

NAME _____

EXAM I

September 26, 2005

Biochemistry I

BICH421/621

I. _____/36

II. _____/21

III. _____/18

IV. _____/11

V. _____/14

TOTAL _____/100

I. MULTIPLE CHOICE (36 points; 3 pts each)

Choose the BEST answer to the question by circling the appropriate letter.

- All of the following compounds are capable of forming hydrogen bonds with water EXCEPT _____.
 - methanol
 - acetamide
 - methyl acetate
 - ethanol
 - hexane
- Titration of valine by a strong base, for example NaOH, results in two pKs. The titration reaction occurring at pK₂ (pK₂ = 9.62) is:
 - $-\text{COOH} + \text{OH}^- \rightleftharpoons -\text{COO}^- + \text{H}_2\text{O}$.
 - $-\text{COOH} + -\text{NH}_2 \rightleftharpoons -\text{COO}^- + -\text{NH}_3^+$.
 - $-\text{COO}^- + -\text{NH}_3^+ \rightleftharpoons -\text{COOH} + -\text{NH}_2$.
 - $-\text{NH}_3^+ + \text{OH}^- \rightleftharpoons -\text{NH}_2 + \text{H}_2\text{O}$.
 - $-\text{NH}_2 + \text{OH}^- \rightleftharpoons -\text{NH}^- + \text{H}_2\text{O}$.
- The pK of the carboxyl group of glycine (pK = 2.3) is less than that for acetic acid (pK=4.8) due to _____.
 - the electronegativity of the carbonyl oxygen
 - the electrostatic stabilization of the adjacent amino group
 - the electronegativity of the nitrogen in the adjacent amino group
 - the electronic nature of amino acids
 - the fact that glycine can be a zwitterion and acetic acid cannot
- Which of the following is true about the change in enthalpy (ΔH) of a reaction that is spontaneous (favorable) at room temperature?
 - It is equal to $T\Delta S$.
 - It is positive and the reaction is exothermic.
 - It is negative and the reaction is endothermic
 - It must be equal to zero.
 - It can be either positive or negative.

5. The peptide Ala-Glu-Gly-Ala-Leu has:
- A. four peptide bonds.
 - B. two free amino groups.
 - C. a disulfide bond.
 - D. no free carboxyl group.
 - E. five peptide bonds.
6. An enzyme that catalyzes the reaction $A \rightleftharpoons B$ changes the ____.
- A. heat of reaction
 - B. equilibrium constant
 - C. equilibrium concentration of A
 - D. entropy of the reaction
 - E. rate of both forward and reverse reactions
7. 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.
8. The reaction shown below is conducted in a closed system containing gaseous CO_2 and a buffered aqueous solution. After the reaction is allowed to reach equilibrium, the concentration of bicarbonate ions in the aqueous phase would most likely be increased by ____.
- $$\text{H}_2\text{O} + \text{CO}_2 \rightleftharpoons \text{HCO}_3^- + \text{H}^+$$
- A. adding water while keeping the partial pressure of CO_2 constant
 - B. adding carbonic anhydrase, a catalyst for the reaction
 - C. increasing the pH of the buffered aqueous solution
 - D. reducing the partial pressure of CO_2
 - E. reducing the temperature of the reaction solution
9. A water-soluble globular protein is most likely to have the highest proportion of which of the following amino acid residues buried within its core?
- A. Ser
 - B. His
 - C. Ile
 - D. Glu
 - E. Lys
10. Which of the following is *not* a biological role for amino acids?
- A. components of proteins
 - B. components of peptide hormones
 - C. function as neurotransmitters
 - D. components of cell walls
 - E. All of the above are biological uses of amino acids.

