Biochemistry I , CHEM 4400 Exam 2 10:00 Fall 2015 Dr. Stone Name_____

rate forward = $k_{forward}$[reactants] rate reverse = $k_{reverse}$[products]	Carbonic acid Ka = $1.6 * 10^{-4}$ K_{eq} for the reaction of carbon dioxide with water = 1.69×10^{-3}	Hydrogen carbonate Ka = $4.68 * 10^{-11}$
		$G^{\ddagger}$ = Energy of activation
K_{eq} = [products]/[reactants] $\Delta G = \Delta H - T\Delta S$ $\Delta G = \Delta G^{\circ\prime} + RT \ln Q$ Q = [products]/[reactants] $\Delta G^{\circ\prime} = -RT \ln K_{eq}$	Phosphoric acid Ka= $7.25*10^{-3}$ Dihydrogen phosphate Ka = $1.38 * 10^{-7}$ Monohydrogen phosphate Ka = $3.98*10^{-13}$ Acetic acid Ka = $1.78 *10^{-5}$	$k = \frac{\mathbf{k}T}{h} e^{-\Delta G\ddagger/RT}$ $k = 1.381 \times 10^{-23}$ J/K $h = 6.626 \times 10^{-34}$ J*sec R = 8.315 J/mol*K

Multiple choice, 2 points each: Circle the correct answers on this test.

1) What are the conditions that are used to determine $\Delta G^{\circ\prime}$?
   a) T= 298, P = 1 atm, Concentrations are 1M
   b) T= 37°C, P = 1 atm, Concentrations are 1M, except $[H_3O^+] = 1 \times 10^{-7}$M
   c) T = 25°C, P = 1 atm, Concentrations are 1M, except $[H_3O^+] = 1 \times 10^{-7}$M
   d) T= 37°C, P = 1 atm, Concentrations are 1M
   e) None of these, the correct conditions are_____

2) In an aqueous solution, protein folding is driven to the most stable conformation. Which of the following is/are major factors that drive protein folding:
   I. formation of the minimum number of hydrophilic interactions.
   II. minimization of hydrogen bonds
   III. placement of polar amino acid residues around the interior of the protein.
   IV. maximization of entropy of bulk water molecules

A.) I and III B.) II and IV C). I, II and III D.) IV only E.) None of these

3) What effect does carbonic anhydrase have on the equilibrium concentrations of carbon dioxide, water and carbonic acid?
I. Carbon dioxide increases
II. Carbon dioxide decreases
III. Carbonic acid increases
IV. Carbon dioxide does not change

A.) I and III B.) II and IV C). I, II and III D.) IV only E.) None of these

4) Which of the following binding constants is for a protein that has the lowest affinity for its ligand?
A.) $K_a = 1.0 \times 10^{8}$ B) $K_d = 1.0 \times 10^{-10}$ C) $K_d = 1.0 \times 10^{9}$ D) $K_a = 1.0 \times 10^{-8}$
E) None of these, they are all the same

Short answer section: Give specific details in brief answers using complete sentences.

5) (5 points) Carbon monoxide is a deadly colorless, odorless gas. Everyone should have a CO detector in their home. What makes carbon monoxide so deadly?

6) (6 points) Why is vitamin C an essential nutrient for humans? Describe the disease that results from a vitamin C deficiency.

7) (6 points) Using complete sentences, briefly describe what each of the following do:

A) peptidyl prolyl isomerase

B) protein disulfide isomerase

C) chaperones

8) (10 points) Using complete sentences, briefly describe how each of the following are used to study proteins:

A) nuclear magnetic resonance

B) mass spectroscopy

C) X-ray crystallography

D) circular dichroism spectroscopy

E) SDS PAGE

9) (6 points) The three dimensional structure of a biochemical macromolecule is formed and maintained by noncovalent interactions. What are three types of intermolecular forces? For each type of IMF, give an example of a pair of amino acids that could have that IMF between their R groups.

10) (6 points) Use this signature sequence to answer the following questions:

a. Which position(s) has/have only positively charged amino acid functional groups at pH 7?

b. Which position has only negatively charged groups at pH 7?

c. Which position(s) has/have an amino acid that is not found in α-helices? d. Which position(s) has/have an amino acid that could be detected by UV spectroscopy?

e. Which position has an amino acid that is essential for the structure of collagen?

f. Is this a signature sequence for collagen? Why or why not?

g. What do the size of the letters indicate in the above figure?

This section requires longer answers, be specific, provide details, and show your work.

11) (10 points) Using complete sentences, describe the structure and function of Keratin and Collagen. Give details about the structure that are related to the function of each of these fibrous proteins.

12) (10 points) The following peptide was determined to have a Tryptophan as the N-terminus amino acid. After treatment with diothiothreitol and iodoacetate, the peptide was then cleaved and the resulting peptides were separated by anion exchange chromatography at pH 7 at 37°C. For all of the peptides, the N terminus amino group pKa is 8 and the C terminus carboxyl pKa is 3.4.

The fragments are:

YSLDSETDKC
CHICAGQ
WINKA
YIKESMETS

a. What is the order of elution from the anion exchange column at pH 7.0:
1st.

2nd

3rd.

b. What enzyme was used to cleave the peptide?

c. Can you determine the sequence of the original peptide? What is it? Or, what are the possibilities?

