Chemistry and Biochemistry 153A
Winter 2010

Exam 1

Instructions:

- You will have 1 hour 45 minutes to complete the exam.
- You may use a pencil (recommended) or blue or black ink pen to write your answers. Other color inks will not be graded.
- Only answers on the answer sheet, in the indicated space, will be graded; writing anywhere else will be ignored. Be sure to write your name on the answer sheet.
- Do not write in the score boxes on your answer sheet; you will be docked points if you do.
- For answers with a word or sentence limit, words beyond this limit will not be read or graded.
- For short- or multi-answer questions, including irrelevant or wrong information or selections in your answer will cause you to lose points.
- Write legibly. If the grader cannot read your answer, you won't get credit.
- Items you may have on your desk:
  - non-programmable scientific calculator, *without its case or cover*
  - writing utensil(s)
  - student ID

  ALL other items must be placed into a bag, which must be zipped up or closed and pushed *completely* under your chair.
- No hats, hoods or earphones are allowed.
- If you continue to write after 'time' is called, your exam will be taken and docked 10 points.
- **Questions are printed on both sides, as is the answer sheet. Be sure you've answered all of the questions!**

1. (3) Roughly how many proteins can fit inside a human cell?
    a. 1,000
    b. 100,000
    c. 1 million (10^6)
    d. 1 billion (10^9)
    e. A googol (10^{100})

2. (2) Given that the boiling point of water is 100°C and of methanol is 65°C:
   True or false? Water has a higher boiling point than methanol because its hydrogen bonds are stronger.

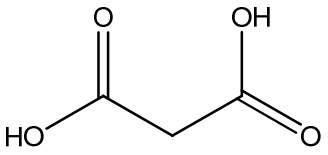
3. (3) In the equation for the dielectric constant, F is the force of interaction between:
    a. Two ions
    b. Two water molecules
    c. Solvent and solute
    d. None of the above

4. (3) Which of the following is most important in stabilizing the structure of *integral* membrane proteins?
    a. hydrogen bonds
    b. the hydrophobic effect
    c. van der Waals contacts
    d. ion pairs
    e. disulfide bonds

5. (4) Which of the following are reasons why mass spectrometry is a useful tool in protein sequencing? (Choose all that apply.)
    a. Sequence identification can be automated
    b. It is possible to identify modifications to amino acids
    c. A peptide's sequence can be unambiguously determined
    d. Mass spectrometric sequencing is faster than Edman sequencing
    e. The masses of all amino acids are unique

6. (3) Complete the sentence to define 'osmosis' as it relates to biochemistry; add 15 words or fewer.

7. (29) Malonic acid is a dicarboxylic acid with the structure shown below. It is toxic to oxygen-dependent organisms like humans because it inhibits an essential enzyme of aerobic metabolism, succinate dehydrogenase. This interaction between malonic acid and succinate dehydrogenase takes place in the matrix of the mitochondrion, which has a pH ~ 8.5.



$pKa_1 = 2.83$
$pKa_2 = 5.69$

   a. (2) What is the predominant charge state of malonic acid in the mitochondrial matrix?
   b. (4) What type of interaction is likely to be most important between malonic acid and succinate dehydrogenase? Name an amino acid that could participate in this interaction.
   c. (2) In what pH range(s) would malonic acid act as a buffer?
   d. (3) What fraction of malonic acid molecules in the matrix has zero charge? Show your work.
   e. (3) At what pH would the average charge of malonic acid in solution be -1.0? Show your work.
   f. (5) We learned that for glycine, $pKa_1 = 2.35$ and $pKa_2 = 9.78$. Explain in terms of the electrostatic effect why the pKa_1 of malonic acid is higher than that of glycine. (50 words or fewer.)
   g. (2) True or false? Glycine is a stronger acid than malonic acid.
   h. (2) True or false? Glycine is a stronger base than disodium malonate.

Compare malonic acid with another 3-carbon compound, dihydroxyacetone.

   i. (2) True or false? Carbon 1 of malonic acid is more oxidized than carbon 1 of dihydroxyacetone.
   j. (2) True or false? Carbon 2 of malonic acid is more oxidized than carbon 2 of dihydroxyacetone.
   k. (2) True or false? Malonic acid is more oxidized than dihydroxyacetone.

8. (8) Below are segments of the sequences of cytochrome C from human and wheat germ. These sequences correspond to the C-terminal 25 residues of the two proteins. Note that residue 'X' in the wheat germ sequence refers to trimethyllysine, the structure of which is shown.

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MIFVGIKKKEERADLIAYLKKATNE (human)
MVFPGLXKPQDRADLIAYLKKATSS (wheat germ)
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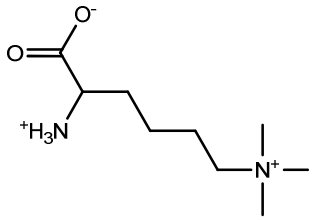
Trimethyllysine:



a. (5) Which of the following values best describes the *identity* of the two sequence fragments? Which best describes their *similarity*?

A. 25%
B. 35%
C. 45%
D. 55%
E. 65%
F. 75%
G. 85%
H. 95%

b. (3) These sequences are (choose all that apply):

A. orthologous
B. paralogous
C. homologous
D. homogeneous

9. (14) Consider a segment of a polypeptide.

a. (6) On the backbone segment provided, draw:

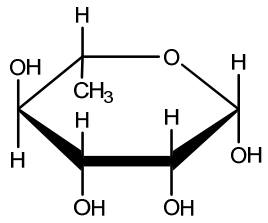
- Additional atoms/groups to show the structure of L-alanine
- Labeled arrows pointing to the bonds about which the ϕ and ψ dihedral angles are measured
- Circles around the bonds about which there is no rotation

b. (5) Starting with the portion provided, redraw the polypeptide segment, but with $\phi = 180°$ and $\psi = 0°$. Include the groups for L-alanine. Assume that the provided bond lines are sitting in the plane of the page.

c. (3) Why is this combination of ϕ and ψ angles (in part **b**) never adopted by polypeptide chains? In other words, what feature of this conformation makes it unfavorable? Explain in 15 words or fewer.

10. (4) If you could pull a 30 Å α-helix into an extended, antiparallel β-strand conformation, how long would it become? Show your work.

11. (15) Pectins are polysaccharide components of plant cell walls. While naturally found in plant-derived foods, they are also used as thickening agents in processed foods. The hexose rhamnose, shown below, is a minor component of pectins:



Rhamnose

a. (2) True or False? Rhamnose is a ketose.
b. (2) True or False? Rhamnose is a glycoside.
c. (2) True or False? Rhamnose is mutarotatory.
d. (2) Which anomer of rhamnose is depicted above?
e. (4) Draw the Fisher projection of rhamnose.
f. (3) Rhamnose is the 6-deoxy form of which sugar?

12. (4) Briefly state two reasons why lipids are more efficient energy storage molecules than carbohydrates.

13. (2) Which fatty acid can potentially provide more energy: stearic acid or linoleic acid?

14. (6) The fatty acid DHA is promoted as a food additive that can help healthy brain development in young children and can benefit cardiovascular health. DHA has the symbol 22:6*n*-3. Draw DHA in its predominant form at pH 7, showing the conformation about any double bonds, and give its delta name.