and high water content what is the most likely phase of a lipid
(A) L- α (B) Cubic (C) Crystalline (D) P- β

19. Invariant or nonvariable region of a DNA structure is composed of

- (A) Phosphodiester and sugar (B) base and phosphodiester (C) base and sugar (D) All regions are variable.

20. A molecule has LJ energy parameter $\epsilon/k_B T = 100$. For a pair of such molecules the the pair interaction potential energy at deepest is

- (A) $-100 k_B T$ (B) $-200 k_B T$ (C) $-\sqrt{100} k_B T$ (D) $-50 k_B T$

21. A protein molecule in a kinetically trapped conformational state has energy

- (A) Higher than Native and lowered than completely denatured state
(B) Higher than completely denatured and lower than Native
(C) Equal to completely denatured state
(D) Equal to native

22. Bovine serum albumin (a protein) molecule has high dipole moment because

- (A) Due to large size of it and its charge distribution anisotropy
(B) Due to the large dielectric constant of water compared to hemoglobin
(C) Due to attached water of hydration in the hydration shell
(D) Due to presence of metal ion in the structure
23. For which of the following pair of basic unit and higher-level structure both are achiral (not chiral)?
(A) Phospholipid and helical bilayer composed of it.
(B) Natural amino acid and protein composed of it.
(C) Natural sugars and DNA composed of it.
(D) None
24. Hydrophobic effect is due to
(A) Attraction between nonpolar solute molecules in water
(B) Because it is entropically favorable to have nonpolar molecules together in water
(C) Because nonpolar molecules can be hydrogen bonded together
(D) Because the nonpolar molecules dissolved easily in water
25. Raman scattering is not possible with molecules having
(A) Isotropic polarizability
(B) Anisotropic polarizability
(C) Homonuclear diatomic structure
(D) None of the above
26. During osmosis process between a pure solvent and a solute, the semipermeable membrane allows to pass
(A) The solvent molecules
(B) The solute molecules
(C) Both
(D) None
27. In the scattering geometry with an angle of deflection (scattering angle) of θ , the related scattering vector is given by,
(A) $\cos \theta / 2\lambda$ (B) $2\sin \theta / \lambda$ (C) $2 \sin (\theta/2) / \lambda$ (D) None
28. The enol and imino forms are present in physiological conditions in natural DNA at following % out of the total of A, T, G, C base pairs (as the case may be), respectively:
(A) 12.3%, 18.4%, 3.2%, 56% (B) 0.01% for all (C) 99.99% for all (D) 18.4%, 3.2%, 12.3%, 56%
29. Positively charge macromolecules are located in side 2 in an osmosis chamber (divided in part 1 and 2 by a semipermeable membrane). A completely ionizable salt ($X^+ Y^-$) is added and the corresponding Donnan ratio is found to be 10. How much excess concentration of X^+ will be after the equilibrium is established and in which side (1 or 2)?
(A) 10 fold, in side 1

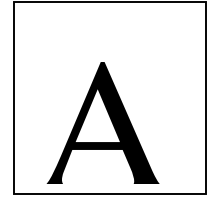
- (B) 10 fold, in side 2
- (C) 20 fold, in side 1
- (D) 20 fold, in side 2

30. Factors favorably affecting the cooperativity of helix – coil transition are

- (A) The hydrogen bonding of residues, The dipole moment alignment
- (B) The van der Waals interactions among residues, The dipole moment alignment
- (C) A,B
- (D) None

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PART I

ANSWER SHEET

ID No. _____ **NAME** _____

No. of correct answer	No. of wrong answer	No. of unanswered question	Total marks

Recheck request (if any): _____

1.	8	15	22	29
2.	9	16	23	30
3.	10	17	24	
4.	11	18	25	
5.	12	19	26	
6.	13	20	27	
7.	14	21	28	

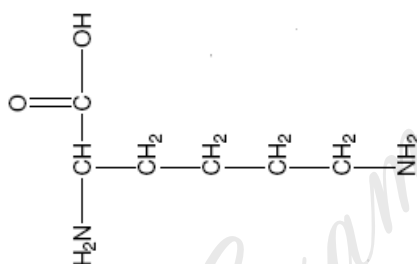
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INSTRUCTION: There are six (6) questions with sub-parts. Attempt all the questions. Start answering each question on a fresh page and answer all parts of the question together. Write brief answers to the point with proper justification. Pencil should not be used.

