THE UNIVERSITY OF MANITOBA

April 18, 2007 FINAL EXAMINATION

PAPER NO: 409 LOCATION: Fr. Kennedy Gold Gym PAGE NO: 1 of 6

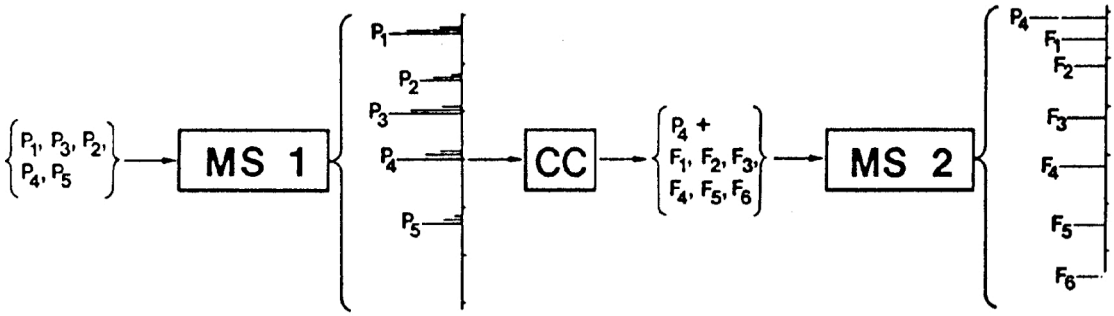
DEPARTMENT & COURSE NO: CHEM 4630 TIME: 3 HOURS

EXAMINATION: Biochemistry of Proteins EXAMINER: J. O'Neil

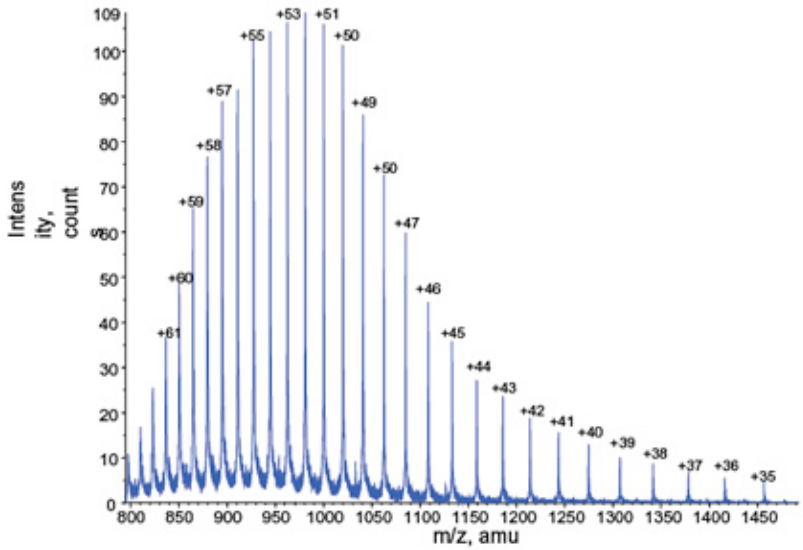
Section 1: *You must answer all of the following questions in* Section 1. *As a guide you can spend up to 2 hours and 35 minutes on this part of the exam. Wherever possible* ***use diagrams*** *to enhance your answers.*

Marks

10 1. With the use of the following diagram, explain how proteins can be sequenced by mass spectrometry.



10 2. The following figure shows the mass spectrum of a protein. Name and then explain the method that was used to introduce the protein into the vacuum of the mass spectrometer. Using the information in the figure calculate the molecular weight of the protein. Show your calculations. Explain the features of the spectrum.



Marks

10 3. Explain what is circular dichroism spectropolarimetry and its use in the study of proteins. In your answer, use the following equation and be sure to explain the meanings of all the symbols.

$$[\varepsilon] = x\,[\varepsilon]_{\alpha} + y\,[\varepsilon]_{\beta} + z\,[\varepsilon]_{t} + r\,[\varepsilon]_{i}$$

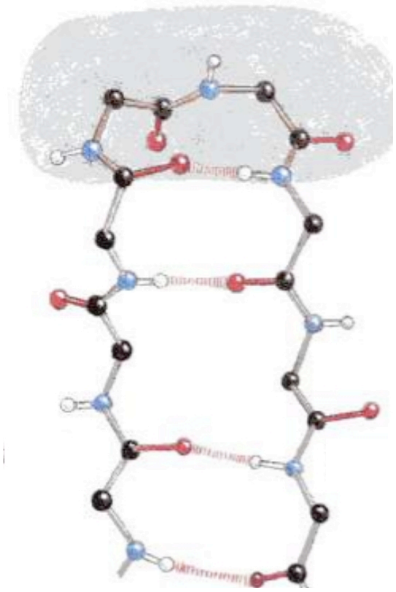
8 4. Draw the chemical structure of the tripeptide Trp-Ile-Val at pH 7 and label all the dihedral angles with Greek letters or names. What conformation do you think the backbone of this peptide prefers? Explain your reasoning.

