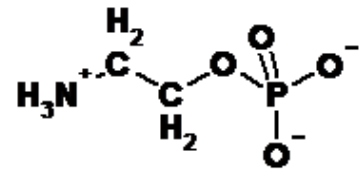


Instructions: This exam has 4 pages. Total points=100. Use the space provided, or the back of the previous page if necessary. On questions with choices, your answer that gives the highest grade will be used.

A. Multiple Choice and fill in the blanks (18 points)

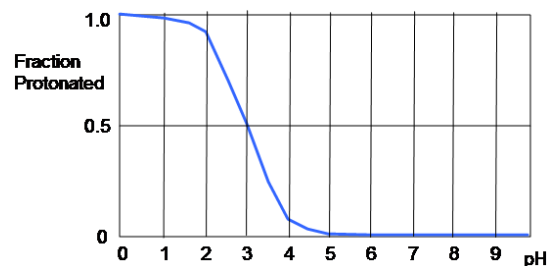
- A carbon will form a chiral center if it forms bonds with 4 different groups (fill in blank).
- Both enantiomers of amino acids are equally likely to be found in proteins (circle correct answer).
True
False
- All amino acids have an amino group as a functional group on their sidechain (circle correct answer).
True
False
- Which solution would have the **highest** hydrogen ion concentration (circle correct answer).
pH = 0 pH = 7 pH = 10

- An antibody binds the following small molecule. The most likely types of sidechains in the binding pocket of the antibody would be (circle all possible answers)



- sidechains with negative charges.
 - sidechains with positive charges.
 - Groups that can form hydrogen bonds
 - non-polar residues
- In a beta sheet the hydrogen bonds are perpendicular to the direction of the strands and the sidechains point up and down (fill in the blanks).
 - In an alpha helix the hydrogen bonds are parallel to the helix axis and the sidechains point outward (fill in the blanks).
 - Polar and charged residues are found on the outside of a folded protein while non-polar residues are found both inside and outside (fill in blanks).
 - The core of folded proteins is **well packed** due to _____ (circle correct answer).
a) the hydrophobic effect
b) hydrogen bonds between the sidechains
c) van der Waals interactions
d) electrostatic interactions

- The following is a plot of fraction protonated for an acid with a pKa=3. When the pH of the solution = 0, the fraction protonated will be (circle correct answer).



- 0
 - 0.1
 - 0.5
 - 0.9
 - 1.0**
- When a protein **folds** in water, the disorder of the water will **increase/decrease** by a large amount, this is **favorable/unfavorable** (circle correct word for the underlined choices). (-1/2 point for **decrease/unfavorable**)
 - Which one of the following four cells is **directly** responsible for killing cells that are infected with a virus (circle correct answer).

T_C
T_H

B Cells
Plasma cells.

B. Short answer.

1. (6 pts) Please do **one** of the following choices:

Choice A: What properties of a virus make it different from a cell? How is it similar?

Choice B: Briefly discuss two differences between eukaryotic and prokaryotic cells

Choice C: Briefly discuss two similarities between eukaryotic and prokaryotic cells

Choice A: A virus cannot reproduce itself and needs enzymes from the cell to copy its genetic material and to synthesize its proteins. It is similar to cells in that it contains genetic material.

Choice B: Differences

Eukaryotic cells have a nucleus

Eukaryotic cells have multiple intracellular compartments for specialized functions

Choice C: Similarities

Both have genetic material

Both have ribosomes

Both have cell membranes

2. (3 pts) Choose **one** component of a cell (prokaryotic or eukaryotic) and describe its function.

Ribosome - protein synthesis

Nucleus - contains genetic material

Golgi, endoplasmic reticulum - protein export

3. (2 pts) Why do some elements, such as Na^+ , K^+ , Mg^{2+} , form ions?

Atoms are most stable when they have a full shell. All of the above ions have a full shell.

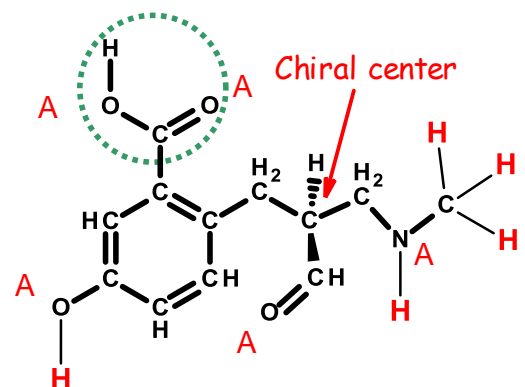
4. (5 pts) For the drug shown on the right, please answer all of the following questions:

i) Add hydrogen atoms as necessary to complete the structure.

ii) Indicate the chiral center with a "C"

iii) Identify one hydrogen bond acceptor; label it with "A"

5. (6 pts) The only ionizable group on the drug from question 4 is circled. It has a $\text{pK}_a=3$. Will this drug pass through the cell membrane at $\text{pH} = 7$? *Be sure to justify your answer.*



