Biochemistry 461, Summer I, 2015, 0101 **Your Name:** Key

University of Maryland, College Park **Your SID #:**

Biochemistry and Physiology **Prof. Jason Kahn**

Exam I (100 points total) **June 12, 2015**

You have 75 minutes for this exam.

Exams written in pencil or erasable ink will not be re-graded under any circumstances.

Explanations should be concise and clear. Use the extra space on the last page if you need more space.

You will need a calculator for this exam. No other study aids or materials are permitted.

Partial credit will be given, *i.e.*, if you don't know, guess.

$\Delta S_{system} - \Delta H_{system}/T \geq 0$ $\quad$ $pH = -\log([H^+])$ $\quad$ $R = 8.314$ J/mol K

$S = k \ln W$ $\quad$ $\Delta G = \Delta H - T\Delta S$ $\quad$ $pH = pK_a + \log([A^-]/[HA])$

$K_a = [H^+][A^-]/[HA]$ $\quad$ $\Delta G^{\circ\prime} = -RT \ln K'_{eq}$ $\quad$ $\Delta G = \Delta G^{\circ\prime} + RT \ln Q$

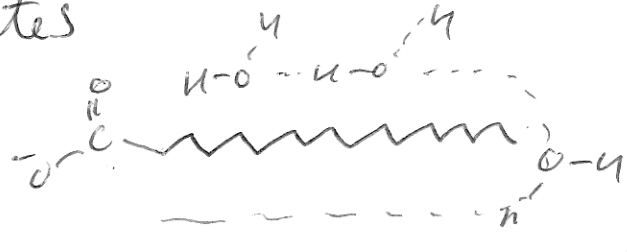
Honor Pledge: At the end of the examination time, please write out the following sentence and sign it, or talk to me about it:

"I pledge on my honor that I have not given or received any unauthorized assistance on this examination."

1. (15 pts) Thermodynamics

(a; 5 pts) What is the origin of the hydrophobic effect (at least at room temperature and below)? What is the sign of ΔS for dissolving a nonpolar solute like octane in water?

order of a defined cage around hydrophobic solutes (+3)



this means ΔH ~ small or 0 b/c of stable cage

But $\Delta S < 0$ (+2)

Score for the page 5/5

(b; 4 pts) The free energy change for a process is given by $\Delta G = \Delta G^{\circ\prime} + RT\ln Q$. Why is it especially important for biochemists to be able to calculate ΔG, whereas chemists are often content to just use the fact that $\Delta G^\circ = -RT\ln K$?

+4 Biochemical reactions in the cell are seldom at equilibrium – metabolic concentrations are at a steady state set by rates of irreversible rxns.

So we need the actual $\Delta G = \Delta G^{o\prime} + RT\ln Q$, when $Q \neq K$

Chemist who looks at one rxn in solution care more about K.

(c; 6 pts) Give an example of an endothermic disordering process, specify the signs of ΔH and ΔS, and describe the temperature dependence of the process.

ice melting or protein unfolding – ~~too~~

+2 energy input (endothermic) needed to break bonds, with a resulting loss of order (increase of entropy)

