University of British Columbia
Mid-term I – February 9th, 2017
Biochemistry 202 – Winter semester, Term 2

Time: **90 minutes**
Total Marks: 50

Candidate's Name: _____
(Please print **family name first.**)

Student Number: _____

Candidate's Signature: _____

This examination consists of 4 parts: A, B, C, & D. Part B has 2 questions, part C has 7 questions, & part D has 4 questions. The exam has a total of 8 pages. Please check to ensure that this paper is complete.

Answer all questions on this examination paper in the space provided.

Read and observe the following rules:

1. Each candidate should be prepared to produce, upon request, his/her library/AMS card.
2. No candidate shall be permitted to enter the examination after the expiration of ½ hour, or to leave during the first ½ hour of the examination.
3. Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions. CAUTION - Candidates guilty of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:
   a) Speaking or communicating with other candidates;
   b) Purposely exposing written papers to the view of other candidates;
   c) Purposely viewing the written papers of other candidates;
   d) Using or having visible at the place of writing any books, papers, or other memory aid devices;
   e) Using or operating electronic devices including but not limited to telephones, calculators, computers, or similar devices other than those authorized by the examiner. **Electronic devices other than those authorized by the examiner must be powered down if present at the place of writing**.
4. Examination candidates must conduct themselves honestly and in accordance with the established rules for a given examination, which will be articulated by the examiner or the invigilator prior to the examination commencing. Should dishonest behavior be observed by the examiner or invigilator, **pleas of accident or forgetfulness shall not be received**.
6. Examination candidates must not destroy or damage any examination material, must hand in all examination papers, and must not take any examination material from the examination room.

Mark Obtained: _____ /50

Part A. Matching terms. Chose the best answer from the following list below and assign a number. Not all terms will be used. (6 marks)

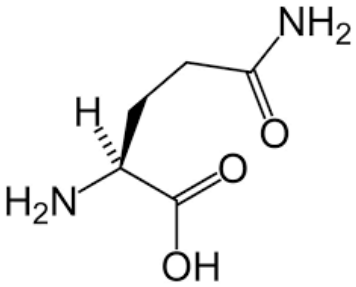
1. Increase
2. Just as likely as
3. Tertiary structure
4. Less likely than
5. More likely than
6. Decrease
7. Stay the same
8. Primary structure
9. Quaternary structure
10. Secondary structure

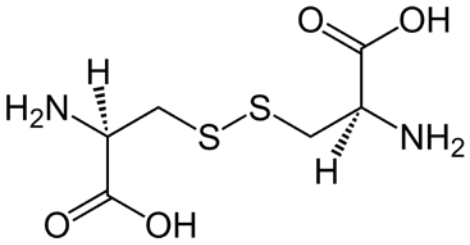
A. _____ If an aspartate residue's R group was brought in close proximity to the R group of methionine, the pK_a of the aspartate's R group would:

B. _____ The spatial arrangement of amino acid residues that are far apart from each other as well as the pattern of disulfide bonds.

C. _____ The sequence RKKDE is **X** RKKRE to form an α-helix. Where **X** is?

Part B. Fill in the blank. Write in the **FULL** name of the structure. (4 marks)
(No abbreviations)





1._____ 2._____

Part C. Multiple Choice. Circle the best answer. (14 marks)

1. At this pH, the dominant form of histidine has a net charge of +1:
   a. pH 4.
   b. pH 10.
   c. pH 1.
   d. pH 8.
   e. None of the above.

2. Which of the following is **NOT** true about enzymes?
   a. They decrease ΔG_{rxn}.
   b. They lower $\Delta G^{\ddagger}$.
   c. They are optimally complimentary to the substrate.
   d. They speed up reactions.
   e. a and c.
   f. None of the above, i.e. all are true!

