

**B.Sc. Semester-VI
Organic Chemistry
Paper-XIV**



1. Amino Acids, Peptides, Proteins and Nucleic Acids

Coverage:

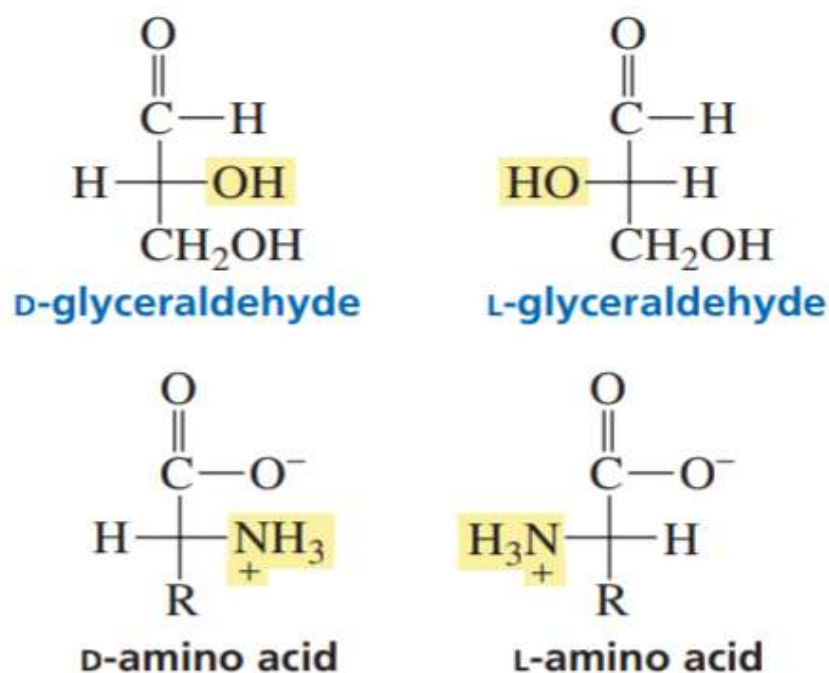
- 3. (i) Configuration of Amino Acids**
- (ii) Acid-Base Properties of Amino Acids**
- (iii) The Isoelectric Point**



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Configuration of Amino Acids

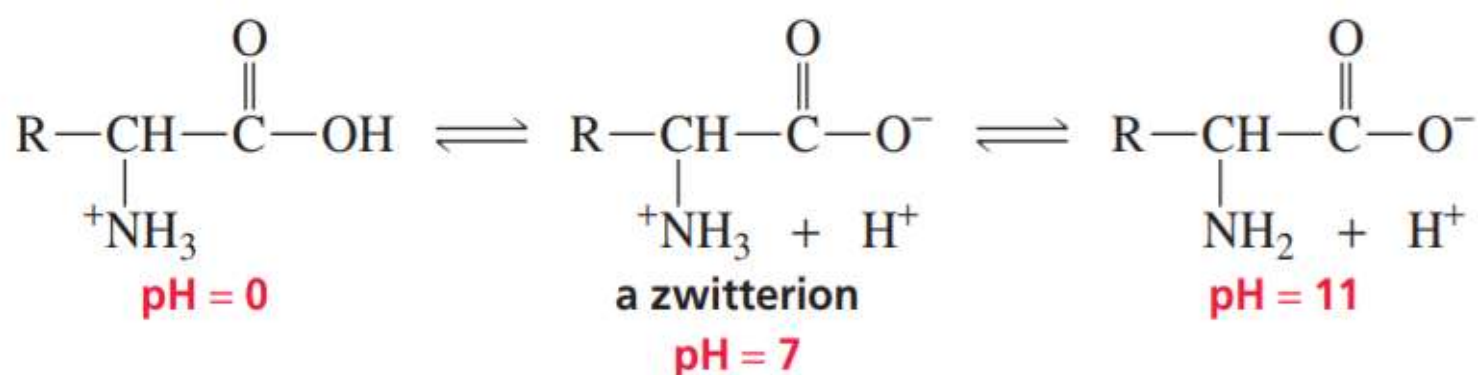
The α -carbon of all the naturally occurring amino acids except glycine is an asymmetric carbon. Therefore, 19 of the 20 amino acids listed in Table 1 can exist as enantiomers. The D and L notation used for monosaccharides is also used for amino acids. The D and L isomers of monosaccharides and amino acids are defined the same way. Thus, an amino acid drawn in a Fischer projection with the carboxyl group on the top and the R group on the bottom of the vertical axis is a **D-amino acid** if the amino group is on the right and an **L-amino acid** if the amino group is on the left. Unlike monosaccharides, where the D isomer is the one found in nature, most amino acids found in nature have the L configuration. To date, D-amino acid residues have been found only in a few peptide antibiotics and in some small peptides attached to the cell walls of bacteria.



