Exam I - Chemistry 341 - October 15 1999 - 130 points total - 20 bonus points

Show all your calculations if you want to receive partial credit.
Be clear and concise.

Name: _____

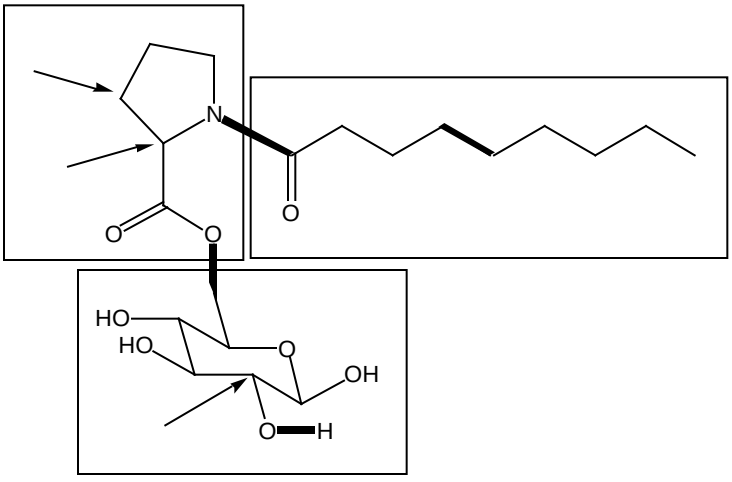
1) True or false (10 points).

   i) Biochemical systems tend to increase their entropy and approach equilibrium.
   ii) Biological systems are characterized by their ability to transform nutrients into energy.
   iii) Different organisms use very different chemical building blocks to synthesize biological macromolecules with similar functions.
   iv) All living organisms use the same set of amino acids to synthesize their proteins.
   v) Interactions among biological macromolecules are dictated only by the formation of strong covalent bonds between them.

2) What is the energy in Kcal/mol for a salt bridge between an amino ($-NH_3^+$) group and a carboxylate ($-COO^-$) group in water (5 points)? Will this value increase or decrease if the solvent is changed to chloroform ($CHCl_3$), a non-polar organic solvent (5 points)?

3) In the following molecule (15 points):

   i) Identify the bolded bonds as roatatable, partially rotatable, or fixed. Order them according to their polarity, from most polar to less polar.
   ii) Indicate if the atoms marked with arrows are chiral or non-chiral.
   iii) Indicate to what family of monomers each of the boxed groups in the molecule belong.



4) You have an aqueous solution that contains proline as its sole component (15 points).

   i) Which forms of proline will you have at pH 2.2? What will be the ratios between these two forms?
   ii) Same as above, but at pH 11.2.
   iii) Will proline be an effective buffer near these pH values? Explain briefly.

5) You have a mixture of two peptides with the following primary structures:

Tito: AFDLIGRP
Pepe: MLWQREG

a) For each peptide (15 points):

   i) Write them using the three-letter code and draw clearly their full chemical structures.
   ii) Enclose with a box the **peptide groups** in the chemical structure of in Pepe.
   iii) Calculate their isoelectric points.
   iv) Calculate their approximate charges at pH 1, 7, and 14

b) What will be the optimal pH to separate Tito and Pepe using ion exchange chormatography if you have a cationic exchange column (5 points).

6) The following polypeptide chain is a critical part of your PhD thesis, and not getting the primary structure right is keeping you in grad school for more time than what you initially bargained for:

ASMTISVRMILQSFHAGPHGMCVSDMQFDMPGGPILVMQFDMGGNMSAD

You received the results from the sequencing lab, and they told you that it was almost impossible to get it, and that some parts may be wrong. Although you think the sequence is right, your boss is a mean old man and wants a better result. The technician in charge of the sequencing lab told you he needs smaller polypeptide fragments to get the sequence right using Edman degradation, but if you give him more than 5 fragments he will have the results too late for you to have your final defense on time. You looked in your lab and found two reagents/enzymes that you could use to obtain smaller polypeptide fragments: cyanogen bromide (CNBr) and chymotrypsin. Which one would you choose to fragment your polypeptide? Explain you reasoning (15 points).

7) The following polypeptide forms a right-handed α-helix at pH 1 (20 points).

GG**E**GGEGG**E**GGEGG**E**GGEGG**E**GG

a) When the pH of the solution is brought to 8, the α-helix is destroyed. Explain why.
b) A researcher in your lab found out that replacing the amino acids marked in bold by another amino acid, the α-helical conformation is conserved from pH 5 to pH 9. What could be the identity of this amino acid? Why?

8) You finally solved the 3D structure of a polypeptide that can be used in the fight against cancer, AIDS, hepatitis B, and the Y2K bug. A figure of the 3D structure is shown in the attached page and on the over head in front of you. However, the commission in charge of handing out Nobel Prizes told you that unless you can tell them the following information, they will give the Prize to your bitter enemy, who only found a cure against zits. They want to know the following (20 points):

i) The secondary structure of the polypeptide from residues Val8 to Pro19.
ii) The secondary structure element from residues 41 to 44.
iii) What type of β-sheet is formed by the two β-strands enclosed in the box.
iv) How many domains does the protein has.

The sequence of your peptide is:

$^{+}H_3N$-THR^{1}-THR^{2}-CYS^{3}-CYS^{4}-PRO^{5}-SER^{6}-ILE^{7}-VAL^{8}-ALA^{9}-ARG^{10}-SER^{11}-ASN^{12}-PHE^{13}-ASN^{14}-VAL^{15}-CYS^{16}-ARG^{17}-LEU^{18}-PRO^{19}-GLY^{20}-THR^{21}-PRO^{22}-GLU^{23}-ALA^{24}-ILE^{25}-CYS^{26}-ALA^{27}-THR^{28}-TYR^{29}-THR^{30}-GLY^{31}-CYS^{32}-ILE^{33}-ILE^{34}-ILE^{35}-PRO^{36}-GLY^{37}-ALA^{38}-THR^{39}-CYS^{40}-PRO^{41}-GLY^{42}-ASP^{43}-TYR^{44}-ALA^{45}-ASN^{46}-COO^{-}

9) The structure of a protein has been solved both by NMR and X-ray crystallography. Although for the most part the two 3D models look alike, there are significant differences between the structures for residues at the N- and C-termini, as well as for residues in the protein surface. Explain briefly why these differences are observed between the structures obtained with the two different methods (5 points).

BONUS QUESTION (20 points):

10) Design a polyeptide with 5 residues with general structure Ala-Xaa-Xaa-Xaa-Gly (Xaa can be any amino acid) with an isoelectric point (pI) of 10.11.

Problem 8 attachment