3. Which of the following is true regarding the backbone of a polypeptide?
    a. The nitrogen in the N-H group can act as a hydrogen donor.
    b. The nitrogen in the N-H group can act as a hydrogen acceptor.
    c. The oxygen in the C=O group can act as a hydrogen acceptor.
    d. a and c.
    e. All of the above.

4. Your Favorite Enzyme (YFE) catalyzes the reaction S → P and obeys Michaelis-Menten kinetics. Which of the following is **NOT** true of the YFE catalyzed reaction?
    a. Decreasing YFE concentration decreases V_{max}.
    b. Decreasing YFE concentration decreases k_{cat}.
    c. Adding a non-competitive inhibitor to YFE decreases k_{cat}.
    d. All of the above. i.e., none are true.
    e. None of the above. i.e, all are true.

5. Which of the following is true?
    a. ΔG_{rxn} controls the reaction rate.
    b. Increasing temperature always makes a process more spontaneous.
    c. A process is always spontaneous if the change in entropy and the change in enthalpy have positive values.
    d. a and c.
    e. All of the above. i.e. all are true.
    f. None of the above, i.e. none are true.

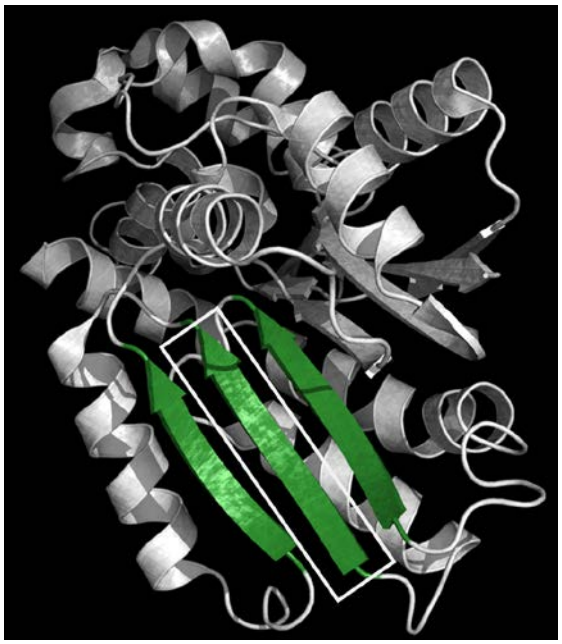
6. Which of the following conditions would **NOT** increase the chance that a globular protein like myoglobin would become denatured (unfolded)? You may assume the protein was initially at physiological conditions.
    a. Increasing pH.
    b. Decreasing pH.
    c. Adding (with mixing) an organic solvent like phenol.
    d. a and c.
    e. b and c.
    f. None of the above. i.e., all can lead to increased denaturation.

7. Consider a protein folding at physiological conditions:
    a. Tertiary structure is determined by the linear sequence of amino acids.
    b. Secondary structure is only determined by the linear sequence of amino acids of that secondary structure.
    c. Folding of the protein is partly driven by the spontaneous association of hydrophobic residues in the core of the protein even though this decreases entropy.
    d. a and b.
    e. a and c.
    f. all of the above.

Part D: Short Answer Questions: (26 marks)

1. $TrisH^+$/Tris buffer is commonly used in research labs. Starting with a stock solution of 0.5M Tris buffer at pH 7.5 explain how you would make 100ml of 10mM Tris buffer at pH 8.5. The pKa of $TrisH^+$/Tris is 8.1 and you have access to 0.1M solutions of HCl and NaOH. You do **NOT** have access to a pH meter. Show your calculations. (4 marks)
(You do not need to fill in all of the space to answer the question!!!)