Why D-sugars and L-amino acids? While it makes no difference which isomer nature “selected” to be synthesized, it is important that the same isomer be synthesized by all organisms. For example, if mammals ended up having L-amino acids, then L-amino acids would need to be the isomers synthesized by the organisms upon which mammals depend for food.

Acid-Base Properties of Amino Acids

Every amino acid has a carboxyl group and an amino group, and each group can exist in an acidic form or a basic form, depending on the pH of the solution in which the amino acid is dissolved. The carboxyl groups of the amino acids have pK_a values of approximately 2, and the protonated amino groups have pK_a values near 9 (Table 2). Both groups, therefore, will be in their acidic forms in a very acidic solution ($pH \sim 0$). At $pH = 7$, the pH of the solution is greater than the pK_a of the carboxyl group, but less than the pK_a of the protonated amino group. The carboxyl group, therefore, will be in its basic form and the amino group will be in its acidic form. In a strongly basic solution ($pH \sim 11$), both groups will be in their basic forms.



Notice that an amino acid can never exist as an uncharged compound, regardless of the pH of the solution. To be uncharged, an amino acid would have to lose a proton from an $^+\text{NH}_3$ group with a pK_a of about 9 before it would lose a proton from a COOH group with a pK_a of about 2. This clearly is impossible: A weak acid cannot be more acidic than a strong acid. Therefore, at physiological pH (7.3) an amino acid exists as a dipolar ion, called a *zwitterion*. A **zwitterion** is a compound that has a negative charge

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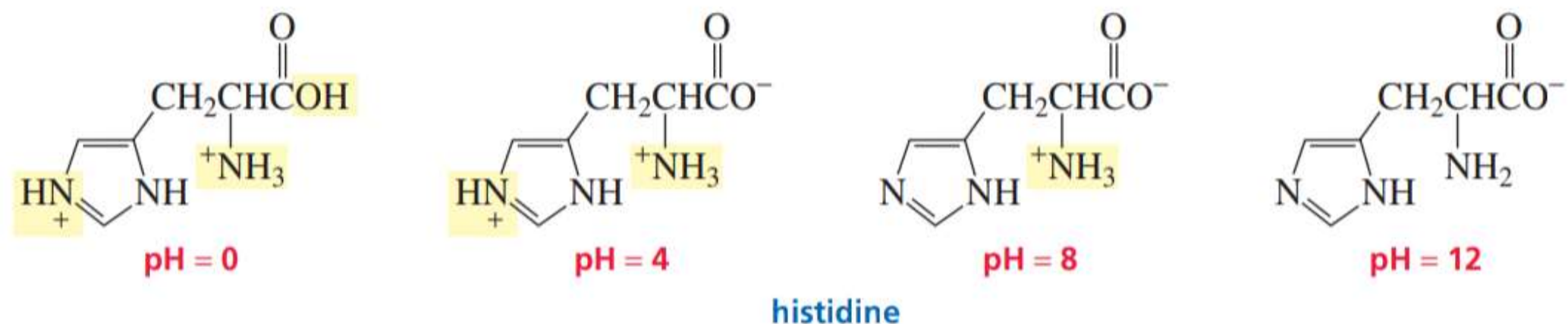


