NAME _____

EXAM I
September 25, 2000
Biochemistry I
BICH421/621

I. _____/ 36
II. _____/ 26
III. _____/ 38
TOTAL /100

I. **MULTIPLE CHOICE** (36 points)
Choose the BEST answer to the question by circling the appropriate letter.

1. An amino acid contains at least two functional groups: a carboxylic acid and an amine. Condensation of an amino group and a carboxyl group with loss of water forms a(n):

   A. carbonyl.
   B. ester.
   C. imidazole.
   D. guanidine.
   E. amide.

2. Three buffers are made by combining a 1 M solution of acetic acid with a 1 M solution of sodium acetate in the ratios shown below.

	1 M acetic acid	1 M sodium acetate
Buffer 1:	10 mL	90 mL
Buffer 2:	50 mL	50 mL
Buffer 3:	90 mL	10 mL

   Which of these statements is true of the resulting buffers?

   A. pH of buffer 1 > pH of buffer 2 > pH of buffer 3
   B. pH of buffer 1 < pH of buffer 2 < pH of buffer 3
   C. pH of buffer 1 = pH of buffer 2 = pH of buffer 3
   D. The problem cannot be solved without knowing the value of pK_a.

3. Which of the following statements about aromatic amino acids is correct?

   A. Compared to tyrosine, tryptophan absorbs more ultraviolet light because the double bonds in its R group are more extensively conjugated.
   B. The major contribution to the characteristic absorption of light at 280 nm by proteins is the phenylalanine R group.
   C. Histidine's ring structure results in its being categorized as aromatic or basic, depending on pH.
   D. The presence of a ring structure in its R group determines whether an amino acid is aromatic or not.
   E. The ring structure of aromatic amino acids results in two peaks of strong absorbance, one at 280 nm and one at 595 nm.

NAME _____

4. The three-dimensional structure of macromolecules is formed and maintained primarily through noncovalent interactions. Which of the following is not considered a noncovalent interaction?

   A. hydrogen bonds
   B. van der Waals interactions
   C. disulfide bonds between two Cys residues
   D. ionic interactions
   E. hydrophobic interactions

5. The pH of a sample of blood is 7.4. The pH of a sample of gastric juice is 1.4. The blood sample has:

   A. 5.29 times lower $[H^+]$ than the gastric juice.
   B. 6 times lower $[H^+]$ than the gastric juice.
   C. 6000 times lower $[H^+]$ than the gastric juice.
   D. a million times lower $[H^+]$ than the gastric juice.
   E. 0.189 times the $[H^+]$ as the gastric juice.

6. The four covalent bonds in methane (CH_4) are arranged around carbon to give what geometry?

   A. linear
   B. trigonal planar
   C. trigonal pyramidal
   D. tetrahedral
   E. trigonal bipyramidal

7. Which of the following has the cellular components arranged in order of increasing size?

   A. amino acid < ribosome < protein < virus
   B. protein < ribosome < virus < amino acid
   C. amino acid < protein < ribosome < virus
   D. protein < amino acid < virus
   E. amino acid < protein < virus < ribosome

8. Which of the following statements about buffers is true?

   A. The pH of a buffered solution remains constant no matter how much acid or base is added to the solution.
   B. The strongest buffers are those composed of strong acids and strong bases.
   C. A buffer composed of a weak acid of $pK_a = 5$ is stronger at pH 4 than at pH 6.
   D. When $pH = pK_a$, the weak acid and conjugate base concentrations in a buffer are equal.

9. Given the following peptide sequence, GSECDNCR, the estimated net charge at the given pH is:

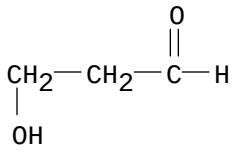
   A. -2 at pH > 13.5
   B. -1 at pH ~11.5
   C. +1 at pH ~6.5
   D. +2 at pH ~5.5
   E. 0 at pH ~4.5

NAME _____

10. Amino acids are ampholytes because they can function as either a(n):

A. polar or a nonpolar molecule.
B. acid or a base.
C. neutral molecule or an ion.
D. transparent or a light-absorbing compound.
E. standard or a nonstandard monomer in proteins.

11. What functional groups are present on this molecule?



A. hydroxyl and carboxylic acid
B. hydroxyl and aldehyde
C. hydroxyl and ketone
D. ether and aldehyde
E. hydroxyl and ester

12. As the phase changes from water to ice, the decreased density of the water is due to:

A. the loss of hydrogen bonds
B. the gain of ionic bonds
C. the gain of more van der Waals contacts
D. the spacial arrangement of the assymetrical water molecules as they form the maximum number of hydrogen bonds possible
E. the hydrophobic effect, which is driven by electrostatic interactions

II. **STRUCTURES**. (26 points)

13. Draw the structure of glycine, threonine, lysine, and tryptophan at pH 7.0. Give the 3-letter and 1-letter abbreviation for each and circle the one that is most likely found in the interior of proteins. (17 pts)

NAME _____

14. The artificial sweetener NutraSweet®, also called aspartame, is a simple dipeptide, aspartylphenylalanine methyl ester. (The free carboxyl of the dipeptide is esterified to methyl alcohol.) a) Draw the structure of aspartame, showing the ionizable groups in the form they have at pH 7. (The ionizable group in the side chain of aspartate has a pK_a of 3.96.) b) How might you explain why this molecule taste's sweet? (9 pts)

III. **SHORT ANSWER**. (38 points)
Give a brief answer or diagram to each problem or question.

15. A weak acid HA, has a pK_a of 5.0. If 1.0 mol of this acid and 0.091 mol of NaOH were dissolved in one liter of water, what would the final pH be? [NOTE: for logs round to the nearest factor of 10] (6 pts)