11. An acid or base that dissociates less than 100% in water is described as being _____.
- A. a Lewis acid or base
 - B. a weak acid or base
 - C. a strong acid or base
 - D. a little acid or base
 - E. hydrophobic acid or base
12. The condition called _____ results when a person's blood pH becomes lower than normal.
- A. metabolic acidosis
 - B. vitamin deficiency
 - C. beri-beri
 - D. strong acid
 - E. weak acid
 - F. gastric acid

II. **STRUCTURES.** (21 points)

13. Draw the structures of the following functional groups, pH 7.0: (5 pts)
(a) hydroxyl (b) carboxylate (c) amino (d) phosphoryl (e) indole
14. Draw the amino acid asparagine as you would find it at pH 7. Identify the hydrogen bond donor and acceptor groups using arrows. (6 pts)
15. Draw the peptide ATLDAK. (a) Calculate its approximate pI. (b) What is the net charge at pH 7.0? (10 pts)

III. SHORT ANSWER. (18 points)Give a brief answer or diagram to each problem or question.

16. If all living organisms use the same amino acids, nucleotides, and monosaccharides to form proteins, nucleic acids, and polysaccharides, how can there be so many different kinds of living organisms? (2 pts)
17. Draw the titration curve for a weak acid, HA, whose pK_a is 3.2. Label the axes properly. Indicate with an arrow where on the curve the ratio of salt (A^-) to acid (HA) is 10:1. What is the pH at this point? (5 pt)
18. Suppose you have just added 100 mL of a 1.5 M solution of acetic acid to 400 mL of 0.5 M NaOH. What is the final pH? (The pK_a of acetic acid is 4.7.) (3 pts)
19. What is the uniquely important acid-base characteristic of the histidine R group? (2 pts)

20. A beaker of distilled water sitting out on your lab bench is slightly acidic. Explain. (2 pts)
21. For the reaction A to B at 300 °K, the change in enthalpy is -7kJ/mol and the change in entropy is -30 J/°K-mol. Is the reaction favorable? If not, should the temperature be increased or decreased to make the reaction favorable (spontaneous)? (4 pts)

IV. **TRUE/FALSE.** (11 points)

CIRCLE the appropriate answer.

- T F 22. The O-H bonds of water are polar due to the high electronegativity of hydrogen.
- T F 23. Water is a polar molecule (has a dipole moment) because it is V-shaped.
- T F 24. In a medium of pH 2.0, aspartic acid has a net positive charge.
- T F 25. All 20 of the amino acids used to make natural proteins are optically active.
- T F 26. The isoelectric point for most of the amino acids that have non-polar side chains is about 6.
- T F 27. The hydrophilic side chains of amino acid residues normally locate themselves toward the exterior of globular proteins.
- T F 28. For life to exist, the $-T\Delta S$ term in the Gibbs free energy equation must be more negative than ΔH is positive.
- T F 29. The gecko utilizes van der Waals interactions to walk on ceilings.
- T F 30. Hyperventillation will lower the CO₂ concentration in the blood by changing the pK_a of the bicarbonate reaction.
- T F 31. Morphine must have the same configuration as Met-enkephalin because both can bind to the same brain receptor proteins
- T F 32. Enzymes can make a reactions more or less "spontaneous".

V. **MATCHING**. (14 points)

33. The choices on the left refer to the substances on the right. Select the one substance that is most closely related to the choice on the left. A substance can be used ONLY once and all have a best choice. (6 pts)

_____	1. Largely insoluble in aqueous solutions	A. NaCl
_____	2. Highly soluble in water and solvated largely by hydrogen bonds	B. the R-group of Glutamine
_____	3. Forms hydrated ion pairs in aqueous solutions	C. Valine
_____	4. Exists largely as a zwitterion in aqueous solution at pH 7	D. the R-group of Phenylalanine
_____	5. Structure is largely determined by the hydrophobic effect	E. a ligand with its receptor protein
_____	6. van der Waals interactions help stabilize the bonding	F. SDS micelles