6 5. Explain why the peptide bond is planar. What are the structural implications of this for protein folding?

6 6. What is a helical wheel diagram? Draw a helical wheel of an amino acid sequence of your choice and use it to illustrate a structural feature of an alpha helix.

12 7. Identify the following structures. Describe the main features of each using examples wherever possible.

A



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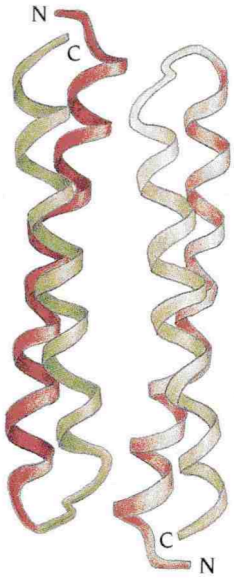

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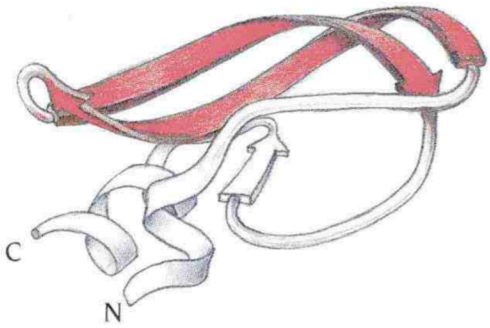

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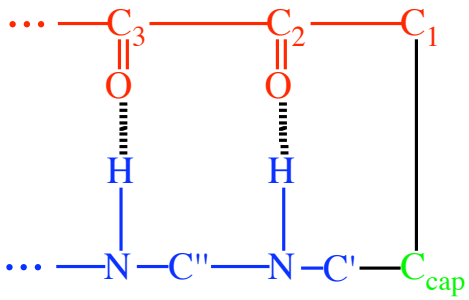
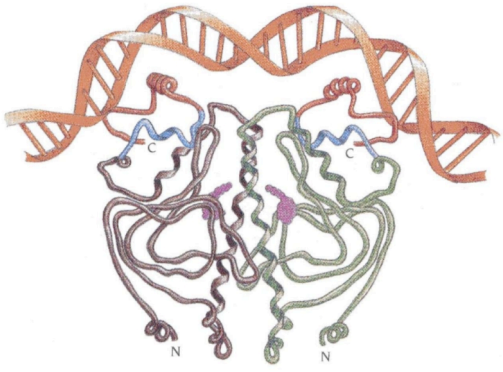


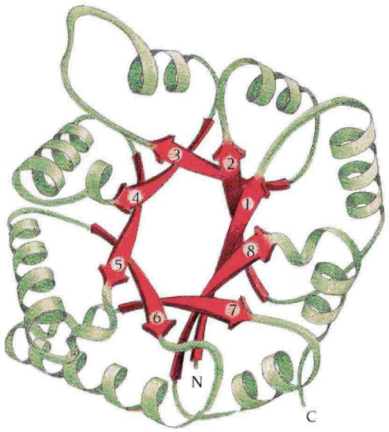
6 8. The first high-resolution protein structure was solved in 1960 by the research group of John Kendrew. The protein was myoglobin, extracted from the muscles of the sperm whale. These animals' muscles need lots of myoglobin to store O_2 for deep dives in the ocean. Knowing the positions of all the atoms revealed a puzzle about how the protein works. Explain both the puzzle and how it was solved.

6 9. Explain the layering of side-chains in the core of a parallel β–barrel.

8 10. Describe the following structure and briefly relate the structure to the function of the molecule:



6 11. Describe the main features of the following structure and name a protein that makes use of it.



7 12. Explain the principles and uses of FRET (Fluorescence Resonance Energy Transfer).

2 13. What feature of β-sheet packing is shared by the integral membrane protein OmpF *porin* and the water-soluble *retinol-binding protein*?

6 14. Draw and label a 3-dimensional folding funnel. Outline the main features of protein folding that are illustrated in folding funnels.

4 15. Briefly describe the molten globule state of proteins.

5 16. Explain the role of side-chain entropy in the formation of secondary structure.

2 17. Briefly explain how extremes of pH cause proteins to unfold.