+2 $\Delta H > 0$
$\Delta S < 0$

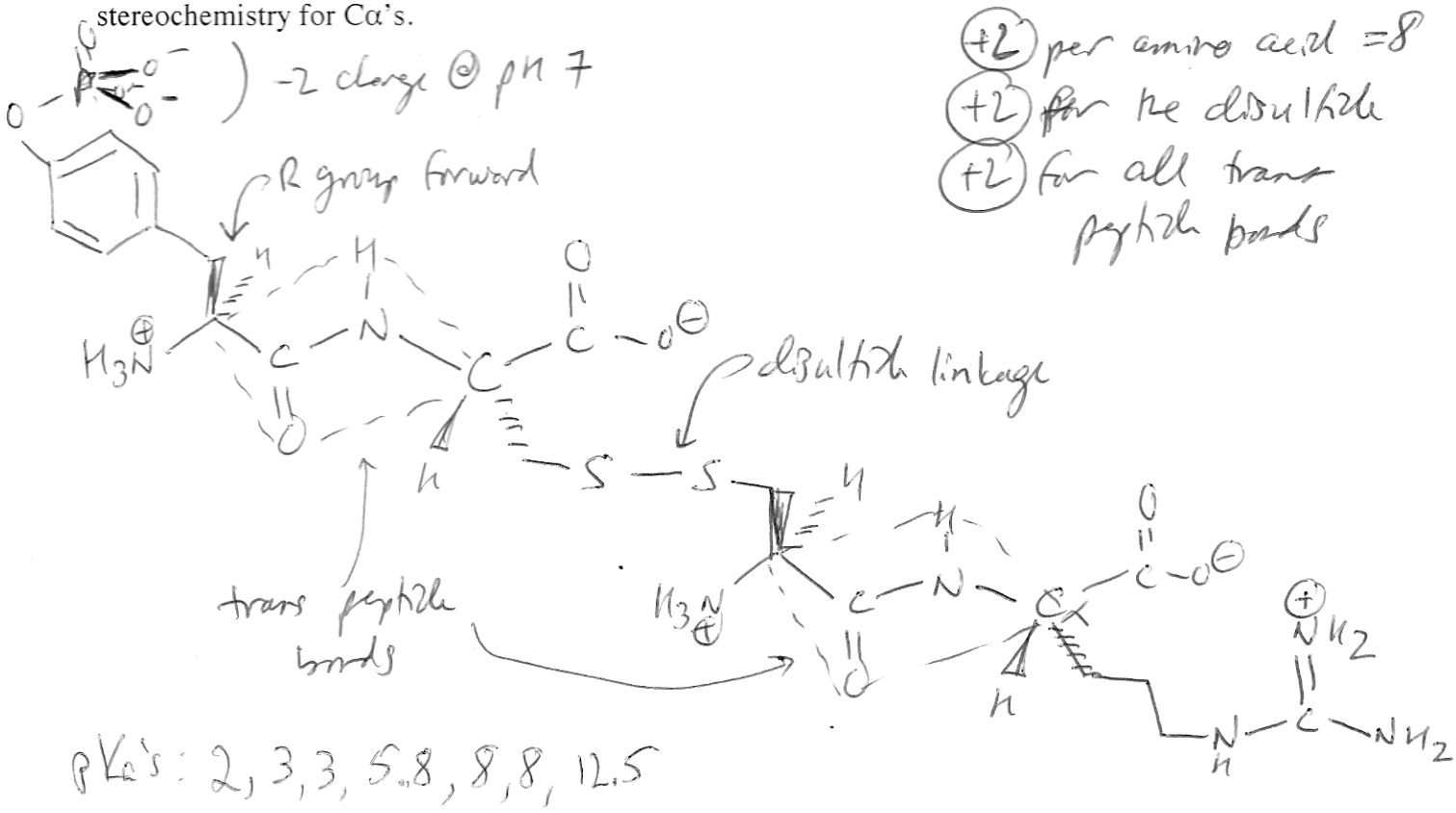
+2 So $\Delta G = \Delta H - T\Delta S$ >0 at low T – structure is stable

<0 at high T – structure is disrupted

Score for the page 10/10

2. (24 pts) Peptide Structure

(a; 12 pts) Draw the structure of the dipeptide (phospho-Y)C disulfide-linked to the dipeptide CR. Draw the predominant ionic form at pH 7. The pKa's of protonated phosphotyrosine are about 2 and 5.8. The pKa's for protonated C- and N-termini are about 3 and 8. Assume all *trans* peptide bonds, and give correct stereochemistry for Cα's.



+2 per amino acid = 8
+2 for the disulfide
+2 for all trans peptide bonds

(b; 12 pts) Fill in the table for the charge of the peptide above, to the nearest integer or half-integer. You do not need a calculator.

pH	0	3 (+1)	7 (+1)	10 (+1)	14 (+1)
Charge on peptide	+3	+1	-1	-3	-4

From your table, without doing any more calculations, specify a range for the possible pI of the peptide and give your reasoning. (+2) (+2)

Between 3 and 7 the average charge must cross 0 - near 4.5 somewhere

Why is the pI important for protein separation procedures?

(+2) When the pH is equal to the pI, net charge is zero and the amino acid / peptide / protein does not migrate in an electric field

And/or: the pH of minimum solubility

Why does the cytoplasm have to be a reducing environment?

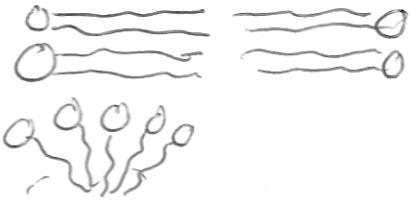
(+2) - To maintain cysteines as –SH (thiols) so they can chelate metals or act as nucleophiles

Score for the page 12.4/24

3. (15 pts) Lipids and Carbohydrates

(a; 5 pts) Sketch the structural aspect of a lipid molecule that determines whether it will form a micelle vs. a lipid bilayer? How does *cis*-unsaturation in the lipid chain increase membrane fluidity (or cause lipids of the same molecular weight to be liquids rather than solid)?

