

CHEM-342 Introduction to Biochemistry
Midterm Examination - Individual Part
Wednesday, 21 March 2007
H. B. White - Instructor

Name _____

Important - Please read this before you turn the page.

There are eight pages to this examination including this page.

Write your name on every page.

This individual part of the midterm examination is worth 90 points with 6 bonus points possible.

There are 10 questions of which you need to answer six.

You may refer to your notes, course reader, handouts, or graded homework assignments Textbooks, reference books, and wireless laptop computers cannot be used.

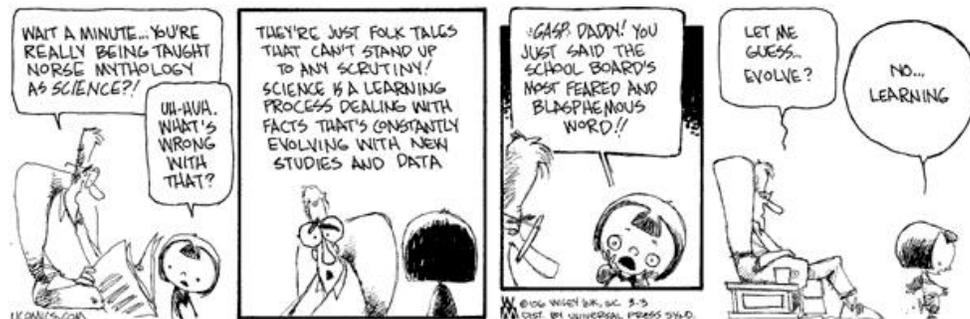
This examination will assess your learning, problem-solving skills, and ability to communicate clearly. It is intended to be challenging even to the best students in the class.

Writing reflects how you think. Better quality answers will receive higher marks. Therefore organize your thoughts before you write and draw. Among the “right answers” I will read for the following questions, some will be better than others because they

- show greater depth of understanding,
- provide a more logical structure,
- use appropriate examples,
- include appropriate illustrations,
- avoid extraneous or inaccurate information, and
- choose words with precision.

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.

Non Sequitur by Wiley Miller



1. (15 Points) In the 1920's scientists wanted to understand why the red blood cells in certain individuals sickled and those in other people did not. The following is an experiment that was done. You are asked to predict the results and describe clearly what hypothesis the experiment was designed to test.

Blood samples were taken from a person with sickle cell anemia and from a person whose red blood cells did not sickle. Citrate was added to prevent clotting. The samples were separately centrifuged and the blood fractions recombined in different combinations as displayed in the table below. After the fractions were mixed and the four samples of resuspended red blood cells were capped, they were allowed to stand for several hours before the cells were examined under a microscope.

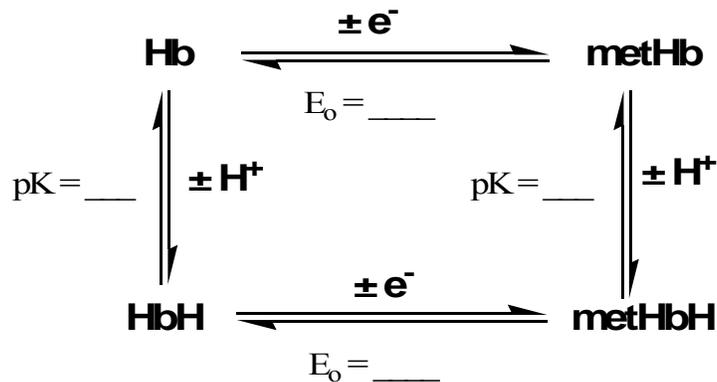
	Red Blood Cells from a Normal Patient	Red Blood Cells from a Sickle Cell Patient
Blood Serum from a Normal Patient		
Blood Serum from a Sickle Cell Patient		

- a. (8 pts) In the empty boxes above, write your predictions about whether the cells sickled or did not sickle. In the space below, state the basis for your prediction.
- b. (7 pts) State concisely what hypothesis the experiment was designed to test.
- c. Bonus Question (2 pts) What does citrate do that prevents blood from clotting?

(30 Points) Answer only **two** of the following four questions (Q3-6) for 15 points each.

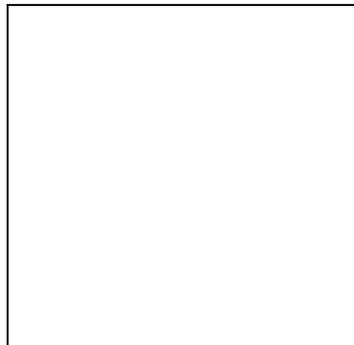
3. The following diagram represents the fact that hemoglobin not only undergoes oxidation-reduction reactions but also has acid-base properties, i. e. it can gain and lose both electrons and protons. Conant measured the E_o (π_o) for hemoglobin at several different pHs and modified the Nernst Equation to incorporate the Henderson-Hasselbalch Equation.

a. (6 pts) Based on Conant's paper, fill in the values he determined.



