Chemistry 333
Principles of Biochemistry
Fall 2004
First Exam
September 21, 2009

NAME: KEY

To be eligible for a regrade, the exam must be done in ink.

1. _________/5 points

2. _________/12 points

3. _________/20 points

4. _________/4 points

5. _________/5 points

6. _________/4 points

7. _________/24 points

8. _________/26

9 _________/2 points (EXTRA CREDIT)

TOTAL: _______________/100 points

Acid	HA	K_a	pK_a
Formic acid	$HCOOH$	1.78×10^{-4}	3.75
Acetic acid	CH_3COOH	1.76×10^{-5}	4.75
Pyruvic acid	$CH_3COCOOH$	3.16×10^{-3}	2.50
Lactic acid	$CH_3CHOHCOOH$	1.38×10^{-4}	3.85
Malic acid	$HOOC—CH_2—CHOH—COOH$	(1) 3.98×10^{-4}	3.40
		(2) 5.5×10^{-6}	5.26
Citric acid	$HOOC—CH_2—C(OH)(COOH)—CH_2—COOH$	(1) 8.14×10^{-4}	3.09
		(2) 1.78×10^{-5}	4.75
		(3) 3.9×10^{-6}	5.41
Carbonic acid	H_2CO_3	(1) 4.3×10^{-7}	6.4
		(2) 5.6×10^{-11}	10.2
Phosphoric acid	H_3PO_4	(1) 7.25×10^{-3}	2.14
		(2) 6.31×10^{-8}	7.20
		(3) 3.98×10^{-13}	12.4
Ammonium ion	NH_4^+	5.6×10^{-10}	9.25

TABLE 4.2

Table of pK values for the 20 amino acids found in proteins[a]

Name	pK_1	pK_2	pK_R
Glycine	2.4	9.8	
Alanine	2.3	9.9	
Valine	2.3	9.6	
Leucine	2.4	9.6	
Isoleucine	2.4	9.7	
Methionine	2.3	9.2	
Phenylalanine	1.8	9.1	
Proline	2.0	10.6	
Serine	2.1	9.2	
Threonine	2.6	10.4	
Cysteine	1.8	10.8	8.3
Asparagine	2.0	8.8	
Glutamine	2.2	9.1	
Tyrosine	2.2	9.1	10.9
Tryptophan	2.4	9.4	
Aspartate	2.0	10.0	3.9
Glutamate	2.2	9.7	4.3
Histidine	1.8	9.2	6.0
Lysine	2.2	9.2	10.8
Arginine	1.8	9.0	12.5

[a] pK_1 values are assigned to the α-carboxyl group, pK_2 values to the α-amino group, and pK_R to ionizable groups in the R group (side chain).

1. Biological macromolecules are multimers made up of monomeric building blocks. Use **arrows** to match the monomers used to synthesize these naturally occurring polymers. Each monomer may be used more than once or not at all. (5 points)

Multimers	Monomers
1. DNA and RNA	a. glucose
2. proteins	b. nucleotides
3. cellulose	c. amino acids
4. starch	d. lipids
5. membranes	e. vitamins

2. How many **grams** each of solid KH_2PO_4 (MW = 136 g/mol) and solid K_2HPO_4 (MW = 174 g/mol) would you use to prepare 2 L of a 0.3 M phosphate buffer (phosphoric acid) at pH 6.8? (12 points)

Write out and **identify** the **ACID** and the **CONJUGATE BASE**. (Ignore the K^+ except when calculating the grams needed.)

Partial credit will be awarded, so please show all of your work including any equations!

KH_2PO_4 - Acid

K_2HPO_4 - Conjugate Base

$$pH = pKa + \log \frac{[A^-]}{[HA]}$$

$$6.8 = 7.2 + \log \frac{[A^-]}{[HA]} = \frac{0.4 \leftarrow A^-}{1 \leftarrow HA}$$