(+3) Two head groups like PE, PC → bilayer
One head group like SDS → micelles



(+2)  vs. : the double bond does not pack as well — prevents membrane / oil from solidifying

(b; 4 pts) Give two reasons that fat packs more dietary calories per gram than carbohydrates.

(+2) – more electrons per carbon atom (ox # -2 vs. 0)

(+2) – more efficient packing because the fats don't carry non-calorie water around with them.

(c; 6 pts) What are the three functions of carbohydrates that we discussed? Name carbohydrate-containing molecules that carry out each of the three functions.

- information – blood group glycoproteins (+1) (+1)
- fuel – glucose / glycogen / starch (+1) (+1)
- structure – cellulose, proteoglycans (+1) (+1)

Score for the page 15/15

4. (36 pts) Secondary Structure in Proteins

(a; 4 pts) What was the point of drawing the simple lattice models for the compaction of chains into small areas (volumes)?

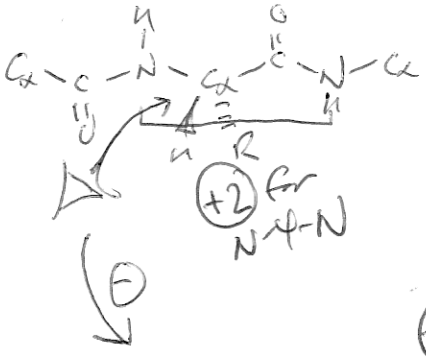
- When a chain is forced into a small volume, there aren't many ways to pack it - regular secondary structure emerges (+2) (+2)

(b; 4 pts) List the two essential structural characteristics of stable secondary structures discussed in class.

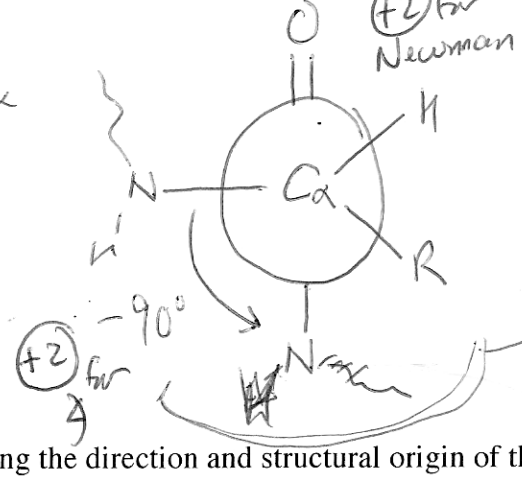
(+2) - All H-bonding valences along the backbone are satisfied

(+2) - Any side chain can be accepted in ~~each~~ better helix or sheet (except Pro), [w/ preferences from eg. Chou-Fasman]

(c; 8 pts) Draw a Newman projection for ψ(Psi) = –90°, with the Cα being the forward end of the bond that is going straight into the page for the Newman projection. Explain why ψ values between about –90° and –150° are a forbidden region of the Ramachandran diagram.



(+2) for N-ψ-N

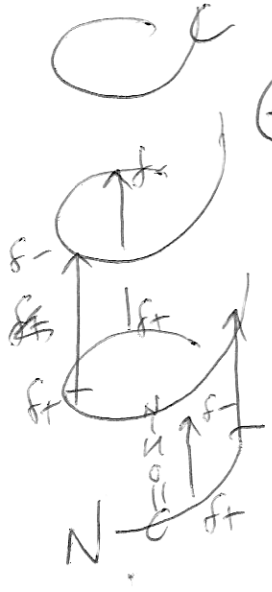


(+2) for Newman

(+2) for ψ

over the range of -90 to -150, the R group and the NH will be ~eclipsed [- the H comes out of plane toward us]

(d; 4 pts) Sketch a picture explaining the direction and structural origin of the macrodipole of the alpha helix.



(+2) (+2) (+2) right-handed helix

(+2) (+1) All the δ+ C=O in H–N δ- dipoles

C → C+4

add up to give a ⊕ end at the N-terminus and a ⊖ end at the C-term.