16. Proteins are constantly being synthesized in a living cell. Why doesn't the number of protein molecules become too great for the cell to contain, leading to cell destruction? (3 pts)

17. One-tenth mL of a protein solution was diluted with 2.9 mL of water. The A_{280} of the diluted solution was 0.25. How many mL of the original protein solution and water should be mixed to make 1.0 mL of solution of A_{280} = 0.75? (6 pts)

NAME _____

18. Identify 2 groups in a protein that can form hydrogen bonds or electrostatic interactions with the amino-terminus at pH 10. Be certain to give not just the name of the amino acid, but ALSO the functional group. For each identify the donor and acceptor. (6 pts)

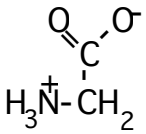
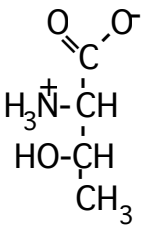
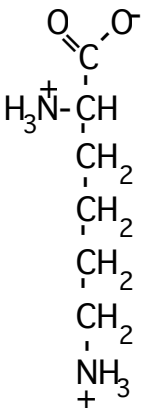
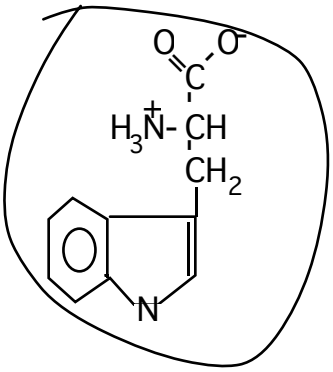
19. Enzymes provide a specific binding site for substrates where one or more chemical steps can be carried out. Often these sites are designed to exclude water. Suppose that at a binding site, a negatively charged substrate interacts with a positively charged atom in the enzyme's active site. Using Coulomb's equation, show how the presence of water might affect the interaction. What sort of environment might be preferable for a strong ionic interaction? How would an ionic interaction be affected by the distance between the substrate and this enzyme's active site? (6 pts)

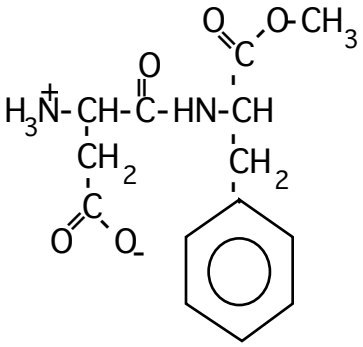
20. Arrange the following in order of increasing energy content: (3 pts)
    (a) Protein molecule
    (b) Glucose molecule
    (c) Covalent C-C bond
    (d) hydrogen bond

21. The net charge of a peptide at a particular pH can be determined by considering the pK_a values for each ionizable group in the protein. For an oligopeptide composed of 10 amino acids, how many of the α-carboxyl and α-amino groups must be considered? (2 pts)

22. How can isoelectric focusing be used in conjunction with SDS gel electrophoresis? (6 pts)

Answers for Exam 1, 9/25/00

Test Question	Correct Answer
Multiple Choice	
1	E
2	A
3	A
4	C
5	D
6	D
7	C
8	D
9	E
10	B
11	B
12	D
Structures	
13	Gly, G  Thr, T  Lys, K  Trp, W 

14	
	There is a conformation of this dipeptide that can adopt the same conformation of those for sugars that bind to taste-bud receptor proteins.

Short Answer	
15	Combining 1 mol of weak acid with 0.091 mol of NaOH yields 0.91 mol of weak acid and 0.091 mol of salt. $pH = pK_a + \log \frac{[salt]}{} = 5.0 + \log(0.091/0.91) = 5+\log 0.1 = 4$

Test Question	Correct Answer	
		[acid]

16		The proteins in a cell are continuously being synthesized and degraded. The cell maintains a dynamic steady state in which the amount of each protein remains fairly constant at the level required under given conditions.

17		The A_{280} of the undiluted protein solution is 30 x 0.25 = 7.5. This is at 10-fold more concentrated than desired. Mix 0.1 mL protein solution and 0.9 mL of water to give an A_{280} = 0.75.

18		At pH 10 the amino terminus is largely dissociated and uncharged, therefore, there are no strictly electrostatic interactions possible. The $-NH_2$ can be a donor to the hydroxyl of Ser, Thr, Tyr; the carbonyl of the peptide bond, Asn, Gln; the carboxyl of Glu, Asp, or the C-term., or the nitrogen of any other deprotonated amino group of Lys, or the imidazole of His. Because its deprotonated, the filled orbital can be the acceptor from the –OH of Ser, Thr, Tyr; the amide nitrogen (NH) of the peptide bond, Asn, Gln; and the nitrogen (N–H) of any other amino group of Lys, or the imidazole of His.

19		The magnitude of the electrostatic attraction would be decreased by the presence of water because D, the dielectric constant, is relatively high for water. Coulomb's equation shows that the attractive force is inversely related to the dielectric constant. Therefore, higher values of D will give lower values for the attractive force. This would mean that environments where water is excluded and the value of D goes down will increase the strength of an ionic interaction. Coulomb's equation also states that there is an inverse relationship between the distance between two charges. Therefore, two oppositely charged atoms will have less interaction as there is more distance between them.

20		d, c, b, a

21		The only α-carboxyl and α-amino groups that must be considered are the ones at the amino- and carboxyl-termini, or TWO, because the others are involved in the condensation reaction to form the peptide bonds.

22		Isoelectric focusing can separate proteins of the same molecular weight on the basis of differing isoelectric points. SDS gel electrophoresis can then separate proteins with the same isoelectric points on the basis of differing molecular weights. Together a great resolution of large numbers of proteins can be achieved. ----