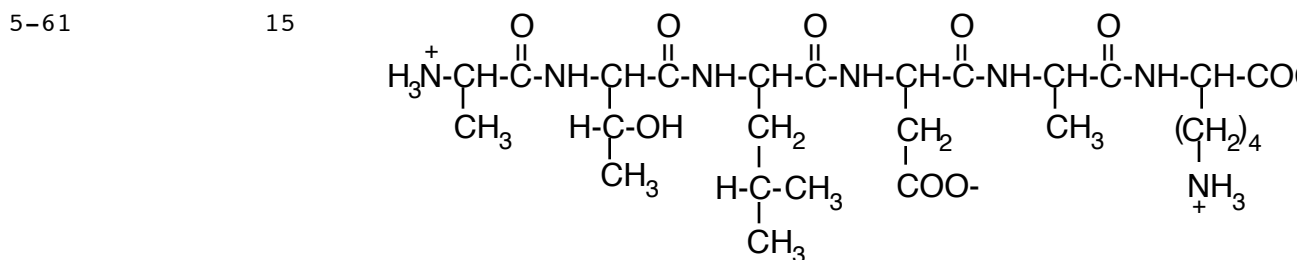
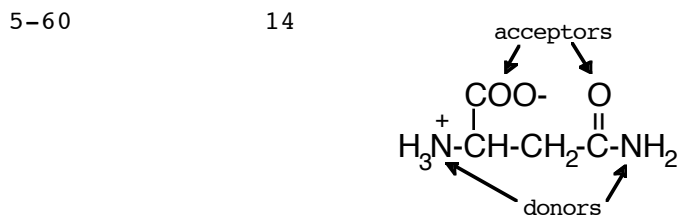
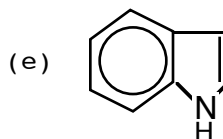
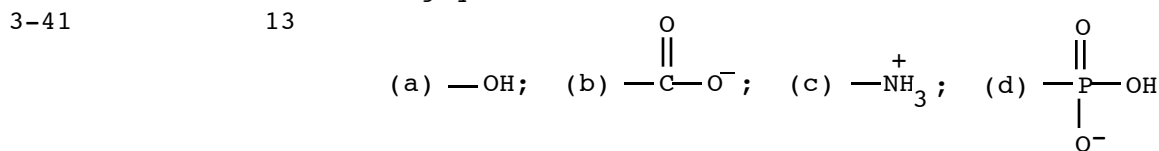
34. For the bonds or interactions in the left column, indicate all the characteristics in the right column that are appropriate. Items on right can be used more than once. (8 pts)

1. Charge-charge electrostatic interactions	A. Has an energy of around 0.2-0.5 kcal/mole per bond
2. Hydrogen bond	B. Has an energy between 3 and 7 kcal/mole per bond
3. van der Waals interactions	C. Is optimal at or near the van der Waals contact distance
4. Hydrophobic interactions	D. Requires nonpolar species
	E. Is also called a salt-bridge
	F. Involves polarizable atoms
	G. Involves O and H or N and H atoms
	H. Requires polar or charged species
	I. Exists only in water
	J. Involves charged species only

Answer Sheet for Test "test1.05", 9/24/5

Chapter/ Question	Test Question	Correct Answer
The following questions are in section "Multiple Choice"		
3-38	1	E
5-8 (-,b,-)	2	D
5-59	3	B
3-37	4	E
5-13 (-,a,-)	5	A
3-35	6	E
3-3 (-,b,-)	7	E
3-36	8	C
3-39	9	C
3-14 (-,c,-)	10	E
4-37	11	B
4-38	12	A

The following questions are in section "Structures"



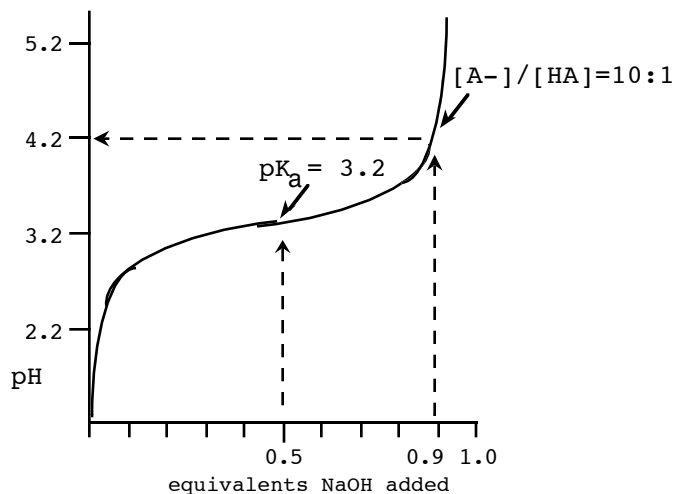
Ala(A) Thr(T) Leu(L) Asp(D) Ala(A) Lys(K)

(a) pI is about 6; C-term and D have pK ~4 and ~3, respectively; N-term and K have pK ~8 and ~11, respectively. The pI is midway between the pK's of the ionizations involving the neutral species; $4+8/2 = 6$
 (b) zero; at 7 both C-term and D are negative and both N-term and K are positive. Although, it might be slightly negative due to some N-term deprotonation and loss of plus charge.