(+2) (+1)

Score for the page 120

(e; 8 pts) We emphasized the idea of "sidedness" of alpha helices and beta sheets. **Why is this important in protein folding?**

(+1) = hydrophilic tends to face out toward the surface –

(+1) – AA's on one side of a sheet often back to form the hydrophobic core

For the two sequences below, identify which one is more likely to be two strands of a beta sheet: 2 (+1) and which one is more likely to be an alpha helix: 1 (+1)

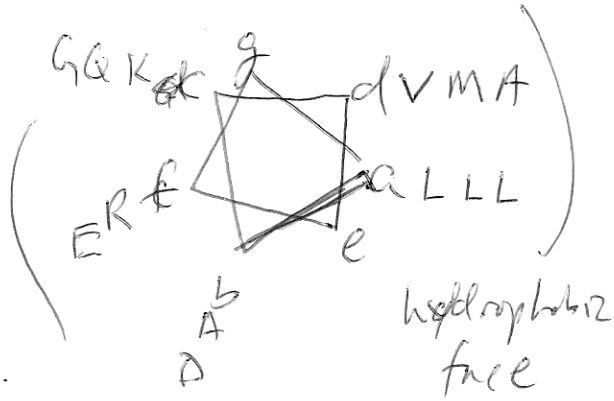
Sketch how each one exhibits sidedness – either draw a picture or add labeling to make your point.

(1) PELAKVARTLDQMLENLAGA

fgabcdefgabcdefgabcd

(+2)