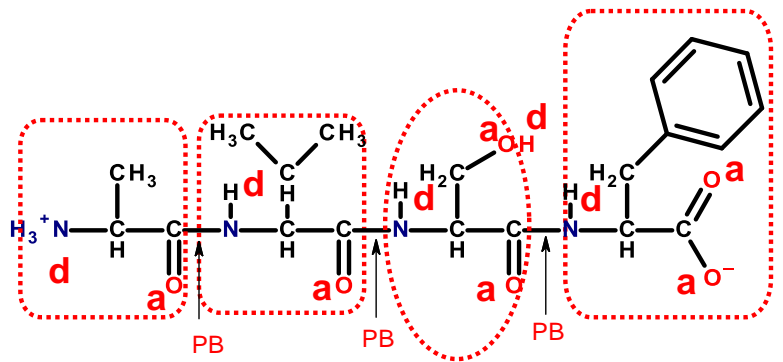
NO

- Since the pH is much higher than the pK_a , the group will be deprotonated.
- This will produce a negative charge on that group.
- The charge will make it difficult to go through the membrane.

6. (6 pts) The drug from question 4 has a chiral center, what problems could this cause if a racemic mixture of both enantiomers is given to a patient?

- The two enantiomers may have very different biological properties.
- One form will treat the disease.
- The other enantiomer may be toxic (e.g. thalidomide, naproxen)

7. (12 pts) The following diagram shows a short protein containing four amino acids. Please answer all of the following questions:

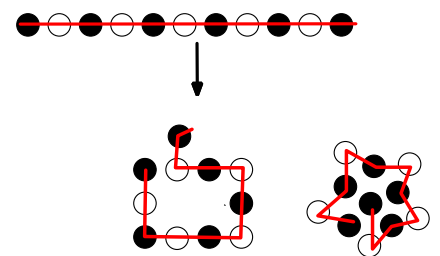


- a) Indicate a peptide bond with "PB". (2 pt)
- b) Circle the amino acid residue with a polar sidechain. (2 pts)
- c) Put a box around the amino acid residue that you would expect to find in the core of the protein. (2 pts)
- d) Identify one hydrogen bond donor with a "d". 1 ½ pt (all NH and OH groups)
- e) Identify one hydrogen bond acceptor with an "a". 1 ½ pt (all oxygens, no nitrogens)
- f) Give the correct amino acid sequence for this protein, using the three letter code: (3 pts)

Ala - Val - Ser - Phe

8. (3 pts) What molecule is released when two amino acids are joined with a peptide bond? H_2O , water.

9. (12 pts) The unfolded structure (top), and one possible folded structure (bottom), of a protein are shown. The filled circles represent non-polar amino acids and the open circles represent polar amino acids.



- i) The folded structure would not be stable. Explain why, with clear reference to the types of interaction that stabilize folded proteins (6 pts)
- ii) Sketch a structure for this protein that would be stable, and explain why it would be stable. stable [Note: The atoms need not be arranged on a grid] (6 pts)

i) The folded structure is not stable because:

- There is no non-polar core (5 pts)
- There is poor packing in the core giving weak van der Waals interactions. (1 pt)

ii) A possible structure is shown. This structure has a non-polar core and good packing.

10. (5 pts) Please do **one** of the following choices:

Choice A: Briefly describe how mutations in proteins can lead to disease conditions.

Choice B: Briefly describe how protein misfolding can lead to disease conditions.

Choice A: the mutation can destabilize the folded, or active form of the protein. The protein will lose its function and the loss of function could result in a disease.

Choice B: the protein can fold into multiple different shapes, only one of which is functional. The other shapes could result in disease, say due to protein aggregation.

11. (8 pts) Please do **one** of the following choices

Choice A: Draw and label an antibody, be sure to indicate where the antigen binds.

Choice B: Briefly describe how cells that are infected with a virus are destroyed by the immune system, beginning with activation of that cell.

Choice A:

Y-shaped molecule with two light chains and two heavy chains (labeled).

Variable regions of light and heavy chains should be labeled with Fv

Antigen should bind to Fv region

Choice B:

T_C cells that will recognize the virally infected cell are activated by T_H cells.

The T_C cells recognize the infect cell because the infected cell presents some proteins from the virus on the MHC molecules on the surface of the infected cell.

The T_C cell kills the infected cell.

12. (6 pts) Briefly discuss the properties of the four levels of protein structure (primary, secondary, tertiary, quaternary). Give an example of a protein with a quaternary structure.

Primary = amino acid sequence

Secondary = helices and sheets.

Tertiary = structure of one chain

Quaternary = multiple chains. E.g. Antibodies (and TCR and MHC)

13. (3 pts) The HIV virus causes an immune deficiency in infected individuals; they can no longer kill virally infected cells or make any antibodies. What cell type does the HIV virus infect and kill?

T-helper (T_H) cells, which are required to activate B and Tc cells.