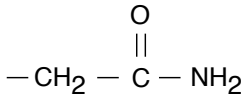
Biochemistry I – Problem set 1 *Due Monday, Sept 12* Total Time required: ~80 min

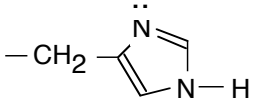
A: The following problems from Campbell are recommended:
Chapter 1: 2, 3, 10, 11, 17, 18, 21, 24, 25, 26, 34, 35, 37, 39-43
Chapter 2: 1, 2, 6, 7, 10, 11, 12, 16, 17, 18, 19, 20, 21, 22, 25, 27, 33, 41, 45
Answers to these problems are in the back of the textbook. Please do **not** submit them for grading.

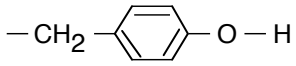
B: Submit answers to the following problems for grading:
Note: For answers that require calculations, the highest scores are reserved for those who: 1) show their work; 2) underline or "box" their final answer; 3) use the correct units on numerical answers.

1. (8 points, 10 min) The side chains of some amino acids possess functional groups that readily form hydrogen bonds in aqueous solution. Identify the following amino acid side chains (1 pt each) and draw one hydrogen bond likely to form between each side chain and water (1 pt each):
[Draw the waters as "H-O-H" and indicate for each whether the water is the H-bond donor or acceptor].

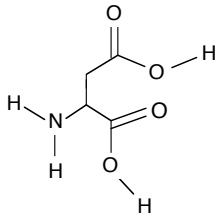
(a) 

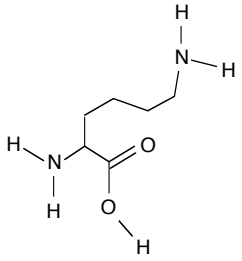
(b) 

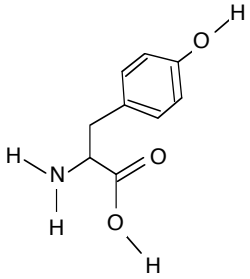
(c) 

(d) 

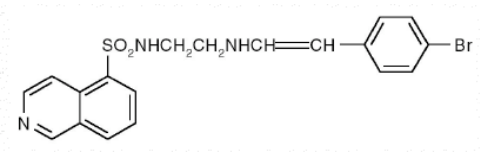
2. (15 points, 15 min) The side chains of several amino acids possess ionizable side chains. Identify the following amino acids (1 pt each), add any protons that may be missing from each structure (1 pt), and draw each in its correct ionic form at pH 7.0 (see table 3.2 in Campbell for pK_a values). Label *all* ionizable groups with their pK_a values, include electrostatic charges and indicate the net charge of each amino acid (2 pts each).

(a) 

(b) 

(c) 

3. (4 points, 5 min)
(a) You are required to make a concentrated solution of potassium chloride and have the choice of two solvents, methanol and water. Indicate which would make a better solvent and why (2pts).
(b) You are required to make a solution of the drug shown below and have the choice of two solvents, ethanol and water. Indicate which would make a better solvent and why (2pts).



4. (9 points, 25 min) You are required to make 100 ml of a 0.05 M potassium phosphate solution for a biological experiment at pH 7.4. You only have the fully protonated form of this acid (H_3PO_4) in the lab, plus 1 M solutions of HCl, acetic acid, NaOH and KOH. [Hint: pK_a values listed in table 2.6 of Campbell may be useful for answering these questions.]
   (a) Is phosphate a reasonable choice for a buffer in this case? (1 pt) *Briefly* justify your answer.
   (b) How many moles of phosphoric acid would you need for your buffer? (1 pt)
   (c) Would you use acid or base to adjust the pH of the solution? (1 pt) Which type? (1 pt) *Briefly* justify your answer (1 pt).
   (d) What volume of the 1 M solution of the acid or base (determined in part c) would be required to adjust the pH of the phosphoric acid solution to 7.4? (5 pts) Please show your work.

5. (10 points, 25 min) A polypeptide contains *two* Arginine residues and *one* Histidine residue, and no other amino acids with ionizable sidechains. The pK_a of the sidechains of the Lysine residues are 12.5 and that for the Histidine is 5.0. Assume that the pK_a of the mainchain carboxylic acid group is 2.0 and that of the amino group is 10.0.
   (a) *Sketch* a titration curve for this protein, assuming that you are beginning from the fully protonated form. (You need not calculate the curve, just try to reproduce its general features). Be sure to indicate the scale on the x-axis in units of equivalents. Also mark the inflection points and equivalence points on your diagram. (5 pts)
   (b) Calculate the fraction of the Histidine side chain that is protonated at pH 6.0. (3 pts)
   (c) What is the normal pK_a for a Histidine sidechain? Suggest a reason why it is lower than normal in this particular polypeptide. (2 pts)