Chemistry and Biochemistry 153A
Spring 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. Your choice of writing utensil will not affect your ability to request a regrade.
- 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

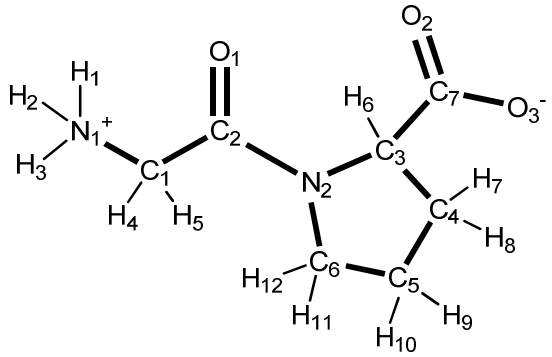
  ALL other items must be placed into a bag, which must be zipped up or closed and pushed *completely* under your chair.
- No hats, hoods, earphones, or cellphones are allowed.
- If you continue to write after 'time' is called, your exam will be taken and docked 10 points.
- **Questions are printed on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

1. (2) True or false? Hydrogen bonding is what causes ice to be less dense than liquid water.

2. (2) True or false? Water has a high dielectric constant because it has a dipole moment.

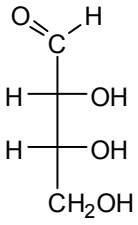
3. (3) A buffered solution (choose all answers that apply):
   a. Has a pH close to 7.
   b. Resists changes in pH.
   c. Contains an acid and a base.
   d. Has a zero average charge.
   e. Has a pKa close to 7.

4. (7) Given the following dipeptide:



   a. List all atoms contained within one peptide plane.
   b. List the four atoms whose positions are used to measure the ϕ dihedral angle.
   c. List the four atoms whose positions are used to measure the ψ dihedral angle.

5. (7) The structure of D-erythrose is shown to the right:

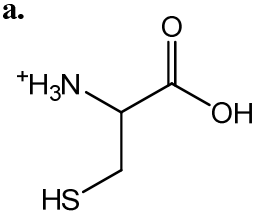


   a. Considering aldoses and ketoses, how many different (linear) tetroses are there? Briefly show your reasoning.
   b. Which carbon of a tetrose determines if it is D or L? (Give the carbon's number.)
   c. Draw a Haworth projection of one anomer of D-erythrofuranose and circle the anomeric carbon.

6. (4) You see a news report describing the discovery of a new polysaccharide in fungi. The report says the polysaccharide is composed only of repeating, linked sucrose units, but gives no further details of the polysaccharide structure. Why is it likely that either the report is inaccurate or the discovery is false? (Explain in 40 words or fewer.) *Hint: Consider the linkages in polysaccharides*.

7. (3) The sidechain of Histidine can act as a (choose all that apply):
    a. H-bond donor, always.
    b. H-bond acceptor, always.
    c. H-bond donor, depending on the pH.
    d. H-bond acceptor, depending on the pH.

8. (4) Given the following protonation states of cysteine, list the approximate pH range over which each predominates. (Write 'none' if the state never predominates.)

a.


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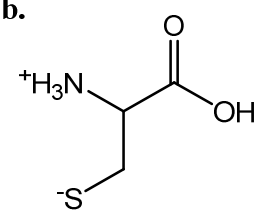

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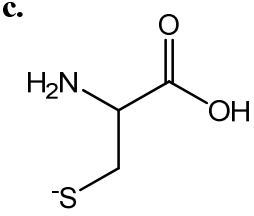

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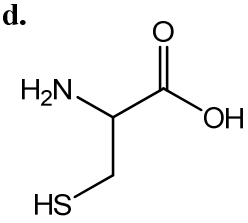

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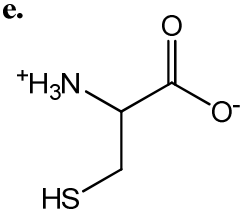

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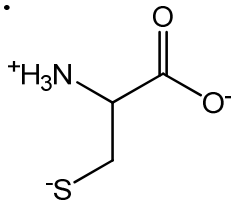

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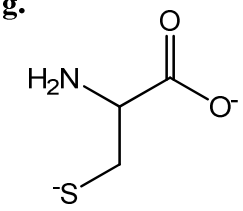

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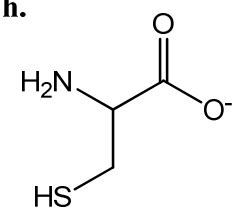
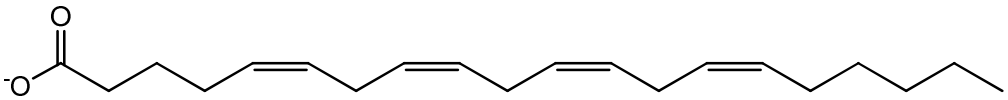


9. (2) Which of the following lipids has the designation 20:4*n*-6?

a.