6 18. Proteome analysis suggests that 33% of eukaryotic proteins contain segments of 30 amino acids or longer that are biologically active in an unfolded state. What properties of amino acid sequences are such predictions based upon?

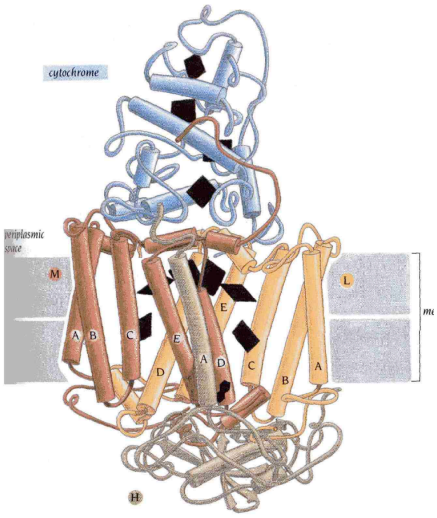
Section 2: *Answer **1 part*** of question 19. *You can spend about 25 min. on this question.*

Marks

20 19. With the use of the appropriate diagrams discuss the structure and function of the photosynthetic reaction centre from *Rhodopseudomonas viridis* ***OR*** the *E. coli* OmpF porin.

A

B



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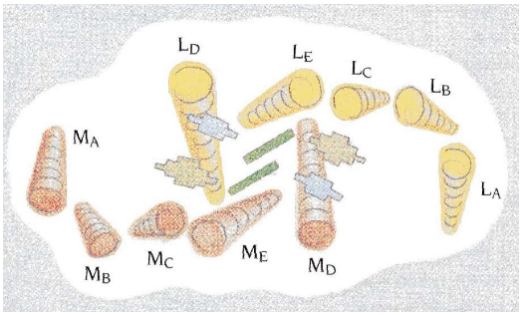

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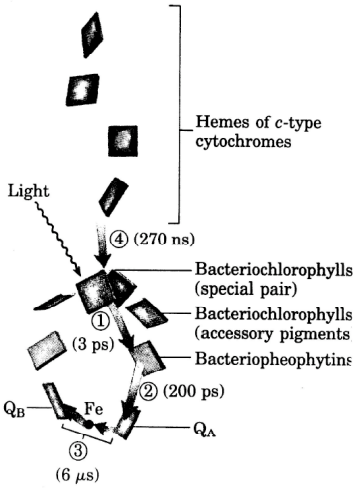

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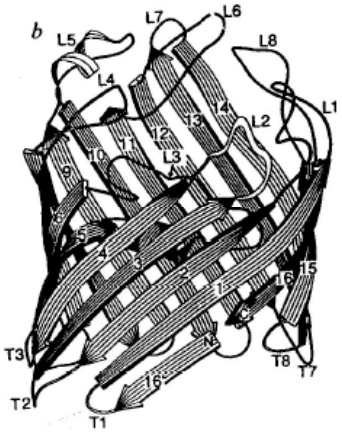

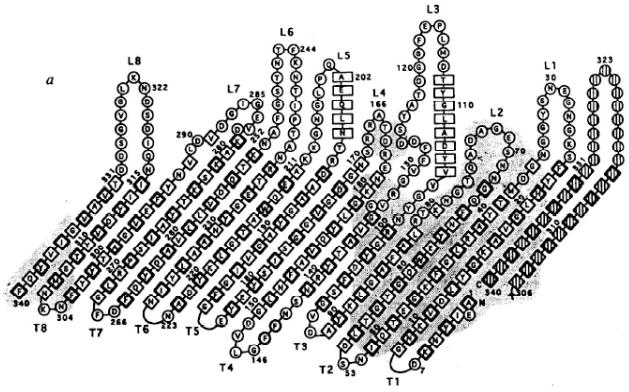

Section 3: *Answer **1** of the following questions in* Section 2. *You can spend about 25 min. on this question.*

20 19. In general, peptides shorter than about 25 amino acids do not fold into a stable tertiary conformation. In amino acid homopolymers hundreds of residues in length, a single α-helix forms by a highly cooperative folding mechanism. In proteins, short helices with fewer than 5 turns are commonplace. Describe the features of protein structure that contribute to stabilization of short helices in proteins.

20 20. Explain the different mechanisms by which helices pack together in proteins. Give examples of each.

20 21. Interactions between electromagnetic radiation and proteins can provide useful information about protein structure, dynamics, folding, and function. Describe the theory and application of ultraviolet and visible absorption and fluorescence spectroscopies, circular dichroism spectropolarimetry, and X-ray diffraction to proteins.

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