2. . Draw the stick model of the tripeptide with the amino acid sequence YKW at **pH 9.0**. Draw the dominant form and show all hydrogen atoms. Ensure that all peptide bonds are in the trans orientation and label the bonds that have φ and ψ dihedral angles (5 marks)



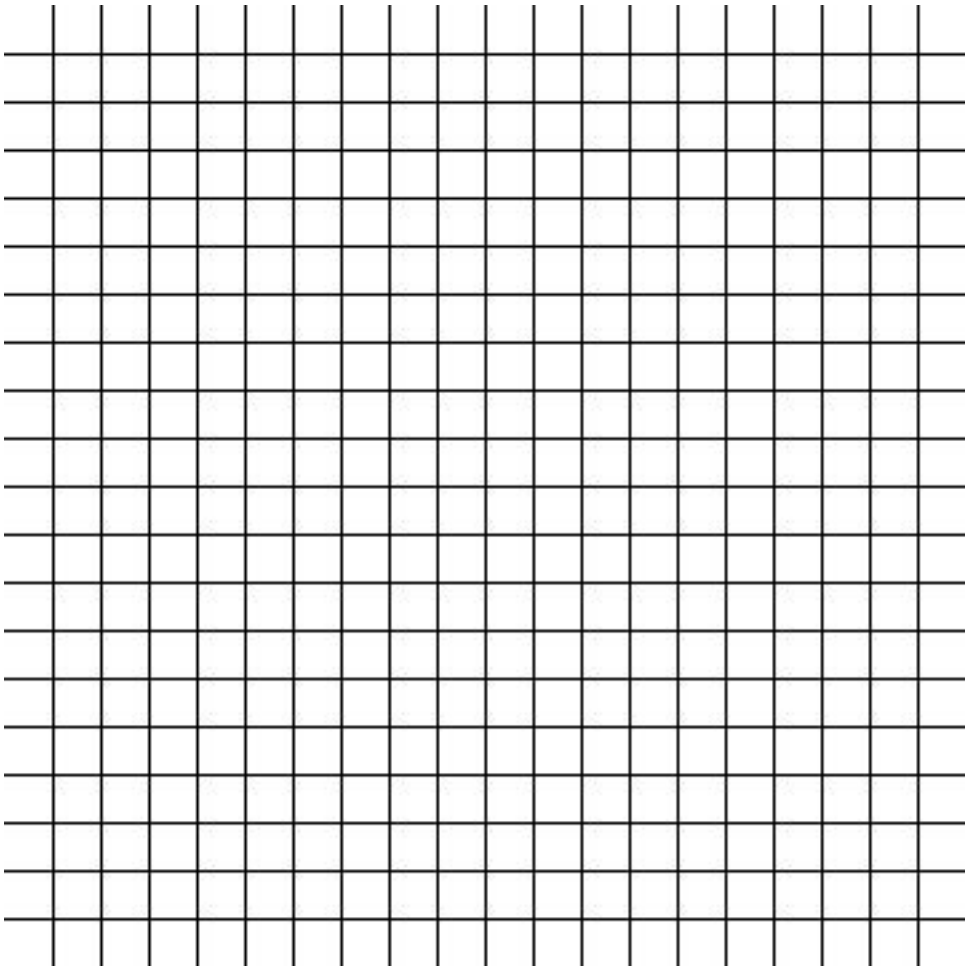
3a. Identify the structure enclosed in the white box in the image to the left . (2 marks)

3b. Describe the secondary structure element formed by the structure identified in 3a. What are the key characteristics that define its structure? (4 marks)

4. Amino acids can be used to synthesize proteins or can be broken down to generate energy in the form of ATP. Amino acyl tRNA synthetases attach amino acids to tRNAs and thus are the gateway for amino acids being used for protein synthesis. Conversely, aminotransferases remove amino groups from amino acids and thus are usually the first step in amino acid breakdown. Both enzyme types obey Michaelis-Menten kinetics.