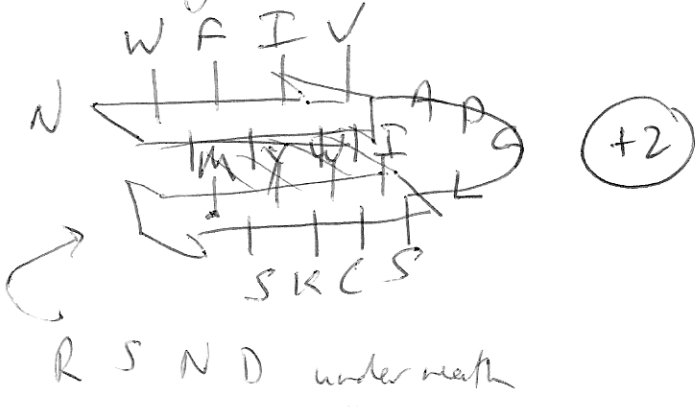
hydrophilic



(2) WRFSINVDAPGLSICWKYSM

turn

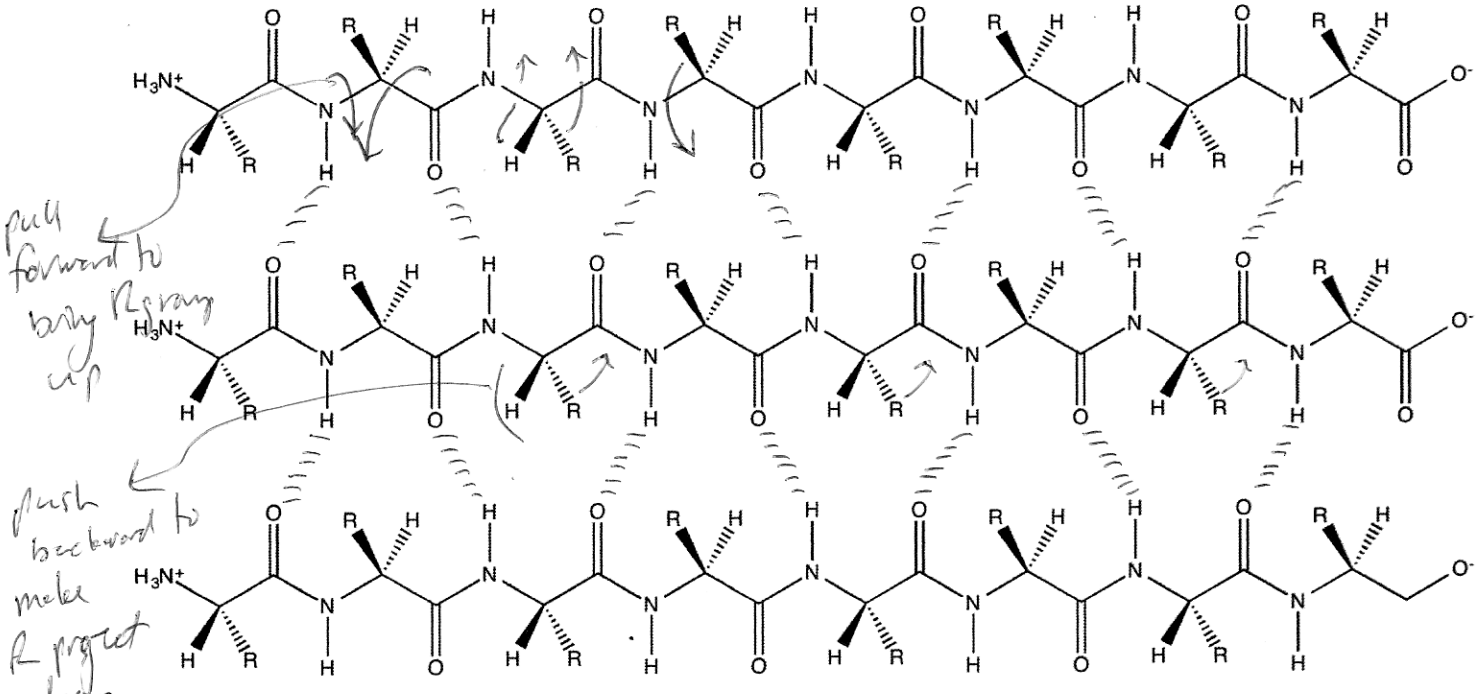
Alternating hydrophilic + hydrophobic

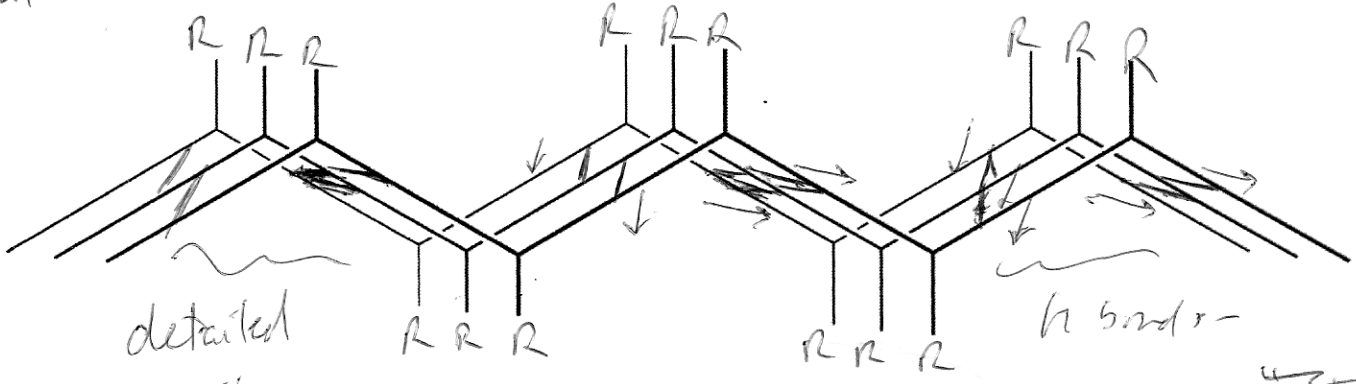


(+2)

Score for the page 18

(f; 8 pts) On the extended polypeptides below, sketch in the H-bonding pattern of the parallel beta sheet. Sketch on the picture how and why the backbone is deformed out of the plane to make the pleated sheet conformation. Label the R groups and draw in H bonds on the pleated picture at the bottom.





detailed position doesn't matter

H bonds - one per "pleat"

+3 for H-bonding between chains
+2 for idea of torquing R groups to be ⊥ to the plane of the sheet
+2 for R groups labeling
+1 for H-bond labeling

Score for the page 18

5. (10 pts) Buffers

(a; 2 pts) Calculate the pH for a solution of acetic acid/Na acetate composed of 50 mM HOAc and 50 mM NaOAc. The pKa of acetic acid (HOAc) is 4.75.

$pH = pKa + \log \frac{[A^-]}{[HA]} = 4.75 + \log \frac{50}{50} = 4.75$

(b; 3 pts) Adding 10 mM HCl will give 60 mM HOAc and 40 mM OAc^-. What is the new pH?

$pH = 4.75 + \log \frac{40}{60} = 4.57 \quad (\Delta = -.18)$

↑ mM, but it doesn't matter since both are $>> [H^+]$

(c; 2 pts) Adding an additional 31 mM HCl will give 91 mM HOAc and 9 mM NaOAc. What is the new pH?

$pH = 4.75 + \log \frac{9}{91} = 4.75 - 1.0048 = 3.75$ ($\Delta = -0.82$ for 3x more acid)

(d; 3 pts) What will the pH after the addition of a further 10 mM HCl? [Hint: HCl will be in excess, which we assume will completely suppress the dissociation of HOAc.]

Net concentration of excess HCl = 1mM

Acetic acid is ~ fully protonated so does not buffer much (or contribute to additional $[H^+]$)

$pH = -\log(10^{-3} M) = 3 \quad (\Delta = -0.75$ vs. $-.18$ above)

Page	Score
1	/5
2	/10
3	/24
4	/15
5	/20
6	/8
7	/8
8	/10
Total	**/100**

Score for the page 10