$$\frac{0.4}{1.4} = 0.286$$

$$\frac{1}{1.4} = 0.714$$

$$2L \times \frac{.3 \text{ Moles}}{1L} = 0.6 \text{ moles}$$

0.286×0.6 moles $= 0.1716$ moles A^-

0.714×0.6 moles $= 0.4284$ moles HA

0.1716 moles $\times \frac{174\ g}{mol} =$

29.86 g A^-

0.4284 moles $\times \frac{136\ g}{mol} =$

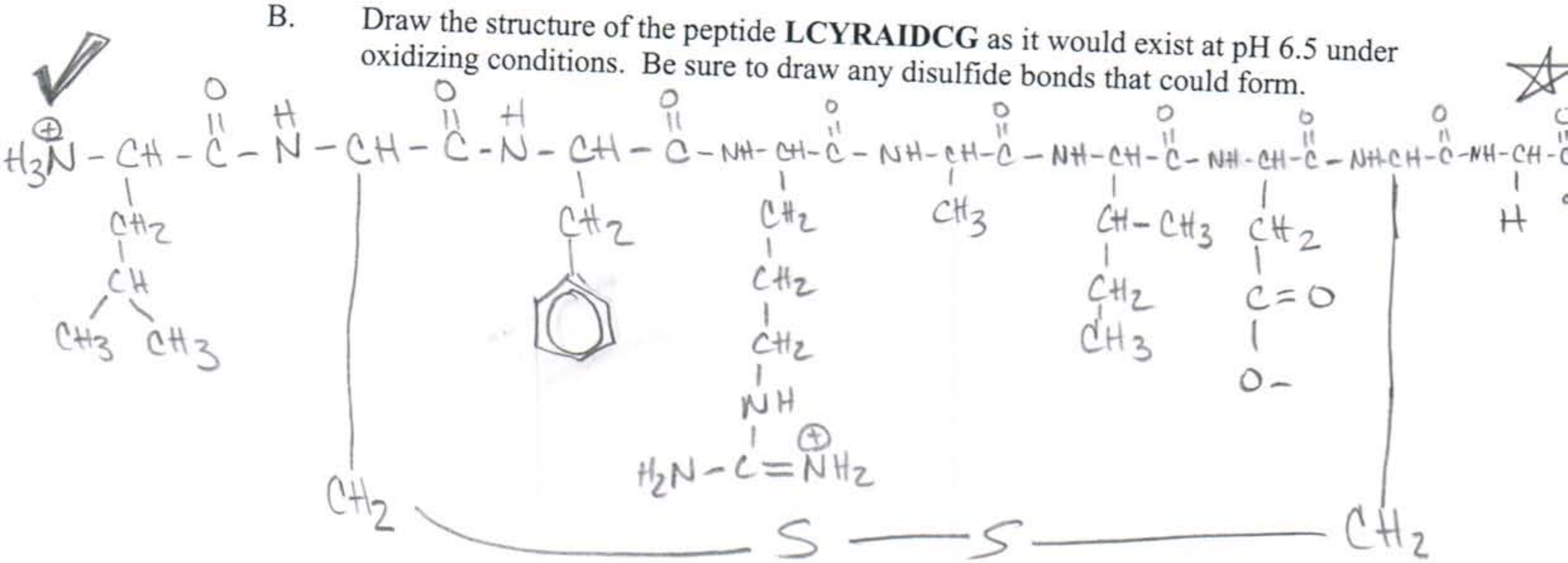
58.26 g HA

3. Answer the following questions regarding the peptide **LCYRAIDCG** (20 points)

A. What is the sequence of amino acids written as the **THREE** letter code?

Leu-Cys-Tyr-Arg-Ala-Ile-Asp-Cys-Gly

B. Draw the structure of the peptide **LCYRAIDCG** as it would exist at pH 6.5 under oxidizing conditions. Be sure to draw any disulfide bonds that could form.



