1. pH, pK_a, and all that (25 pts):

(a; 9 pts) The imidazole side chain of histidine has a pK_a of 6.04 (referring to the protonated side chain). Draw the dominant prototropic forms of histidine at (1) pH 4, (2) pH 8, and (3) pH 12. Don't worry about C_α stereochemistry.

(b; 6 pts) Calculate the ratio of neutral to protonated histidine at pH 6.5.

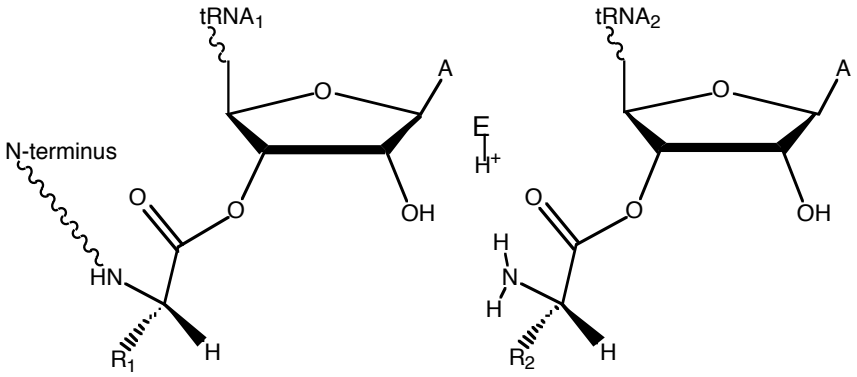
(c; 10 pts) We have mentioned that the pK_a of an amino acid side chain can change substantially in different protein contexts. If a histidine side chain were found buried among isoleucines in the center of a protein, what effect would this have on the actual pK_a of that particular side chain, and why? What if there were a buried aspartate as well?

2. Amino acid and peptide bond structure and chemistry (26 pts):

(a; 6 pts) Name the two sulfur-containing amino acids, and very briefly list one unique functions for each.

(b; 15 pts) Draw the structure of Valine-Proline-Glutamate at pH 7. Make the valine-proline peptide bond *cis* and the proline-glutamate peptide bond *trans*. Give the 3- and 1-letter codes for each amino acid below your structure.

(b; 5 pts) The structure below shows two charged tRNA molecules aligned for the process of peptide bond synthesis. Draw the first step of the reaction mechanism, leading to the key intermediate.



3. Thermodynamics (25 pts):

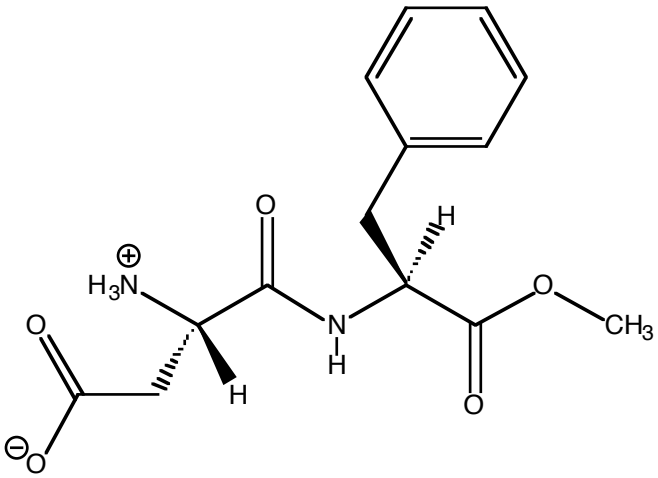
(a; 6 pts) What are the two most important functions for lipids?

(b; 9 pts) Briefly describe how typical aerobic cells maintain order in the face of the universal tendency toward increasing entropy.

(c; 10 pts) You have discovered an enzyme that converts substance A to substance B without requiring any input of free energy (i.e. the reaction proceeds without high-energy cosubstrates like ATP). The equilibrium lies far to the side of B. What then must be true about any process that carries out net conversion of B to A under the same conditions? Also, explain why your discovery either does or does not preclude the possibility that there may be a separate energy-consuming path for going from A to B, and a biological rationale for your answer.

4. Intermolecular interactions(22 pts):

(a; 12 pts) The structure of the artificial sweetener Aspartame is shown below. Identify potential hydrogen bond donors and acceptors, and electrophilic carbons. Why must phenylketonurics avoid Aspartame? (Memory jogger: would Aspartame absorb UV light?)



(b; 10 pts) Briefly describe the origin of the hydrophobic effect. Give the signs of $\Delta H°$, $\Delta S°$, and $\Delta G°$ for the process of dissolving a long alkyl chain in water.

Score:	1.	pH, pK_a, and all that (25 pts):	_____
	2.	Amino acid and peptide bond structure and chemistry (26 pts):	_____
	3.	Thermodynamics (25 pts):	_____
	4.	Intermolecular interactions(22 pts):	_____
		Total: out of 100 (2 pts for Honor Pledge)	_____