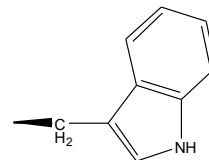
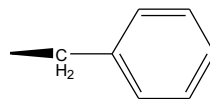
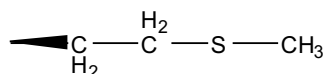
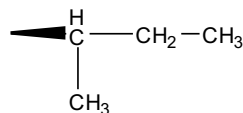
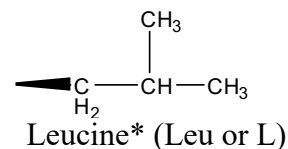
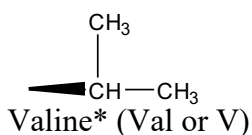
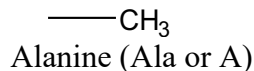
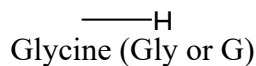


# Amino Acid Sidechains

## Neutral - Nonpolar

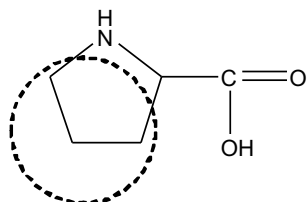


Isoleucine\* (Ile or I)

Methionine\* (Met or M)

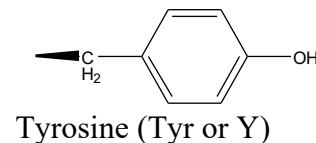
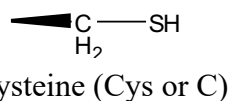
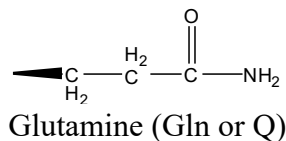
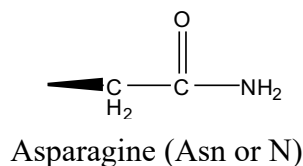
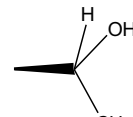
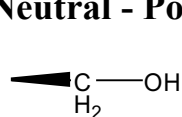
Phenylalanine\* (Phe or F)

Tryptophan\* (Trp or W)

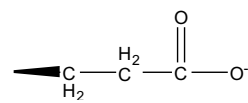
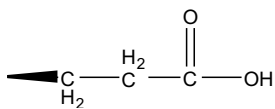
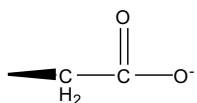
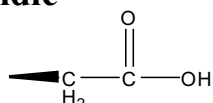


This is the entire amino-acid. The side chain is circled

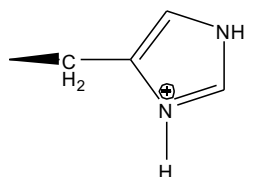
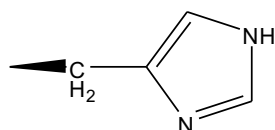
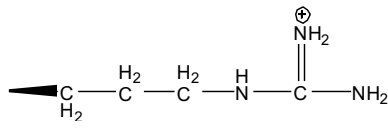
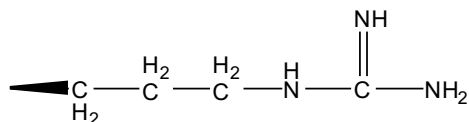
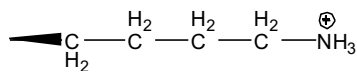
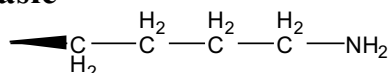
## Neutral - Polar



## Acidic



## Basic



\* These amino acids are essential in human nutrition (we can not synthesize them).

## Relationship of pK and pH to charge

Every acidic or basic group on a molecule has a different “pK” (K is the dissociation constant) value. The relationship between the pH of the solution it is in and the pK of the ionizable group will determine the predominant form of the ionizable group. Every acidic or basic group has an “acid form” (also known as the “protonated form”) and a “base form” (also known as the “deprotonated form”). For carboxylic acids, the protonated form (acid form) is  $\text{—COOH}$  and the deprotonated form (base form) is  $\text{—COO}^-$ . For amines, the protonated form (acid form) is  $\text{—NH}_3^+$  and the deprotonated form (base form) is  $\text{—NH}_2$ .

If the pH of the solution **equals** the pK of the ionizable group, then the acid and base forms of that group will be present in equal amounts.

If the pH of the solution is **lower** than the pK of the ionizable group, then the acid form of that group will be more abundant than the base form. (The predominant form is the protonated form.)

If the pH of the solution is **higher** than the pK of the ionizable group, then the base form of that group will be more abundant than the acid form. (The predominant form is the deprotonated form.)

Knowing the pH of the solution and using the previous three possible scenarios, you can determine if an ionizable group will be neutral, positively or negatively charged. Once you have drawn all the ionizable groups in their respective forms, you can add up all the charges present to give the overall charge of the amino acid or peptide you are drawing.

### pK values of ionizable groups in proteins.

Group	Acid $\rightleftharpoons$ Base + $\text{H}^+$	Typical pK*
Terminal Carboxyl	$\text{—COOH} \rightleftharpoons \text{—COO}^- + \text{H}^+$	3.1
Aspartic acid	$\text{—C}^{\text{H}_2}\text{—COOH} \rightleftharpoons \text{—C}^{\text{H}_2}\text{—COO}^- + \text{H}^+$	3.9
Glutamic acid	$\text{—C}^{\text{H}_2}\text{—C}^{\text{H}_2}\text{—COOH} \rightleftharpoons \text{—C}^{\text{H}_2}\text{—C}^{\text{H}_2}\text{—COO}^- + \text{H}^+$	4.0
Histidine	$\text{—C}^{\text{H}_2}\text{—} \begin{array}{c} \diagup \text{NH}^+ \diagdown \\ \text{C} \\ \diagdown \text{NH} \diagup \end{array} \rightleftharpoons \text{—C}^{\text{H}_2}\text{—} \begin{array}{c} \diagup \text{N} \diagdown \\ \text{C} \\ \diagdown \text{NH} \diagup \end{array} + \text{H}^+$	6.0
Terminal amino	$\text{—NH}_3^+ \rightleftharpoons \text{—NH}_2 + \text{H}^+$	8.0
Cysteine	$\text{—SH} \rightleftharpoons \text{—S}^- + \text{H}^+$	8.2
Tyrosine	$\text{—C}_6\text{H}_4\text{—OH} \rightleftharpoons \text{—C}_6\text{H}_4\text{—O}^- + \text{H}^+$	10.5
Lysine	$\text{—(CH}_2)_4\text{—NH}_3^+ \rightleftharpoons \text{—(CH}_2)_4\text{—NH}_2 + \text{H}^+$	10.5
Arginine	$\text{—(CH}_2)_3\text{—N—C}^{\text{NH}_2}_{\text{NH}_2} \rightleftharpoons \text{—(CH}_2)_3\text{—N—C}_{\text{NH}_2}^{\text{NH}} + \text{H}^+$	12.5

\*pK values depend on temperature, ionic strength, and the microenvironment of the ionizable group.