PART II (60M)

Q.1.

(a) Following amino acid (only neutral form is shown) is titrated and pK_a values are obtained as 2.18, 8.9 and 10.28, respectively. Given that *n*-butyl amine has $pK_a = 10.59$. Write the ionization scheme (successive ionizations) of the amino acid from low pH (=1) to high pH (=14). Provide justification supporting the scheme.



(b) A 88 kilo Dalton protein has a two-stranded alpha-helical structure (ignore any turn in the structure *i.e.* consider the whole structure as composed of helical form). If the mean residue mass is 110 Daltons and rise per residue of an alpha helix is 1.5 Å, then calculate the length of the molecule

(c) A 50 residue segment of a protein folds into a two stranded antiparallel beta sheet structure with a 4-residue hairpin turn, rise per residue of an beta sheet is 3.5 Å then calculate the longest dimension of this motif.

3+3+4 = 10M

Q.2.

(a) The shape of hair is determined in part by the pattern of disulfide bonds in its major protein, keratin. How curls are induced?

(b) Considering only the two major factors leading to the formation of an alpha helical structure, where it is more probable to form helix: in water or in hexane? Justify your answer.

(c) Write the relation describing the supercoiling of nucleic acid and explain each parameter.

3+3+4 = 10M

Q.3.

Time scale of orientational motion of pure water molecules is $\tau_w = 8$ ps. When the aqueous solution of whale myoglobin is studied, at least three different time scales are observed experimentally. They are of the order of $\tau_1 = 80$ ns, $\tau_2 = 10$ ns and $\tau_3 = 40$ ps.

(a) Explain the origin of τ_1

(b) Explain the origin of τ_2 and τ_3 .

(c) Which experiment can investigate the rotational motions indicated by τ_1 , τ_2 and τ_3 and describe the basic principle of the experimental technique (you can explain for a single component system, for example).

3+3+4 = 10M

Q.4.

After drawing the scattering geometry of X-ray, explain what is structure factor and derive a relation for atomic scattering factor (atom placed at origin).

3+3+4 = 10M

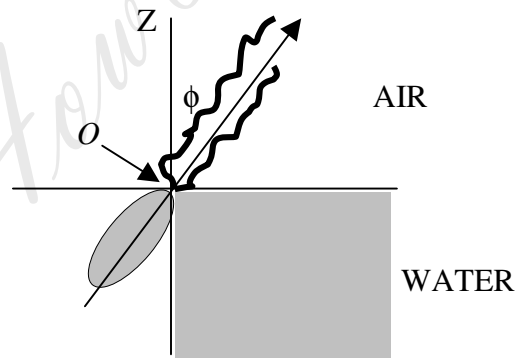
Q.5.

Write principles of two experimental methods for determining the molecular weight of biological molecules in solution without destroying the molecular structure.

5+5 = 10M

Q.6.

A lipid molecule has head group immersed in aqueous medium (which has dielectric constant as $\epsilon(w)$) as shown below. The average direction of the head group and alkyl chain is indicated by the arrow (\rightarrow) in the diagram. The head group has opposite charges of magnitude $\pm Q_L$ separated by y . Suppose the solution is made acidic by HCl and a Chloride ion of charge Q_{Cl} is situated at a distance $[(y \cos \phi)/2]$ vertically from air/water interface and t distance away from the center O . Consider that ion is in the grey quadrant (region). Derive an expression for the interaction between the head group and chloride ion. The final expression should contain the given symbol like $\epsilon(w)$, Q_L , Q_{Cl} , y , ϕ etc and no different symbol.



10M

END