4a. To characterize the kinetics of tyrosine tRNA synthetase (TyrRS) and tyrosine aminotransferase (TyrAT) you collect the following data (below) using Tyrosine as a substrate. Using the graph paper below, determine K_m and V_{max} for TyrRS and TyrAT (4 marks)

TyrRS or TyrAT [S] mM	TyrRS V_o (μM/min)	TyrAT V_o (μM/min)
0.71	8.33	6.25
1.00	10.00	8.33
1.67	12.50	12.50
5.00	16.67	25.00



4b. Assuming the experiment in 4a was carried out with either 4nM TyrRS (a dimer) or 2.5nM TyrAT (a tetramer), calculate k_{cat} for each enzyme. You may assume that each subunit has one active site. (3 marks)

4c. Based on your answers in 4a & b, how does a typical cell prioritize and process tyrosine? Your answer should include a discussion of each enzyme's K_m and k_{cat} values. (4 marks)

Equations & Constants:

K = $^oC + 273$ $\quad \Delta G' = \Delta H - T\Delta S$

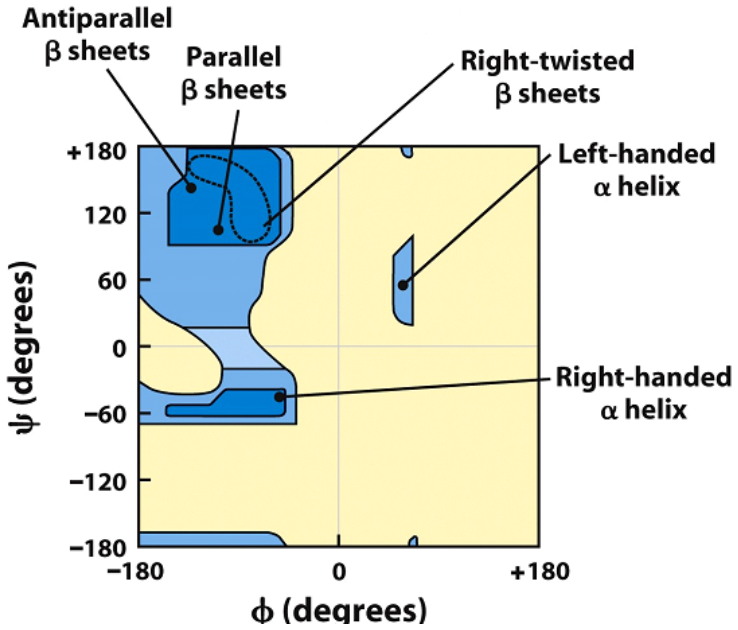
F: 96,480 J/V mol $\quad \Delta G^{o'} = -nF\Delta E_o'$

R: 8.315 J/mol K $\quad \Delta G' = \Delta G'^o + RT \ln \frac{[C][D]}{[A][B]}$

1 kDa: 1000 g/mole

$V_o = V_{max}([S]/([S] + K_m))$ $\quad$ Where A & B are reactants and C & D are products

$pH = pK_a + \log([A^-]/[HA])$ $\quad 1/V_o = 1/V_{max} + (K_m/V_{max})(1/[S])$



Ramachandran plot of L-alanine

Amino Acid	α-carboxylic acid	α-amino	Side chain
Alanine	2.35	9.87	
Arginine	2.01	9.04	12.48
Asparagine	2.02	8.80	
Aspartic Acid	2.10	9.82	3.86
Cysteine	2.05	10.25	8.00
Glutamic Acid	2.10	9.47	4.07
Glutamine	2.17	9.13	
Glycine	2.35	9.78	
Histidine	1.77	9.18	6.10
Isoleucine	2.32	9.76	
Leucine	2.33	9.74	
Lysine	2.18	8.95	10.53
Methionine	2.28	9.21	
Phenylalanine	2.58	9.24	
Proline	2.00	10.60	
Serine	2.21	9.15	
Threonine	2.09	9.10	
Tryptophan	2.38	9.39	
Tyrosine	2.20	9.11	10.07
Valine	2.29	9.72	

pK_a values for various amino acids. A terminal α-carboxyl group has a pK_a of ~3 and a terminal α-amino group has a pK_a of ~8.