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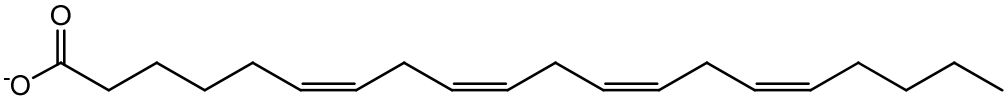

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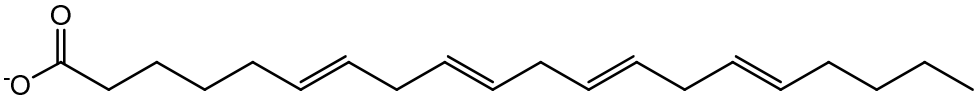

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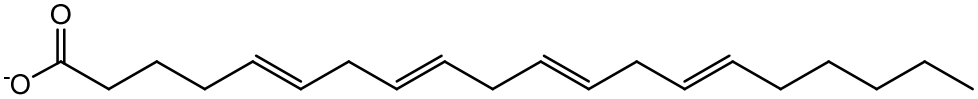

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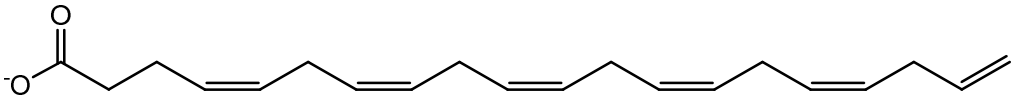
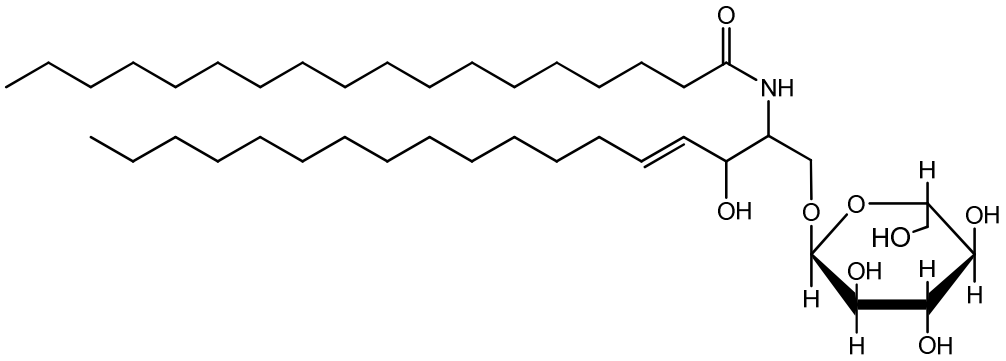
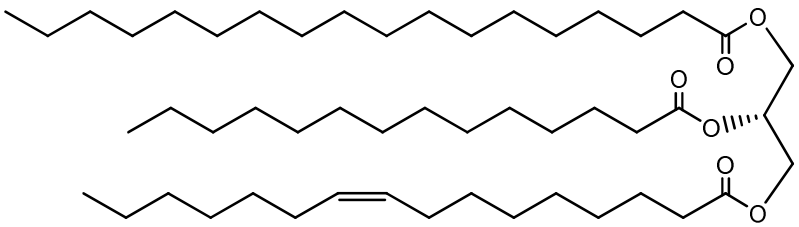


10. (6) Choose the correct descriptor for each of the following molecules:

a.



b.



