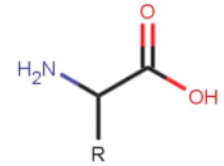


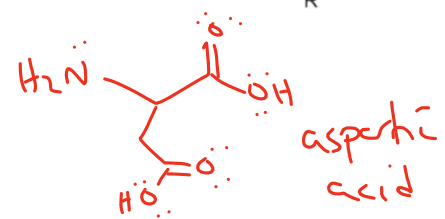
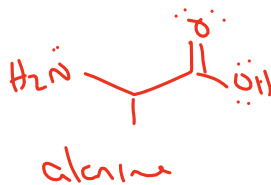
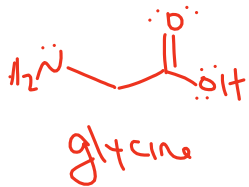
Amino Acids and Primary Structure

Goal: Our goal in this activity is to expand our understanding of amino acids so that we can predict how amino acids combine to form peptide chains and to understand how the formation of peptide chains influences the physical and chemical properties of the amino acid.

Common biological amino acids adopt the structure shown here. The N-C-C linkage is called the backbone. The only difference between the 20 common variations is the "R" group, which is also known as a side chain.



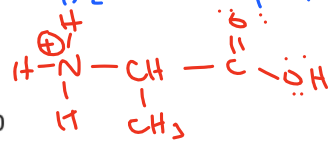
1. Draw glycine (R = H), alanine (R = CH₃), and aspartic acid (R = CH₂COOH).



2. Which of these three amino acids do you expect to have a side chain that will participate in acid-base chemistry? *Aspartic acid*
3. Sketch a titration curve for alanine. The two pKa values are 2.34 and 9.69. You should be able to determine the pH for 3 points.

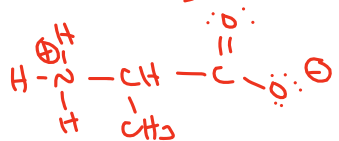
Draw the major form of the amino acid at each pH:

pH = 2.0 — H₂X (both protonated)



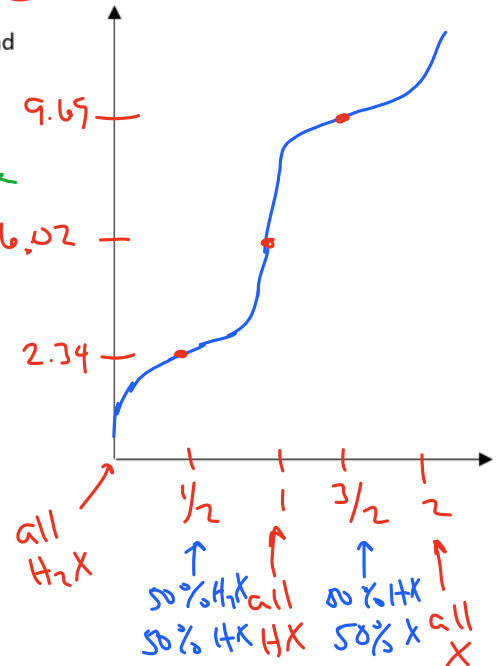
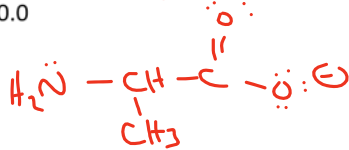
pH = 7.0

HX



pH = 10.0

X



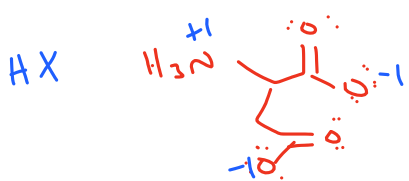
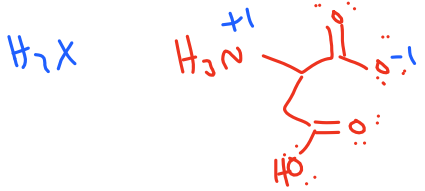
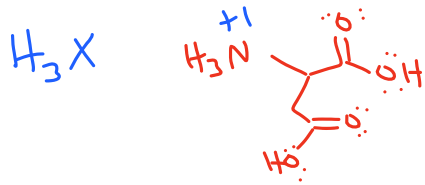
4. What form of this molecule has an overall neutral charge? *HX*
5. At what pH is 100% of the amino acid in this form? This point is known as the isoelectric point or pI?

6.02

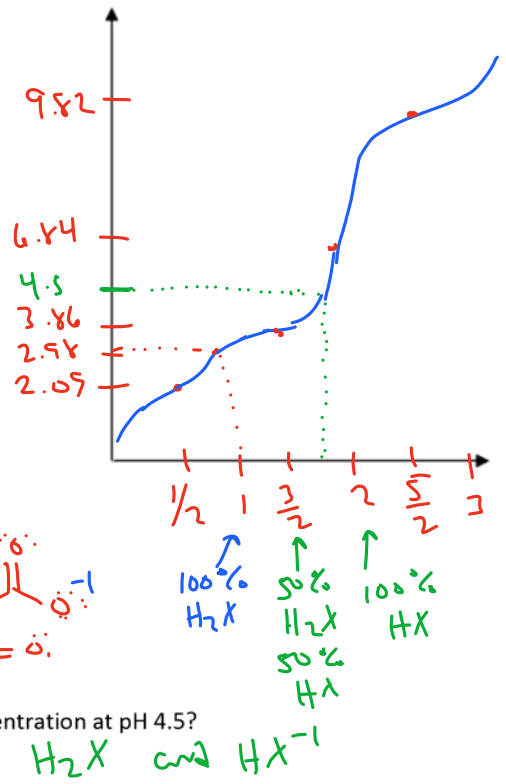
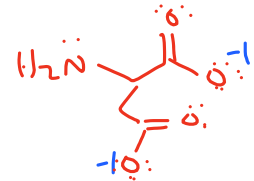
6. What is the charge of the amino acid at a pH above the pI? *Negative*

How about below? *positive*

7. In problem 2, you should have determined that aspartic acid will have a side chain that can be ionized.
- Sketch the titration curve – the pKa values are 2.09, 9.82, and 3.86 (side chain).