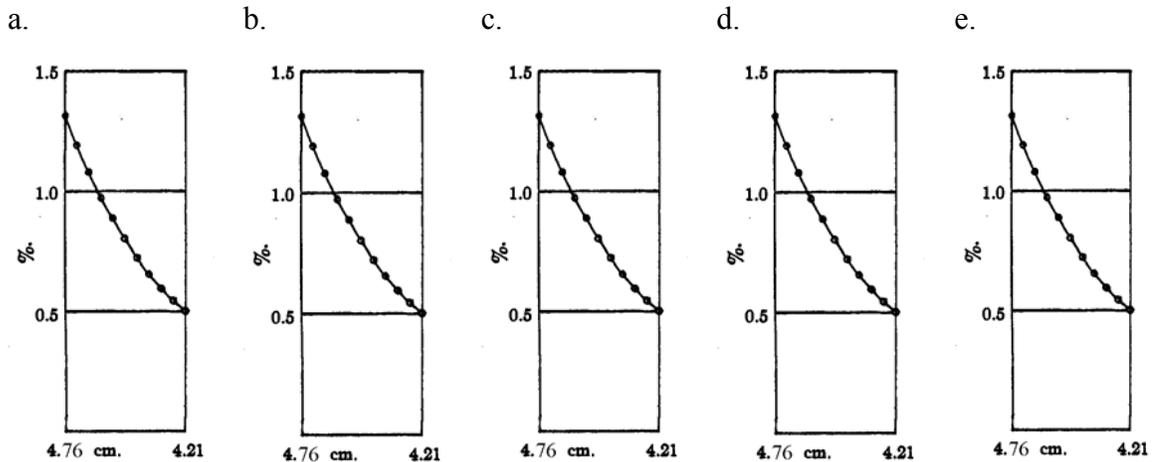
b. (9 pts) Modify the above diagram to include oxygen binding and dissociation.

4. Although they didn't know it, Diggs and coworkers estimated the genetic frequency of the sickle gene in the US black population. At that time, they and others did not appreciate the genetic relationship between sickle cell anemia and sickle cell trait. Had they known that, they could have applied the Hardy-Weinberg Law to their data and estimated the frequency of sickle cell anemia from the frequency of sickle cell trait. The Hardy-Weinberg Equation predicts the frequency of different genotypes based on allele frequencies and has the form $(p + q)^2 = p^2 + 2pq + q^2$, for two alleles. This relationship can be displayed visually as a Punnet Square in which each side has length $p + q$, and the areas within the square correspond to each term in the expanded equation. Using the reasonable values for the frequencies of the sickle cell allele and the normal allele, fill in and label the diagram below. Identify the area that would represent people with sickle cell anemia. Estimate the percentage of the US black population that would suffer from sickle cell anemia.



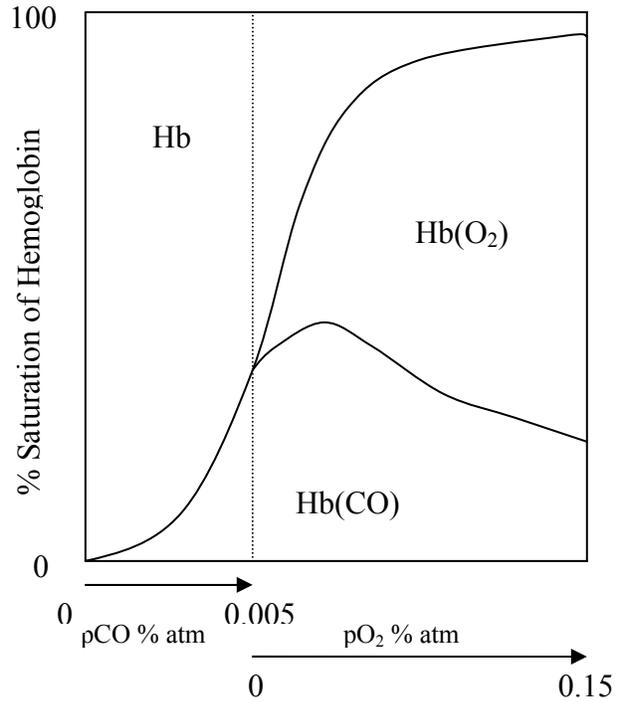
5. Figure 7 from the Svedberg and Fåhræus article is reproduced five times below. If conditions in the ultracentrifuge or the properties of hemoglobin were different, the hemoglobin concentration profile in Figure 7 might have been different. This question asks you to sketch in the concentration profile expected for five different hypothetical situations. In all cases the initial hemoglobin concentration in mg/ml is the same. Each answer is worth 3 points.

- a. Methemoglobin rather than CO hemoglobin was used.
- b. The angular velocity of the centrifuge was lowered by half.
- c. The molecular weight of hemoglobin was $\sim 17,000$, not $\sim 68,000$.
- d. Hemoglobin exists as an equilibrium mixture of tetramers and dimers.
- e. The partial specific volume of hemoglobin was 1.0



6. The figure at the right depicts parts of different figures in Douglas et al. (1912). Before the dotted vertical line represents binding of CO to hemoglobin at increasing pressures of CO. Beyond the dotted line represents the binding of CO and O₂ as a function of O₂ pressure at a constant CO partial pressure of 0.005 atm.

a. (6 pts) What was unexpected about these data?



b. (9 pts) How does one explain this phenomenon?