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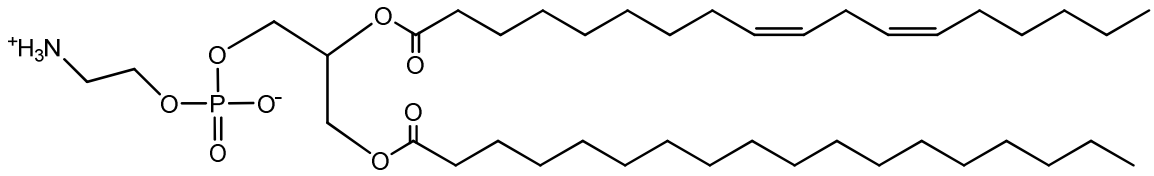
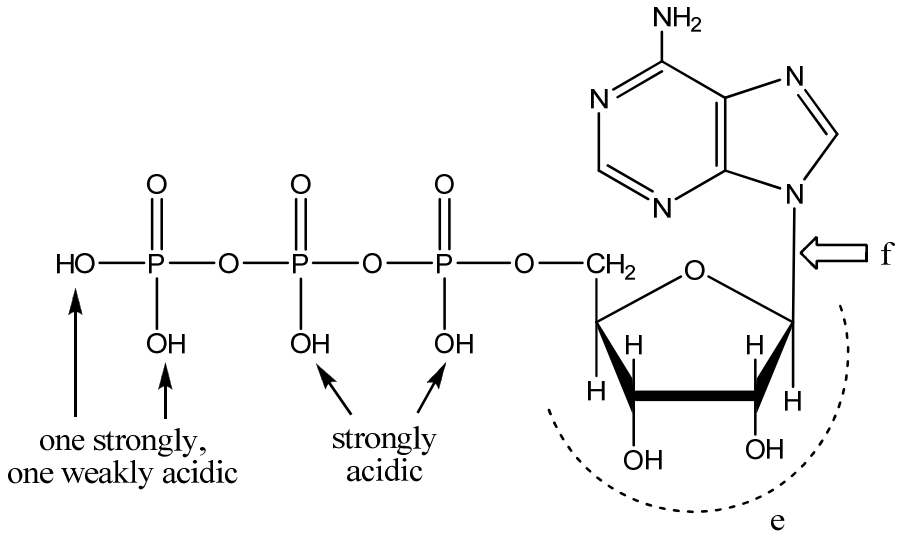


Descriptors:

A. Ganglioside
B. Proteoglycan
C. Triacylglycerol
D. Sphingomyelin
E. Cerebroside
F. Glycerophospholipid
G. Fatty acid

11. (5) The presence of amphipathic compounds (like detergents) can disrupt a protein's ability to fold properly. How do these compounds interfere with protein folding? Explain in 50 words or fewer.

12. (16) The structure of ATP is shown below. The phosphates of ATP have 3 strongly acidic groups and one weakly acidic group, as indicated. At physiologic pH (7.4), the average charge on ATP is -3.86.



a. Complete the provided structure to show the predominant form of ATP at physiologic pH.

b. What percentage of ATP is in this predominant form at physiologic pH? Show your work.

c. Calculate the pKa of ATP's weakly acidic group. Show your work.

d. At physiologic pH, is ATP better at *preventing* a dramatic *increase* in pH, *decrease* in pH, or *neither*? Briefly explain your answer in 40 words or fewer.

e. Name the portion of ATP indicated by the dotted curve. Be as specific as possible.

f. Name the linkage indicated by the open arrow. Be as specific as possible.

13. (2) True or false? Excluding proline, every residue in an α-helix participates in at least one hydrogen bond.

14. (3) The pattern of backbone H-bonding in an α-helix can be described as i→i-4. Can such a pattern be defined for H-bonding in an antiparallel β-sheet? If so, what is the pattern? If not, why not?

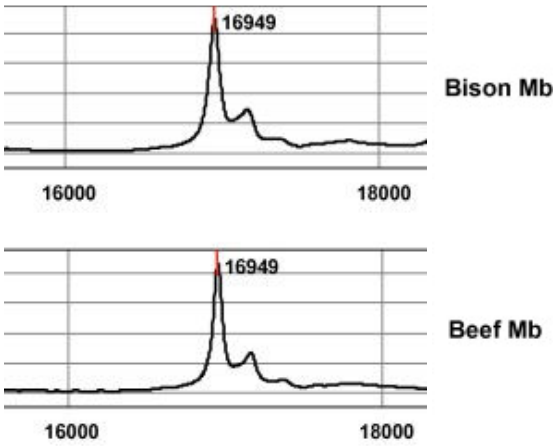
15. (6) How many backbone H-bonds are formed in a 2-stranded β-hairpin in which each strand is 14 Å long? Show or explain your reasoning.