X

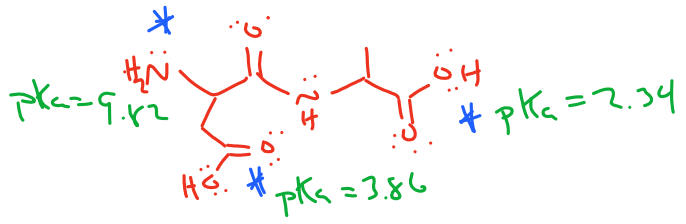


- Which 2 forms of the amino acid are present in highest concentration at pH 4.5?
- Which form of the amino acid has an overall neutral charge?
- Determine the pI.

H_2X and HX^{-1}
 2.98 (100% H_2X on curve)

Amino acids are able to combine together through condensation reactions. The bond that is formed is known as an amide, but in biochemistry it's known as a peptide bond. When multiple amino acids combine together, their product is a peptide. Peptides have two ends (or termini), the N-terminus (for amine) and the C-terminus (for carboxylic acid).

- Draw the product of condensation of alanine and aspartic acid where aspartic acid is at the N-terminus and alanine is at the C-terminus.

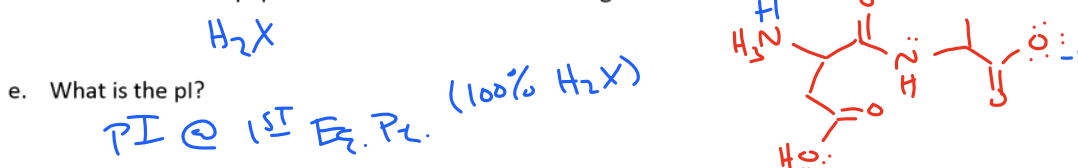


- How many ionizable protons exist on this molecule (e.g. how many pKa values will it have)?
- 3 - starred on structure

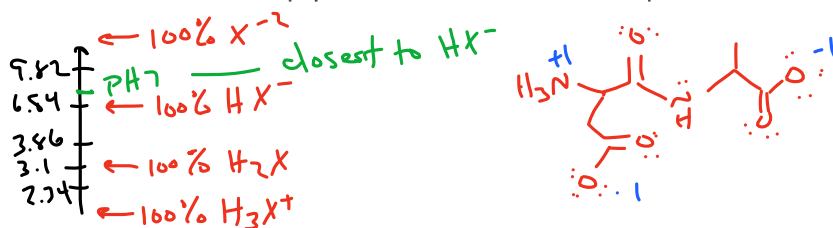
b. What is the charge on each functional group when protonated? $-COOH \rightarrow \emptyset$ $-\overset{+}{N}H_3 \rightarrow +$

c. What is the charge of the fully protonated form of this peptide? $+1$ (only amine is charged)

d. What form of the peptide will have a net neutral charge? Draw it.



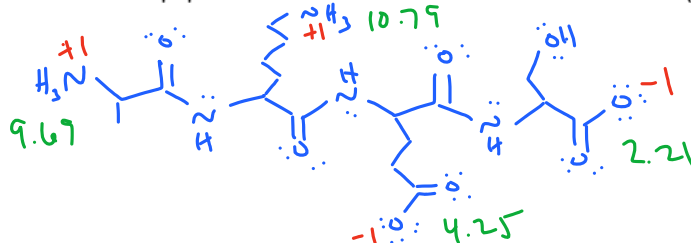
f. Now redraw the peptide as it would look at neutral pH.



9. Now consider the peptide: Alanine – Lysine – Glutamic Acid – Serine. The side chains and pKa values for each of the amino acids are listed.

Amino Acid	Side Chain (neutral form)	pKa1	pKa2	pKa3 (side chain)
Alanine	-CH ₃	2.34	9.69	
Glutamic Acid	-CH ₂ CH ₂ COOH	2.16	9.67	4.25
Serine	-CH ₂ OH	2.21	9.15	
Lysine	-CH ₂ CH ₂ CH ₂ CH ₂ NH ₂	2.18	8.95	10.79

a. Draw this peptide. Make sure to draw it in the correct order (N-term \rightarrow C-term).



b. Which functional groups are charged when they are protonated?

$-\overset{+}{N}H_3$ only

c. Which functional groups are charged when they are deprotonated?

$-COO^-$ only

d. What is the charge of the peptide when it is fully protonated?

$+2$ ($2 \overset{+}{N}H_3$)

e. What is the charge of the peptide when it is fully deprotonated?

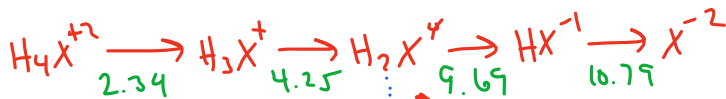
-2 ($2 COO^-$)



f. Which form of the peptide has a net neutral charge?

g. Which form of the peptide exists in the highest abundance at pH 7.4?

pKa values are listed on the peptide ... taken from the table



6.97 \uparrow 7.4 is between H_2X^0 & HX^{-1} , so they are most abundant

10. If you still have time, sketch a titration curve and label the pI of this peptide:

