Amine Molecules are Weak Bases
Aliphatic & Aromatic Amines

- Amines are relatives of ammonia, \( \text{NH}_3 \), in which the hydrogen atoms on nitrogen have been replaced by one or more non-carbonyl substituent groups.

- Aliphatic amines in which alkyl groups replace hydrogen are slightly more basic than ammonia.

- Aromatic amines in which one or more of the substituent groups is an arene, are considerably less basic than ammonia.

- Heterocyclic amines have the nitrogen atom within a ring. The ring may be aliphatic or aromatic.

- Heterocyclic aliphatic amines are stronger bases than ammonia.

- Heterocyclic aromatic amines are considerably weaker bases than ammonia. In these rings the nitrogen atom contributes one or two electrons to the aromatic sextet of electrons.
Aromatic versus Aliphatic Amines

Aliphatic Amines have the amino- group attached by tetrahedral carbon:

\[ \text{NH}_3 \quad \text{C}^\text{N}\text{H}_2 \quad \text{C}^\text{N}\text{H} \quad \text{C}^\text{N}--\text{C} \]

Ammonia primary, 1° secondary, 2° tertiary, 3°

Aromatic amines have the amino- group bonded to a benzene ring:

\[ \text{aniline} \quad \text{N-methylaniline} \quad \text{N,N-dimethylaniline} \]

Aliphatic amines can have aromatic rings as long as the nitrogen is attached by tetrahedral carbon.
Heterocyclic Aliphatic/Aromatic Amines

Heterocyclic aliphatic amines – the nitrogen is incorporated into a ring and is connected by two tetrahedral carbons.

![N-methylpyrroldidine](image)

*N-methylpyrroldidine*  
3° heterocyclic aliphatic amine

![piperidin](image)

*piperidin*  
2° heterocyclic aliphatic amine

Heterocyclic aromatic amines – the nitrogen is incorporated into an aromatic ring – *N* contributes to the aromatic sextet.

![pyridine](image)

*pyridine*

![pyramidine](image)

*pyramidine*

![imidazole](image)

*imidazole*

![purene](image)

*purene*
Naming of Amines

- IUPAC names for aliphatic amines follow that for alcohols. Drop the final -e of the parent alkane and replace it with –amine.

- Use a number to locate the amino group on the parent chain.

- Name unsymmetrical secondary and tertiary amines as N-substituted primary amines. In this case take the largest group bonded to nitrogen as the parent amine.

- Name the smaller group(s) bonded to nitrogen, and show that their location is bonded to nitrogen by using the prefix N- before the listing of that substituent.

\[
\begin{align*}
\text{N,N-dimethylaniline} & \quad \text{propanamine} \quad \text{N-methylpropanamine} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 & \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{NHCH}_3
\end{align*}
\]
Naming of Amines

- IUPAC nomenclature retains the common name aniline for \( \text{C}_6\text{H}_5\text{NH}_2 \), the simplest aromatic amine.

- Name simple derivatives of aniline by using locator numbers starting with the amino group, or locate substituents by using the prefixes ortho (o), meta (m), and para (p).

- Several derivatives of aniline have common names that are still widely used; among them is toluidine.

- If another substituent overrides with a special name locate the amine substituent with a locator number starting at the other substituent.

\[ \text{NH}_2 \quad \text{NH}_2 \quad \text{NH}_2 \]

\[ \begin{array}{c}
\text{aniline} \\
\text{2-methylaniline} \\
\text{o-toluidine} \\
\text{2-aminobenzoic acid} \\
\text{o-aminobenzoic acid}
\end{array} \]
Naming of Amines

Common Names

- For most aliphatic amines, list the groups bonded to nitrogen in alphabetical order in one word ending in the suffix –amine.

- Because amines are bases they react with strong acids to form ammonium salts. In these salts nitrogen has four bonds, has a positive charge and is associated with an anion.
Properties of Amines

- Amines are polar, hydrogen bond with water, and 1° and 2° with each other, but more weakly than alcohols.

- Amines have lower boiling points than alcohols of similar molecular weight, they are also soluble in water if the substituent group part is not too large and non-polar. C₁-C₇ = miscible to slightly soluble, C₈ and higher are insoluble.