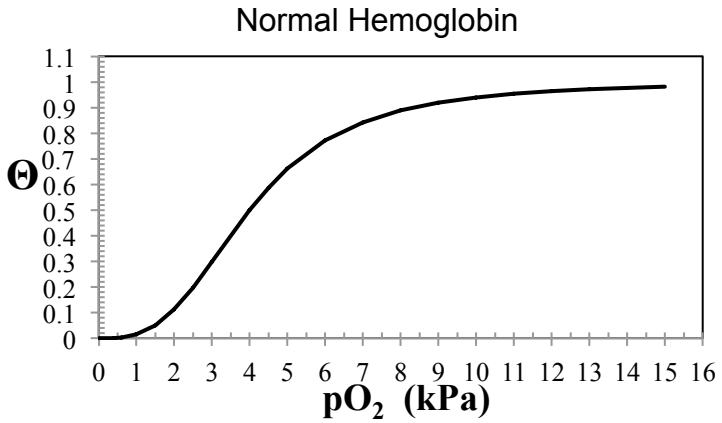
d. What other experiments could be done to help determine the sequence?

13) (10 points) The equilibrium constant K for the binding of oxygen to myoglobin is $3 \times 10^{-6}\ M^{-1}$. The rate constant for the combination of O_2 with myoglobin in $9 \times 10^{6}\ M^{-1}s^{-1}$.

a. What is the rate constant for the dissociation of O_2 from oxymyoglobin?

b. What is the mean duration of the oxymyoglobin complex? (What is the average length of time that the oxygen stays bound to myoglobin?)

14)(6 points) Here is a graph showing the binding of oxygen to normal hemoglobin. Answer the following questions based on this graph**:**



a. What does **Θ** (theta) represent?

b. What type of curve is this?

c. If oxygen is bound in the lungs at pO_2 = 12 kPa, and delivered to the tissues at pO_2 = 4 kPa, what fraction of the bound O_2 was delivered?

d. What is the P_{50} for hemoglobin?

15) (10 points) About 20% of the carbon dioxide that is produced in the tissues (from burning fuel) is transported on the hemoglobin molecule.

A) How is carbon dioxide transported on hemoglobin? (Give specific molecular details.)

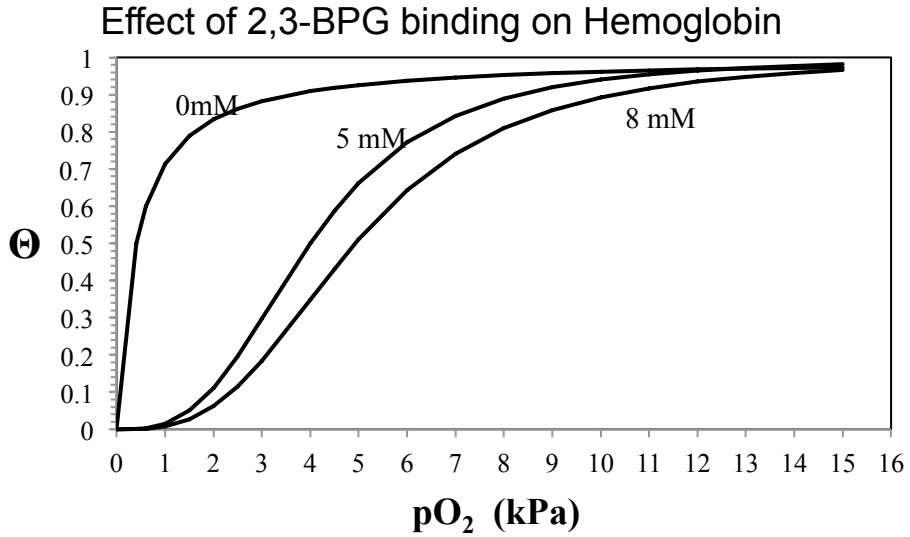
B) How many carbon dioxide molecules can bind to each hemoglobin molecule?

C) How does the other 80% of carbon dioxide move from the tissues to the lungs?

D) During hyperventilation, too much carbon dioxide leaves the lungs, what effect will this have on the function of hemoglobin? Will the hemoglobin deliver more or less oxygen to the tissues? Explain your answer.

16) (20 points) Using complete sentences, in a well organized paragraph, fully explain why the histidine: His^{146} has pKa= 8.1 in the tissues. His^{146} is located on helix H, 3 residues from the carboxy terminus, (HC3) on the beta subunits. In the lungs, this histidine has its regular pKa (the value that was memorized.)

17) (20 points) At high altitudes a person can become light headed, fatigued and nauseous. These effects are exacerbated upon exertion, and can be very dangerous. This effect is due to a lower concentration of oxygen in the air at high altitudes. The body adjusts by making additional red blood cells, so more oxygen can be delivered at the tissues (each hemoglobin delivers about 30% of the oxygen that is bound to it.) But that takes several days, and who wants to wait precious vacation days before having fun on the slopes? The following graph shows the binding curves for three concentrations of 2,3 BPG.



a) When a person travels from sea level to 11,700 feet, what happens to their 2,3-BPG levels?

b) How does 2,3-BPG interact with hemoglobin? Give specific details.

c) What effect does 2,3-BPG binding to hemoglobin have on the structure and function of hemoglobin? Provide specific details. Include numerical data from the graphs to support your answer.

d) Fetal hemoglobin does not have beta chains, instead it has two gamma subunits and two alpha subunits. This fetal tetramer (HbF) does not bind 2,3-BPG. The “0 mm BPG” curve represents the oxygen binding to HbF. Why does the fetus require this type of binding curve?