C. Label the **N-terminus** of the peptide you drew in 3B above with a ✓.

D. Label the **C-terminus** of the peptide you drew in 3B above with a ★.

E. Calculate the **net charge** of **LCYRAIDG** at pH 1.5.

Net Charge = +2

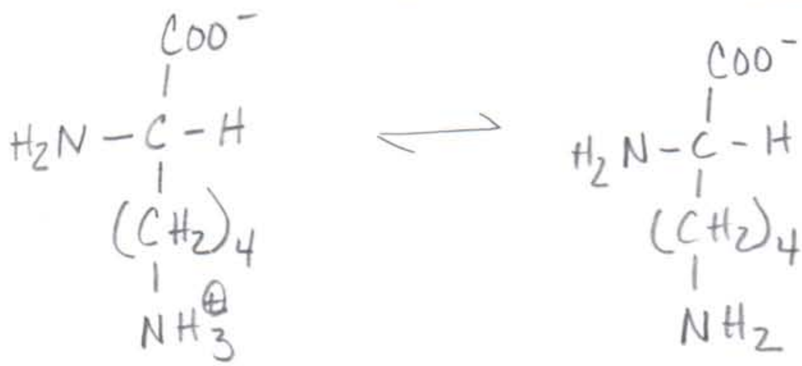
4. Calculate the approximate **pI** of the peptide **DSYRLKCF** (4 points)

10.0 H_3N – D - S - Y - R - L - K - C - F - COOH 1.8
3.9, 10.9, 12.5 (+), 10.8 (+), 8.3

$+3 \xrightarrow{1.8} +2 \xrightarrow{3.9} +1 \xrightarrow{8.3} 0 \xrightarrow{10.0} -1 \xrightarrow{10.8} -2 \xrightarrow{10.9} -3 \xrightarrow{12.5} -4$

$pI = \frac{8.3 + 10.0}{2} = 9.15$

5. **Draw** the form(s) of the amino acid **lysine** that would exist at pH 10.8.
In what relative percentages (% of each) will these forms exits? Why? (5 points)



When pH = pka of the R group, you will have 50% of each form

6 A &B (4 points)

There are six forms of a protein; one is normal and five contain different mutations that change the amino acid at position 150 (called mutants). The normal enzyme has a glutamine residue at amino acid position 150 that is located on the protein surface. Each mutant form of the protein has an amino acid substitution at position 150 as indicated:

6A. Which mutant form of the protein is most like the normal form because it contains the most **conservative** substitution? (i.e. which side chain most resembles that of glutamine?)

a. Form A: glutamine has been replaced by alanine
b. Form B: glutamine has been replaced by arginine
c. Form C: glutamine has been replaced by asparagine
d. Form D: glutamine has been replaced by glutamate
a. Form E: glutamine has been replaced by phenylalanine

6B. Which mutant form has the highest propensity to place amino acid 150 in the **interior** of the protein?

a. Form A: glutamine has been replaced by alanine
b. Form B: glutamine has been replaced by arginine
c. Form C: glutamine has been replaced by asparagine
d. Form D: glutamine has been replaced by glutamate
e. Form E: glutamine has been replaced by phenylalanine

7. Match the characteristics at left with the best matching amino acids at right by entering each characteristic's number in the appropriate blank. Unless otherwise stated, all of the amino acids are at physiological pH 7.4. There are more than one characteristic for many of the amino acids and **24 total answers** each worth one point. There *will* be a deduction for incorrect answers, so don't fill in the lines with unnecessary characteristics. (24 points)

Characteristics	Answer	Amino acid
1. acidic side chain	11	leucine
2. non-chiral amino acid	1, 10	aspartate
3. basic side chain	4, 12, 13	serine
4. side chain can be modified by adding phosphates	3, 8, 9	lysine
5. involved in disulfide cross links	7, 14	phenylalanine
6. often found in the turns of proteins	9, 12, 13	asparagine
7. is converted to tyrosine by hydroxylation	2, 6	glycine
8. important for the structure of collagen	4, 12, 14	tyrosine
9. has more than one amino group	6, 8	proline
10. has an overall net charge of -1 at pH 8.5	5, 10, 12	cysteine
11. only straight or branched hydrocarbons in the side chain		
12. polar, non-charged side chain		
13. side chain can be modified by adding sugars		
14. aromatic side chain		

8. Multiple Choice: 2 points each (26 points)

1. The **primary** purpose of membranes in eukaryotic cells is:
   - A. to increase surface area inside the cell
   - (B) to create compartments to separate biochemical functions
   - C. to provide anchors for the cytoskeleton
   - D. to provide attachment sites for ribosomes
   - E. none of the above

2. What are the energy-producing organelles in eukaryotic cells?
   - A. endoplasmic reticulum
   - B. lysosomes
   - C. nucleus
   - (D) mitochondria
   - E. golgi

3. Aspartame (Nutrasweet) is
   - A. deadly in small amounts
   - (B) a dipeptide
   - C. a modified sugar
   - D. a carbohydrate
   - E. an amino acid

4. Free rotation about the peptide bond in a protein is restricted primarily because of
   - (A) partial double-bond character of the peptide bond.
   - B. hydrogen bonding to the amide backbone groups.
   - C. partial double-bond character of the N-C alpha bond.
   - D. restrictions caused by local folding patterns.
   - E. steric interference of neighboring amino acid side chains.