Chapter/ Question	Test Question	Correct Answer
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The following questions are in section "Short Answer"

- | | | |
|--------------|----|--|
| 1-12 (-,b,-) | 16 | The diversity is achieved through the nearly limitless variety of sequences that can be achieved when amino acids are linked to form proteins, and nucleotides are linked to form nucleic acids. |
| 4-21 (-,c,-) | 17 | The plot of pH vs. added base will look like this, with the midpoint of the titration (inflection point) at pH 3.2. |



The ratio of A^- to HA is 10 when about 0.9 equivalents of base have been added. From the Henderson-Hasselbalch equation, the pH at this point can be calculated:

$$pH = pK_a + \log \frac{[salt]}{[acid]} = 3.2 + \log 10 = 4.2$$

- | | | |
|--------------|----|---|
| 4-27 (-,c,-) | 18 | <p>Addition of 200 mmol of NaOH (400 mL x 0.5 M) to 150 mmol of acetic acid (100 mL x 1.5 M) completely titrates the acid so that it can no longer act as a buffer and leaves 50 mmol of NaOH dissolved in 500 mL, an $[OH^-]$ of 0.1 M. Given $[OH^-]$, $[H^+]$ can be calculated from the water constant:</p> $[H^+][OH^-] = 10^{-14} \text{ M}^2$ $[H^+] = 10^{-14} \text{ M}^2 / 0.1 \text{ M} = 10^{-13} \text{ M}$ <p>pH is, by definition, $-\log [H^+]$
 $pH = -\log (10^{-13} \text{ M}) = 13.$</p> |
| 5-31 (-,b,-) | 19 | Only the imidazole ring of the histidine R group has a pK_a near physiological pH ($pK_a = 6.0$), which suggests that histidine may participate in proton exchanges (acid-base chemistry) in physiological systems. |

Answer Sheet for Test "test1.05", 9/24/5

Chapter/ Question	Test Question	Correct Answer
4-40	20	Atmospheric carbon dioxide reacts with the distilled water in the beaker to form carbonic acid. The carbonic acid dissociates into protons and bicarbonate because of its pK of about 6. These protons make the water slightly acidic.
3-42	21	$\Delta G = \Delta H - T\Delta S$, so $\Delta G = -7 \text{ kJ/mol} - (300)(-0.03 \text{ kJ/}^\circ\text{K-mol})$; this is $-7 \text{ kJ/mol} + 9 \text{ kJ/mol} = +2 \text{ kJ/mol}$. It is not favorable. Since the $-T\Delta S$ term is more positive, the reaction would be favorable if the temperature were decreased.
The following questions are in section "True/False"		
3-29	22	F
3-30	23	T (the shape is asymmetric)
3-31	24	T (COOH not charged for either α -carboxyl or the R-group carboxyl, thus only the positive α -amino is charged)
3-32	25	F (Gly is not)
3-33	26	T; they only have a carboxylate ($\text{pK}_a=2.5$) and an amino-group ($\text{pK}_a=9.5$). $\text{pI} = (\text{pK}_a(\text{acid}) + \text{pK}_a(\text{base}))/2$
3-34	27	T
3-44	28	F (ΔH must be more negative than the positive $(-T\Delta S)$ term (ΔS is negative)).
3-45	29	T
3-46	30	F (it lowers $[\text{CO}_2]$, pK_a does not change.
3-47	31	F (conformation)
3-48	32	F (enzymes change the rate(kinetics) not the thermodynamics).
The following questions are in section "Matching"		
3-40	33	D, B, A, C, F, E
4-39 (a,c,-)	34	1. B, E, J (C) (H) 2. B, G, H (F) 3. A, C, F (G) 4. D, I, (A) [Note: letters in () are correct, but not counted as wrong]