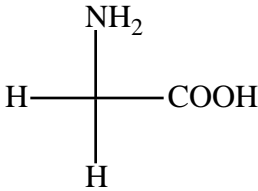
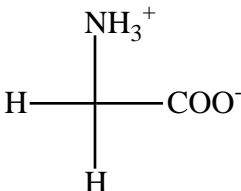


GTQ on Amino Acids. (40 points, nomenclature, acid/base properties, synthesis)

To be precise, amino acids are alpha-amino carboxylic acids, that is, the amino group is attached to the carbon atom that bears the carboxy functional group. Amino acids can be synthesized in many ways and we will be looking at two of these. First, however, let's consider the acid/base properties of aminoacids.

(a) Amino acids contain both a proton donor, the carboxylic acid, and a proton acceptor, the amino group. Consequently, proton transfer from the carboxyl group to the amino group is likely and the result is a zwitterion that contains a negatively charged carboxylato group and a positively charged ammonium group. For the simplest amino acid, glycine $\text{H}_2\text{N}-\text{CH}_2-\text{COOH}$, draw the structures of the **amino-acid form** and of the **zwitterion form** and provide acceptable IUPAC names for both of the structures. (11 p.; 1.5 p. each blank, 2 each structure, 2 each name)

structure of amino-acid form 	structure of zwitterion form 
IUPAC name aminoethanoic acid or aminoacetic acid	IUPAC name ammonium ethanoate

(b) Using any textbook on organic chemistry, look up the structures of the amino acids listed and provide acceptable IUPAC names for them. (2 points each)

leucine	2-amino-4-methyl-pentanoic acid
isoleucine	2-amino-3-methyl-pentanoic acid
glutamic acid	2-aminopentanedioic

(c) In the lecture, we learned about the Hell-Volhard-Zelinsky method for the bromination of carboxylic acids in the alpha-position. Treatment of the resulting alpha-bromo carboxylic acid with ammonium hydroxide results in nucleophilic replacement of the bromine by ammonia. Suggest a synthesis of the amino acid alanine (2-aminopropanoic acid) starting from chloroethane. Show all intermediates and clearly show reagents needed for every step. (10 points)

Alanine synthesis:

STEP 1: Chloroethane to Cyanoethane

Nucl. subst. using NaCN

STEP 2: Acid-catalyzed Hydrolysis of Cyanoethane

Et-CN is converted into Et-COOH

STEP 3: Execute Hell-Volhard-Zelinski Reaction

$\text{CH}_3\text{-CH}_2\text{-COOH}$ is converted to $\text{CH}_3\text{-CHBr-COOH}$

STEP 4: Replace the Br using ammonia

$\text{CH}_3\text{-CHBr-COOH}$ is converted to $\text{CH}_3\text{-CH(NH}_2\text{)-COOH}$

Complete structures and reagents should be given for complete credit.

See details for each step in the book.

(d) Strecker Synthesis (13 points)

Another method of some generality for the preparation of alpha-amino acids is the hydrolysis of alpha-amino nitriles, which are available by the treatment of aldehydes with ammonia and HCN. This method is called the Strecker synthesis. The alpha-amino nitrile is thought to be formed by addition of HCN to the imine, which is formed from the aldehyde and ammonia. Starting with phenylacetaldehyde, show the steps of the Stecker synthesis of **phenylalanine**. (adapted from SHK)

Mechanism of Imine Formation:

VS p. 1032

Phenylacetaldehyde is attacked by the nucleophile ammonia to form a tetrahedral intermediate with an ammonium group and an alkoxide function.

Deprotonate the ammonium group and protonate the alkoxide function \implies hemiaminal.

Dehydrate the hemiaminal as shown on p. 650 in VS.

Mechanism of HCN Addition:

VS p. 1032: Proton addition followed by cyanide addition.

Protonate the imine-N to get the amino-stabilized carbenium ion.

Add cyanide to the protonated imine.

Done.

Acid-cat. Hydrolysis:

The acid-cat. hydrolysis of nitriles is discussed in VS on p. 794.