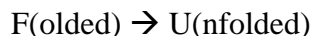


**Biophysical Chemistry – CH 4404 01**  
**Assignment 3**

**Due Friday, September 13 (by 5:00 pm)**

Please complete the answers to this assignment on a separate page (or pages), showing your work and sources (if you referred elsewhere for constants, enthalpies, etc.).

1. State the second law of thermodynamics in three different ways. You can use an equation for one of your restatements. (6 points)
  
2. Empirically, we all know that hot air rises. The upper floors of a building are warmer than the lower floors, and the lower density of hot air creates a buoyancy effect that pushes it up. In this problem, we will answer the following question: Given that warm air rises, why are the mountains cold?
  - (a) Suppose a gust of wind **rapidly** blows 1 liter of an ideal gas (the system) from a valley to a mountaintop. At sea level, the temperature is 25 °C, and the pressure is 1 atm. At the top of the mountain, the atmospheric pressure is 0.7 atm. What assumptions can you make about the gas as it travels from the valley to the mountaintop? (Hint: if the transformation is **rapid** what type of transformation might be a good model?) (2 points)
  
  - (b) Given your assumptions in part (a), calculate the volume and temperature of the gas as it blows from the valley to the mountain. (3 points)
  
  - (c) Given your results from (a) and (b), if warm air rises, why are the mountains cold? (1 point)
  
3. In the first week of class, we discussed the idea of protein folding: Under normal conditions, proteins adopt a folded, compact form (the native state). But it is possible for proteins to “unfold” and adopt a random, disordered form. This unfolded form is thought to behave similarly to a piece of spaghetti, with few (if any) intra-molecular interactions, and no regular secondary or tertiary structure:



- (a) Using PyMOL, open the PDB file 2OED. This file shows the coordinates for a small protein called GB3. Render the file as a cartoon diagram. As you can see, GB3 contains four strands, numbered 1 through 4 starting from the N-terminal end of the protein. It also contains a single alpha helix. If you had to choose an “unfolding pathway” for GB3, what would you devise? In other words, what parts of GB3 would unfold first, and why? (There’s no single correct answer here, just take a look and see what you can come up with.) (2 points)
  
- (b) Intuitively, the entropy of GB3 would be much higher in the unfolded state than in the folded state. Yet in solution, it is observed that the folded state is favored, and unfolding

is not spontaneous. Give a thermodynamic explanation for why this might be (*Hint*: Think about the system vs. the surroundings; for more help see pp. 77-79 of your book.) (3 points)

(c) Which would you expect to have the higher heat capacity: N or U? Why? (3 points)

4. Tinoco chapter 3, question 3. (3 points)
5. Tinoco chapter 3, question 4. You may skip part (c). *Hint 1*: Remember that the definition of mole fraction is  $X_A = \frac{n_A}{n_A+n_B}$ . (6 points)
6. Tinoco chapter 3, question 14. You may skip part (d). The answers are given in the back of the book, but please show your work and justifications. (8 points)
7. Tinoco chapter 3, question 21. (6 points)
8. Tinoco chapter 3, question 22. There are eight parts to this question; you may pick any five to answer. (10 points)