

Some useful equations:

$$v_o = \frac{V_{\max} [S]}{K_m + [S]}$$

$$k_{\text{cat}} = \frac{kT}{h} * e^{-\Delta G^\ddagger / RT}$$

$$V_{\max} = k_{\text{cat}} * E_t \quad \Delta G^\circ = -RT \ln K'_{\text{eq}}$$

$$R = 8.315 \text{ J/mol}\cdot\text{K}$$

$$k = 1.381 * 10^{-23} \text{ J/K}$$

$$h = 6.636 * 10^{-34} \text{ J}\cdot\text{sec}$$

$$\text{rate forward} = k_{\text{forward}}[\text{reactants}] \quad K_{\text{eq}} = \frac{[\text{products}]}{[\text{reactants}]}$$

$$\text{Acetic acid } K_a = 1.78 * 10^{-5}$$

$$\text{rate reverse} = k_{\text{reverse}}[\text{products}]$$

$$\text{Phosphoric acid } K_a = 7.25 * 10^{-3}$$

$$\text{Carbonic acid } K_a = 1.6 * 10^{-4}$$

$$\text{Dihydrogen phosphate } K_a = 1.38 * 10^{-7}$$

$$\text{Hydrogen carbonate } K_a = 4.68 * 10^{-11}$$

$$\text{Monohydrogen phosphate } K_a = 3.98 * 10^{-13}$$

$$K_{\text{eq}} \text{ for the reaction of carbon dioxide with water} = 1.69 * 10^{-3}$$

$$\Theta = \frac{[L]}{[L] + K_d}$$

MATCHING. (1 point each, 5 points total) Write the name of the filamentous protein that best matches each description.

1. Filamentous Proteins:

Keratin
Collagen
Elastin

A. Contains proline and hydroxyproline

1. _____

B. Provides protection

C. Has β sheets _____

D. Provides support to skin and bones

E. has two α helices in a left handed coiled coil _____

MULTIPLE CHOICE. Each is worth 2 points. Choose the one alternative that best completes the statement or answers the question.

2. In almost all of the protein misfolding diseases that were presented in class, a misfolded protein formed aggregates in tissues. These aggregates are then toxic to the tissues. Which of the following statements best describes why these aggregates form? _____

- A. The formation of the maximum number of hydrophilic interactions is energetically favorable
- B. There is a maximization of ionic interactions
- C. There is a synergistic relationship between aggregates and the placement of polar amino acid residues around the exterior of the protein.
- D. There is a maximization of entropy of water molecule
- E. The hydrogen bonding of water is minimized.

3. What effect does carbonic anhydrase have on the equilibrium concentrations of carbon dioxide, water and carbonic acid? 3. _____
- Carbon dioxide increases
 - Carbon dioxide does not change
 - Carbonic acid increases
 - Carbonic acid does not change
- I and III
 - II and IV
 - I, II and III
 - IV only
 - none of these, or more than one of these
4. Where are the hydrogen bonds in an α helix? 4. _____
- Between the carbonyl oxygen and the amide hydrogen, every fourth amino acid.
 - Between adjacent amino acid R groups.
 - Between the carbonyl oxygen and the amide hydrogen of an adjacent amino acid.
 - Inside the helix, between amino acid R groups.
 - none of these
5. The role of an enzyme in an enzyme catalyzed reaction is to 5. _____
- Bind to the transition state intermediate so it can not be converted back to the reactant
 - Convert all of the reactant to product
 - Lower the energy level of the products, so the reaction is more favorable
 - Increase the forward and reverse reaction rates
 - None of these
6. Carbon monoxide is a deadly colorless, odorless gas. What makes it so deadly? 6. _____
- CO binds to the heme iron in Hemoglobin 200 times tighter than O_2 binds.
 - CO binds to the heme iron in Hemoglobin 20,000 times tighter than O_2 binds.
 - CO preferentially binds non heme iron, so when it binds, the heme dissociates from hemoglobin
 - CO increases the affinity of hemoglobin for O_2 , when CO is bound, O_2 is bound tighter.
7. The dissociation constant (K_d) of the rat calmodulin protein for binding calcium ions is $1 \times 10^{-6}M$. What does this mean? 7. _____
- Half of the available available calcium binding sites are occupied when the concentration of calcium is $1 \times 10^{-6}M$,
 - When the concentration of calmodulin is $1 \times 10^{-6}M$, half of the available calcium binding sites are occupied.
 - When the concentration of calcium is $1 \times 10^{-6}M$, all of the available calcium binding sites are occupied.
 - All of the available calcium binding sites are occupied when the concentration of calcium is $0.5 \times 10^{-6}M$
8. How many stereocenters are present in tryptophan? How many stereoisomers are possible? 8. _____
- | | |
|------------------------------------|-------------------------------------|
| A. 1 stereocenter, 2 stereoisomers | B. 2 stereocenters, 2 stereoisomers |
| C. 1 stereocenter, 4 stereoisomers | D. 2 stereocenter, 4 stereoisomers |