16. (28) Bison, or North American buffalo, are large mammals native to the plains of the United States and Canada. Like cattle, bison are raised for meat consumption in the US, and their meat is similar to beef, although leaner (less fatty).

The following text comes from the abstract (summary) of a recent publication in the journal *Meat Science* (84:1, 2010, p71):

Bison is an alternate meat species gaining increased popularity in North America. Although previous investigations reported that bison meat discolors faster than beef, the molecular basis of this observation has not been investigated. Therefore, the objective of the present study was to determine the redox stability, thermostability, and primary structure of bison myoglobin (Mb), in comparison with beef Mb. Purified bison and beef myoglobins were analyzed… Mass Spectrometry was utilized for determining the exact molecular mass of bison Mb, whereas Edman degradation was employed to determine the amino acid sequence. …

The mass spectra of bison and beef myoglobin are shown below. (Note that the ionization method used in this experiment results in only singly (+1) charged molecules.)



a. What are the units of the x-axis?

b. Based only on the mass spectra, what can you conclude about bison and beef myoglobin?
   A. They have the same sequence.
   B. They have similar sequences.
   C. They have dissimilar sequences.
   D. They have the same mass.

c. In a sequencing experiment, these spectra would result from the first stage of:
   A. Top-down sequencing
   B. Bottom-up sequencing
   C. Shotgun sequencing

Part of a multiple sequence alignment of bison and other ruminant myoglobins is shown:

Sequence No.	1	10	20	30	40	50
Bison	GLSDGEWQLV	LNAWGKVEAD	VAGHGQEVLI	RLFTGHPETL	EKFDKFKHLK	
Cattle	GLSDGEWQLV	LNAWGKVEAD	VAGHGQEVLI	RLFTGHPETL	EKFDKFKHLK	
Yak	GLSDGEWQLV	LNAWGKVEAD	VAGHGQEVLI	RLFTGHPETL	EKFDKFKHLK	
Water-buffalo	GLSDGEWQLV	LNAWGKVETD	VAGHGQEVLI	RLFTGHPETL	EKFDKFKHLK	
Red-deer	GLSDGEWQLV	LNAWGKVEAD	VAGHGQEVLI	RLFTGHPETL	EKFDKFKHLK	
Sheep	GLSDGEWQLV	LNAWGKVEAD	VAGHGQEVLI	RLFTGHPETL	EKFDKFKHLK	
Goat	GLSDGEWTLV	LNAWGKVEAD	VAGHGQEVLI	RLFTGHPETL	EKEDKFKHLK	

In preparation for sequencing, bison myoglobin was treated with trypsin, an endopeptidase that cleaves after positively charged residues (except His).

d. Name the amino acids after which trypsin cleaves.

e. How many peptide fragments would be formed as a result of trypsin cleavage of the first 50 residues of bison myoglobin (given its sequence above)?

f. The sequence of bison myoglobin was reassembled from sequences of overlapping fragments produced through different cleavage methods. Using the fragments shown below, reassemble the sequence of the last 50 residues of bison myoglobin. (Order the chymotrypsin fragment numbers to reflect the order of the fragments in the sequence.)

Fragments from chymotrypsin cleavage:

1. HG
2. ISDAIIHVLHAKHPSDF
3. LEF
4. RNDMAAQY
5. GADAQAAMSKALELF
6. KVLGF

Fragments from cyanogen bromide cleavage:

AAQYKVLGFHG
LEFISDAIIHVLHAKHPSDFGADAQAAM
SKALELFRNDM

After sequencing, the sequences of bison and cattle myoglobin were compared and found to be identical. However, the sequences of bison and water-buffalo myoglobin differ at 3 positions (out of 153 total residues):

	(1)	(2)	(3)
Bison	A	A	D
Water-buffalo	T	D	E

g. For each difference, indicate whether the change is a conservative (C) or non-conservative (NC) substitution (circle your choice), and give a brief reason for your answer.

h. Based on your answers to part g, calculate the percent identity *and* percent similarity of the bison and water-buffalo sequences. Show your work.

i. Does bison or water-buffalo myoglobin have a higher pI? Briefly explain your reasoning in 45 words or fewer.