CHEM-342 Introduction to Biochemistry Name _____
Midterm Examination - Individual Part
Monday, 5 April 2004
H. B. White – Instructor

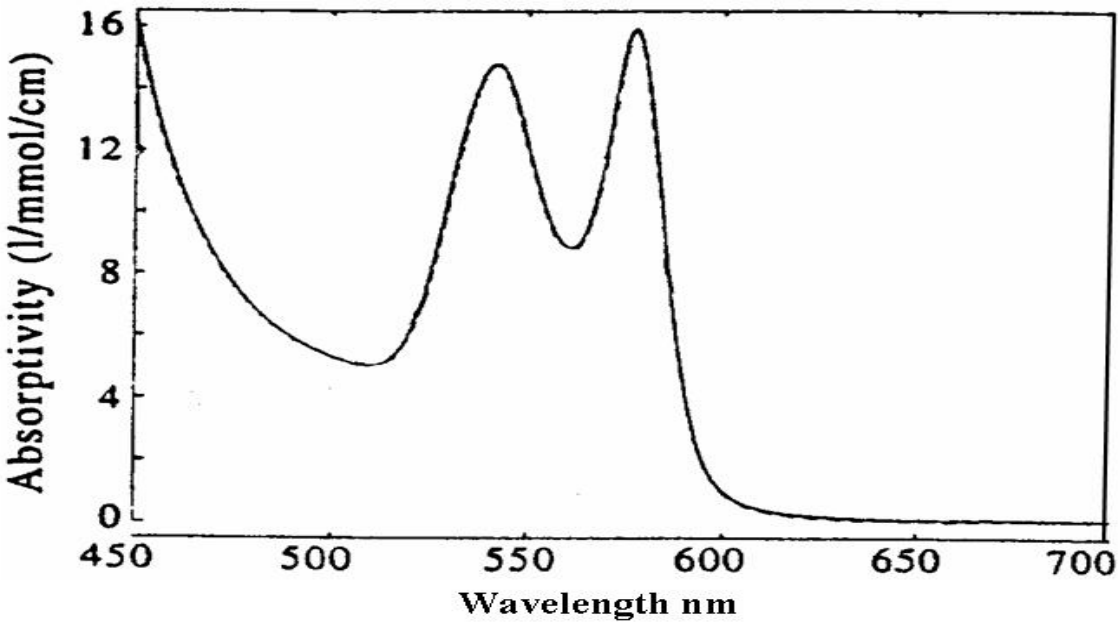
Class Ave ± SD: 50.3 ± 14.2/82 Class Range: 26-77/82 Number taking Exam: 28

Important - Please read this before you turn the page.

- Write your name on each page
- This part of the midterm examination is worth 75 points plus 7 bonus points
- You may refer to your notes, course reader, handouts, or graded homework assignments.
- Textbooks, reference books, and wireless laptop computers cannot be used.
- This examination will assess your learning, problem-solving skills, and ability to communicate clearly. It is intended to be challenging even to the best students in the class.
- Writing reflects how you think. Among the "right answers" I will read for the following questions, some will be better than others because they show greater depth of understanding, avoid extraneous or inaccurate information, provide a more logical structure, use appropriate examples, include appropriate illustrations, and chose words with precision. Better quality answers will receive higher marks. Therefore organize your thoughts before you write and draw.
- Strive to write not that you may be understood, but rather that you cannot possibly be misunderstood. Stream of consciousness answers are rarely well organized or clearly presented.

"This place is all right. Two more weeks and I'll be a molecular biochemist."

1. The figure below displays in black and white the spectrum of hemoglobin as obtained with a recording UV-visible spectrophotometer. Stokes did not have access to such instrumentation, but he was able to see beautiful spectra in full color. Unfortunately, he had to represent the spectra he saw in the black and white woodcut figures in his article.
   a. (4 points) On the figure, label the red and blue ends of the spectrum.
   b. (3 points) What form of hemoglobin is represented in this figure?



c. (8 points) In the box above, draw what Stokes would have drawn to depict the figure above.

Bonus: (2 points) What is the normal range of the visible spectrum?

Bonus: (2 points) What word would we use in place of “thickness” as used by Stokes?

2. The amino acid composition of dog hemoglobin is known accurately for the alpha and beta chains (table below) so one can calculate its actual and empirical formulae precisely.