Table 2. The pK_a Values of Amino Acids

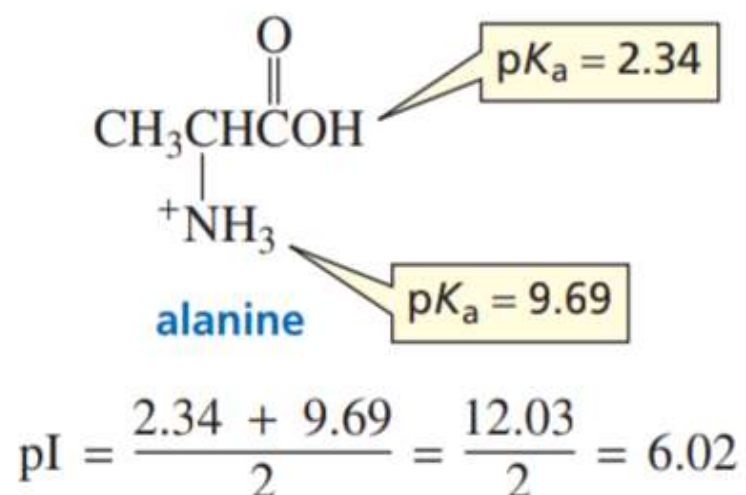
Amino acid	pK _a α -COOH	pK _a α -NH ₃ ⁺	pK _a side chain
Alanine	2.34	9.69	—
Arginine	2.17	9.04	12.48
Asparagine	2.02	8.84	—
Aspartic acid	2.09	9.82	3.86
Cysteine	1.92	10.46	8.35
Glutamic acid	2.19	9.67	4.25
Glutamine	2.17	9.13	—
Glycine	2.34	9.60	—
Histidine	1.82	9.17	6.04
Isoleucine	2.36	9.68	—
Leucine	2.36	9.60	—
Lysine	2.18	8.95	10.79
Methionine	2.28	9.21	—
Phenylalanine	2.16	9.18	—
Proline	1.99	10.60	—
Serine	2.21	9.15	—
Threonine	2.63	9.10	—
Tryptophan	2.38	9.39	—
Tyrosine	2.20	9.11	10.07
Valine	2.32	9.62	—

The Isoelectric Point

The **isoelectric point** (pI) of an amino acid is the pH at which it has no net charge. In other words, it is the pH at which the amount of positive charge on an amino acid exactly balances the amount of negative charge:

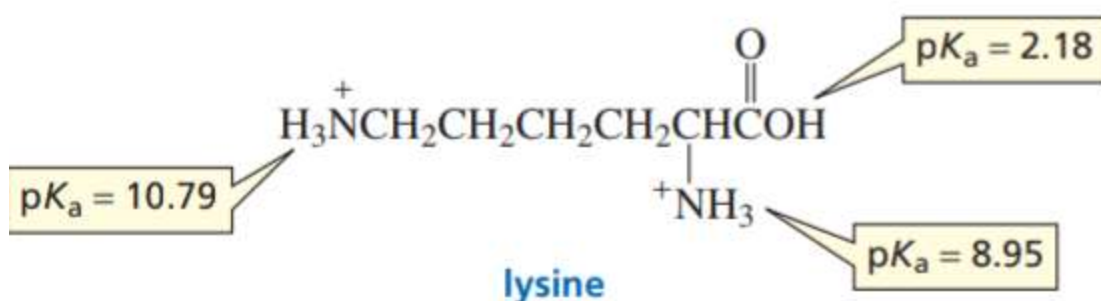
pI (isoelectric point) = pH at which there is no net charge

The pI of an amino acid that does *not* have an ionizable side chain—such as alanine—is midway between its two pK_a values. This is because at $pH = 2.34$, half the molecules have a negatively charged carboxyl group and half have an uncharged carboxyl group, and at $pH = 9.69$, half the molecules have a positively charged amino group and half have an uncharged amino group. As the pH increases from 2.34, the carboxyl group of more molecules becomes negatively charged; as the pH decreases from 9.69, the amino group of more molecules becomes positively charged. Therefore, at the average of the two pK_a values, the number of negatively charged groups equals the number of positively charged groups.

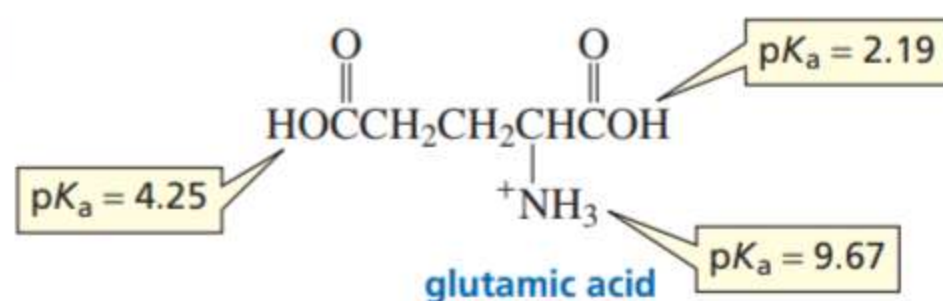


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The pI of an amino acid that *has* an ionizable side chain is the average of the pK_a values of the similarly ionizing groups (a positively charged group ionizing to an uncharged group or an uncharged group ionizing to a negatively charged group). For example, the pI of lysine is the average of the pK_a values of the two groups that are positively charged in their acidic form and uncharged in their basic form. The pI of glutamate, on the other hand, is the average of the pK_a values of the two groups that are uncharged in their acidic form and negatively charged in their basic form.