9. A nonapeptide was determined to have the following amino acid composition: (Lys)₂ (Val)₂, (Phe)₂, His, Leu, Met. The native peptide was incubated with 1-fluoro-2,4-dinitrobenzene (FDNB) and then hydrolyzed; 2,4-dinitrophenylhistidine was identified by HPLC. When the native peptide was exposed to cyanogen bromide (CNBr), an octapeptide and free Valine were recovered. Incubation of the native peptide with trypsin gave a pentapeptide, a tripeptide, and free Lys. 2,4-Dinitrophenyl-histidine was recovered from the pentapeptide, and 2,4-dinitrophenylphenylalanine was recovered from the tripeptide. Digestion with the enzyme pepsin produced a dipeptide, a tripeptide, and a tetrapeptide. The tetrapeptide was composed of (Lys)₂, Phe, and Val. The native sequence was determined to be:
9. _____
- A. His–Leu–Phe–Val–Lys–Lys–Phe–Met–Val.
 - B. His–Phe–Leu–Val–Lys–Lys–Phe–Met–Val.
 - C. His–Leu–Val–Lys–Lys–Phe–Phe–Val–Met
 - D. Val–Phe–Lys–Lys–Val–Leu–Met–Phe–His.
 - E. Met–Leu–Phe–Lys–Phe–Val–Val–Lys–His.

10. Chaperonins _____
- A. help shape proteins by catalyzing the isomerization of proline
 - B. protect proteins from denaturing under high temperature conditions
 - C. help shape proteins by shuffling disulfide linkages
 - D. are elaborate protein complexes that hydrolyze ATP in the process of folding proteins
 - E. ensure that bad genes are not replicated accidentally, thereby ruining the future of the organism.
10. _____

SHORT ANSWER.

11. (8 points) A peptide was cleaved with an enzyme, but the researcher forgot to write down which enzyme they used. Look at the peptides that resulted and determine which enzyme was used. 11) _____

WIN YASRQNHITK TE

enzyme: _____

If the above peptide fragments were separated by cation exchange chromatography at pH 5, what is the order of elution from the column?

- 1. _____
- 2. _____
- 3. _____

12. (10 points) Describe the five types of forces that are involved in stabilizing or destabilizing an alpha helix. Listing the forces is not enough, Please give specific details about each one. 12) _____

13. (15 points) For the following peptide **CARPI** 13) _____
a. Draw the complete structure at pH 7

b. Calculate the pI, show the calculation, use pKa values of 3.0 and 8.5 for the carboxylate and amino termini.

14. (10 points) both Insulin and Amylin are secreted by the pancreas after a meal has been consumed. Use the following equilibrium dissociation constants, to answer questions about the binding of Antibodies to Insulin and to Amylin.

Antigen	Antibody 1	Antibody 2	Antibody 3
Insulin	2×10^{-9}	5×10^{-4}	2×10^3
Amylin	3×10^3	8×10^{-4}	6×10^{-6}

- Based on these K_d values, which antibody binds Insulin the tightest?
- Based on these K_d values, which antibody binds Amylin the tightest?
- For the binding of Antibody 1 to Insulin, what is the amount of Insulin required for $\Theta = 0.5$

Give a brief explanation for your answers.

15. (10 points) Polylysine exists as an alpha helix in solutions above pH 9.

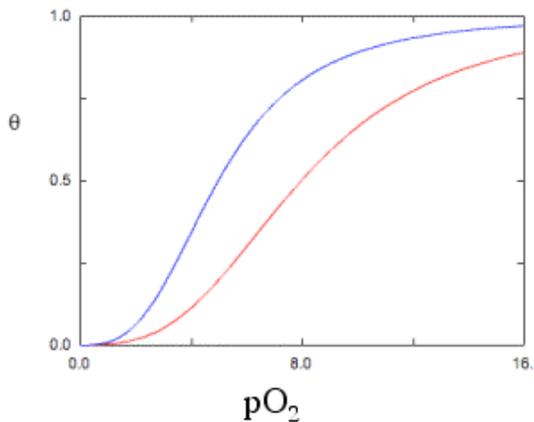
- Why does it exist as a random coil at lower pH values?

- How does this transition from random coil to α helix at pH 9 relate to the pK_a for the free amino acid form of lysine? Be sure to include a relevant discussion of the relationship of K_a and ΔG° .

16. (10 points) The following figure shows the data for the binding of oxygen to hemoglobin in the presence of either 5 mM or 8mM 2,3-bisphosphoglycerate.

16)

Effect of 2,3- bisphosphoglycerate on Oxygen Binding



- Label each line, one is for 5 mM 2,3-bisphosphoglycerate and one is for 8 mM bisphosphoglycerate.
- Fully describe how 2,3-bisphosphoglycerate alters the binding affinity of hemoglobin for oxygen.
- At high altitudes, there is less oxygen, so changes in the amounts of 2,3-bisphosphoglycerate in the blood occur. Do the levels of 2,3-bisphosphoglycerate increase or decrease? Explain why this change occurs.
- Describe how 2,3-bisphosphoglycerate is involved in delivering oxygen from mother to fetus.

17. (14 points) Use this signature sequence to answer the following questions:

17) _____



- Which position(s) has/have only positively charged amino acid functional groups at pH 7?
- Which position has only negatively charged groups at pH 7?
- Which position(s) has/have an amino acid that is not found in α -helices?
- Which position(s) has/have an amino acid that could be detected by UV spectroscopy?
- Which position has an amino acid that is essential for the structure of collagen?
- Is this a signature sequence for collagen? Why or why not?
- What do the size of the letters indicate in the above figure?