5. Quaternary structure refers to:

A. the overall shape of the polypeptide chain

B. the sum of secondary and tertiary interactions

C. simple proteins with one subunit

D. the relative orientation of one polypeptide to another polypeptide in a multisubunit protein complex

E. the linear sequence of amino acids in a protein

6. Enantiomers are:

A. compounds with very different chemical composition

B. molecules with both hydrophobic and hydrophilic characteristics

C. a pair of compounds that are non-superimposable mirror images of one another

D. not chiral

E. superimposable mirror images

7. The lysosome is important for:

A. Biosynthesis of amino acids

B. Disposal of molecular waste/excess

C. Protein translation

D. Glucose breakdown

E. None of the above

8. The primary structure of a protein describes the ____________________.

A. number of each type of amino acid (percent composition)

B. linear sequence of amino acids

C. overall three-dimensional shape

D. rotation angles for each amino acid

E. assembly of protein subunits into complexes

9. Structural proteins that typically assemble into large cables or threads to provide mechanical support to cells or organisms are classified as _________ proteins.

A. fibrous

B. enzyme

C. globular

D. receptor

E. α-helical

10. The [H+] concentration at pH 4.4 is:

A. 10 times higher than the [H+] concentration at pH 6.4

B. 10 times lower than the [H+] concentration at pH 5.4

C. 100 times higher than the [H+] concentration at pH 3.4

D. 100 times higher than the [H+] concentration at pH 6.4

E. 100 times lower than the [H+] concentration at pH 5.4

11. If human blood is not maintained at close to pH = 7.4, a person can develop

A. Acidosis

B. Alkalosis

C. Diabetes

D. Both a and b

E. None of the above

12. Proteins are biopolymers of amino acids in which monomers are linked in a linear fashion with which type of bond?

A. amide

B. ester

C. ether

D. phosphoanhydride

E. phosphate ester

13. Which of the following compounds would you select to construct a buffer at pH 8?

A. acetic acid, pKa = 4.8

(B) N-tris(hydroxymethyl)methylglycine (Tricine), pKa = 8.15

C. N-2-hydroxyethylpiperazine-N'-ethansulfonic acid, pKa2 = 7.6

D. glycine, pKa2 = 9.9

E. tris(hydroxymethyl)aminomethane (Tris), pKa = 8.3

9. EXTRA CREDIT: (2 points)

1. If 70 mL of 0.01 M HCl is added to 150 mL of 0.1M acetic acid, pH 5.0, what is the resulting pH? Identify the appropriate acid and conjugate base and determine their concentrations in the final solution. (2 points)

$CH_3COOH \rightleftharpoons CH_3COO^- + H^{\oplus}$

$pH = pka + \log \frac{[A^-]}{[HA]}$

$5.0 = 4.75 + \log \frac{[A^-]}{[HA]}$

$\frac{[A^-]}{[HA]} = \frac{1.8}{1}$ $1.8 + 1 = 2.8$

70mL = 0.07L

$0.07L \times \frac{0.01 \text{ mol}}{L} = 0.7 \text{mmol } H^+$ added

$\left(\frac{1.8}{2.8}\right)(.15L)\left(\frac{0.1 \text{ mol}}{L}\right) = 9.6 \text{ mmol } A^-$

$\left(\frac{1}{2.8}\right)(0.15L)\left(\frac{0.1 \text{ mol}}{L}\right) = 5.4 \text{ mmol HA}$

$\frac{9.6 \text{ mmol} - 0.7 \text{ mmol}}{.22L} = 40.45M$

$\frac{5.4 \text{ mmol} + .7 \text{ mmol}}{.22L} = 27.7M$

$pH = 4.75 + \log \frac{[40.45]}{[27.7]}$

$pH = 4.91$