$$pI = \frac{8.95 + 10.79}{2} = \frac{19.74}{2} = 9.87$$



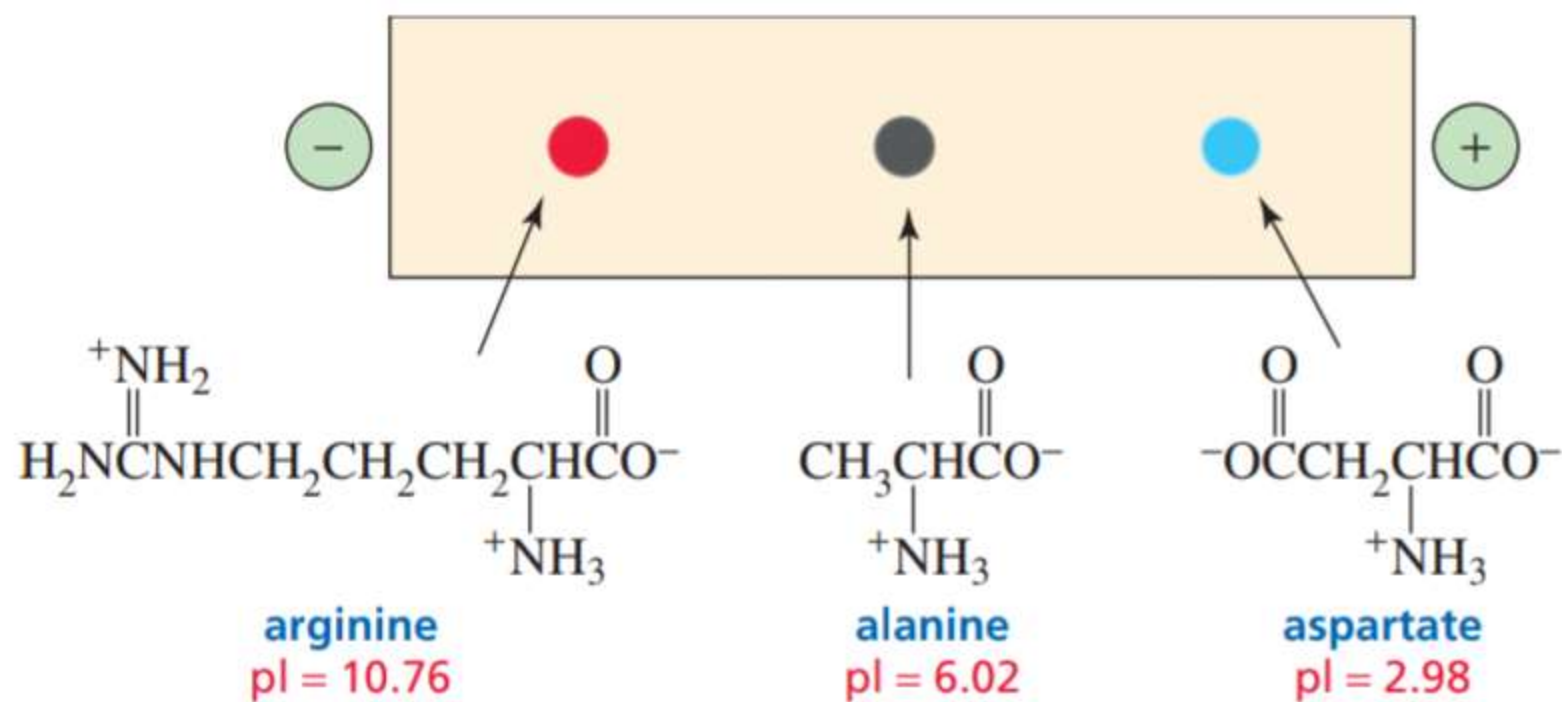
$$pI = \frac{2.19 + 4.25}{2} = \frac{6.44}{2} = 3.22$$

Recall from the Henderson–Hasselbalch equation that when $\text{pH} = pK_a$, half the group is in its acidic form and half is in its basic form.

An amino acid will be positively charged if the pH of the solution is less than the pI of the amino acid and will be negatively charged if the pH of the solution is greater than the pI of the amino acid.

Recall from the Henderson–Hasselbalch equation, that the acidic form predominates if the pH of the solution is less than the pK_a of the compound and the basic form predominates if the pH of the solution is greater than the pK_a of the compound.

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THANK YOU