Canis familiaris alpha chain Hemoglobin

Glycine	8	Phenylalanine 8		Serine	11	Glutamic Acid	2
Alanine	17	Tyrosine	4	Threonine	13	Histidine	9
Valine	10	Tryptophan	1	Asparagine	2	Lysine	11
Leucine	17	Cysteine	2	Glutamine	2	Arginine	3
Isoleucine	2	Methionine	0	Aspartic Acid	11	Proline	8

Canis familiaris beta chain Hemoglobin

Glycine	12	Phenylalanine 8		Serine	8	Glutamic Acid	7
Alanine	13	Tyrosine	3	Threonine	5	Histidine	8
Valine	17	Tryptophan	2	Asparagine	8	Lysine	14
Leucine	19	Cysteine	2	Glutamine	4	Arginine	2
Isoleucine	1	Methionine	1	Aspartic Acid	8	Proline	4

a. (5 points) Based on the table above, what would be the stoichiometry of iron and sulfur in the empirical formula for dog hemoglobin? Explain the basis for your answer.

b. (10 points) In his Table 1, Zinoffsky refers to Schmidt and Hoppe-Seyler who had determined the iron and sulfur content of dog hemoglobin. Based on what we now know about hemoglobin, were the data of either of these researchers reliable or was Zinoffsky correct in claiming these and other workers had used impure hemoglobin preparations or inadequate methods?

3. (15 points) In the articles you have read, many different chemical reactions have been studied or used. Without worrying about balancing each equation, indicate the product(s) for each reaction below. If there is no reaction, indicate NR. (Correctly identified NR count double.)

   a. $Hb + O_2 \rightarrow$

   b. $Hb + CO \rightarrow$

   c. $Hb + S_2O_4^{=} \rightarrow$

   d. $HbCO + S_2O_4^{=} \rightarrow$

   e. $HbO_2 + S_2O_4^{=} \rightarrow$

   f. $O_2 + SnCl_2 \rightarrow$

   g. $metHb + Fe(CN)_6^{-3} \rightarrow$

   h. $HbO_2 + Fe(CN)_6^{-3} \rightarrow$

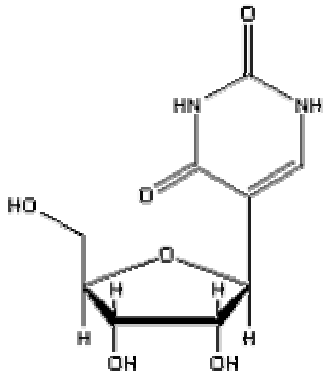
   i. $metHb + S_2O_4^{=} \rightarrow$

   j. $FeCl_2 + KMnO_4 \rightarrow$

   k. $BaCl_2 + Na_2SO_4 \rightarrow$

   l. $AgNO_3 + NaCl \rightarrow$

Bonus (3 points) Identify the molecule shown.



4. Answer **only 2** of the following 4 questions (a through d) for a total of 30 points. For full credit, answers must provide logical explanations based on factual information. Illustrations to support your text are strongly encouraged. Show your work and explain any assumptions.
   a. If 1.0 % of all newborns in a population turnout to have sickle cell disease,
      i. (5 points) what is the frequency, "q", of the sickle cell gene in that population?

      ii. (10 points) What percentage of the population would be expected to have sickle cell trait?

   b. Because oxygen would interfere with Conant's electrochemical titrations, he removed the oxygen from his electrode solutions containing hemoglobin by passing nitrogen through the solution.
      i. (5 points) Why/How would oxygen interfere with Conant's titrations?

      ii. (10 points) Depict with coupled equilibria and pictures how nitrogen removes oxygen.

c. The following questions refer to the article by Svedberg and Fåhraeus.
   i. (7 points) When one measures the sedimentation coefficient for a protein in an ultracentrifuge, the value is dependent on the shape of the molecule. Rod-shaped molecules sediment slower than spherical molecules of the same mass. However, with Svedberg's method, the mass determined is independent of shape. Explain.

   ii. (8 points) For their experiments, Svedberg and Fåhraeus did not use purified hemoglobin. They simply used the solutions from lysed red blood cells which contain other proteins. Why don't these other proteins interfere with the molecular weight determination for hemoglobin?

d. Both Bohr et al. and Douglas et al. have figures displaying the sigmoidal relationship between oxygen partial pressure and binding to hemoglobin.
   i. (7 points) Why is the shape of this curve physiologically important?

   ii. (8 points) Consider the following three situations, anemia with 50% of the normal hemoglobin, CO poisoning with 50% of the hemoglobin as carbonmonoxy hemoglobin, or high altitude where the partial pressure of oxygen is 50% of that at sea level. Rank these in order of greatest to least dangerous. Full credit requires an explanation.