- Amines are basic in water, the pH will go to higher values.

- Amines readily react with acid. The resulting ammonium ion are much more soluble than the parent amines.
Properties of Amines

- The N-H---N hydrogen bond is weaker than an O-H---O hydrogen bond because the difference in electronegativity between N and H (3.0 - 2.1 = 0.9) is less than that between O and H (3.5 - 2.1 = 1.4).

- The effect of hydrogen bonding between molecules of comparable molecular weight can be seen by comparing the boiling points of ethane, methanamine, and methanol.

<table>
<thead>
<tr>
<th></th>
<th>CH₃CH₃</th>
<th>CH₃NH₂</th>
<th>CH₃OH</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW (amu)</td>
<td>30.1</td>
<td>31.1</td>
<td>32.0</td>
</tr>
<tr>
<td>bp (°C)</td>
<td>-88.6</td>
<td>-6.3</td>
<td>65.0</td>
</tr>
</tbody>
</table>

- Like ammonia, low-molecular-weight amines have very sharp, penetrating odors; for example, rotting fish = trimethylamine.
Hydrogen Bonds – Amines in Water
Hydrogen Bonds – Pure Amines – Except 3°
Can You Name these Amines?

Classify them as aromatic, aliphatic, and as primary, secondary or tertiary.
Amines Are Relatives of Ammonia

Amines are basic:  (Aliphatic amines about as basic as ammonia)

- \( \text{NH}_3 \)
- \( \text{C}_2\text{NH}_2 \) primary
- \( \text{C}_2\text{NH} \) secondary
- \( \text{C}_2\text{N—C} \) tertiary

And make ammonium salts in acidic solution.

Note: N has 3 bonds in amines, but 4 bonds in ammonium ions.
Ammonium Ions React with Base

Ammonium salts are weakly acidic:

\[
\begin{align*}
\text{NH}_4^+ & \quad \text{H}^+ & \quad \text{C} \quad \text{NH}^+ & \quad \text{C} \quad \text{N} & \quad \text{C} \\
\text{OH}^- & \quad \text{OH}^- & \quad \text{OH}^- & \quad \text{OH}^- \\
\text{NH}_3 & \quad + \quad \text{H}_2\text{O} & \quad \text{primary} & \quad \text{secondary} & \quad \text{tertiary}
\end{align*}
\]

And react with hydroxide ion to regenerate the original amine + water
Reaction of Amines with Water

\[
\begin{align*}
\text{H}_3\text{C} & \text{N}^\text{+} \quad + \quad \text{H}_2\text{O} \\
\text{H}_3\text{C} & \text{N} \quad + \quad \text{OH}^\text{-}
\end{align*}
\]

Reaction of Ammonium Ions with Water

\[
\begin{align*}
\text{H}_3\text{C} & \text{NH}_3 \quad + \quad \text{H}_2\text{O} \\
\text{H}_3\text{C} & \text{NH}_2 \quad + \quad \text{H}^\text{+}
\end{align*}
\]
What is the form of amines in blood plasma?

pH of blood is 7.4, \([\text{OH}^-] = 2.5 \times 10^{-7}\)

Ethylamine: \(K_b = 4.3 \times 10^{-4} = \frac{[\text{CH}_3\text{CH}_2\text{NH}_3^+] [\text{OH}^-]}{[\text{CH}_3\text{CH}_2\text{NH}_2]}\)

\[\frac{K_b}{[\text{OH}^-]} = \frac{[\text{CH}_3\text{CH}_2\text{NH}_3^+]}{[\text{CH}_3\text{CH}_2\text{NH}_2]} = \frac{4.3 \times 10^{-4}}{2.5 \times 10^{-7}} = 1720\]

An aliphatic amine is mostly in the ammonium form in blood!

Pyridine: \(K_b = 1.5 \times 10^{-9} = \frac{[\text{C}_5\text{H}_5\text{NH}^+] [\text{OH}^-]}{[\text{C}_5\text{H}_5\text{N}]}\)

\[\frac{K_b}{[\text{OH}^-]} = \frac{[\text{C}_5\text{H}_5\text{NH}^+]}{[\text{C}_5\text{H}_5\text{N}]} = \frac{1.5 \times 10^{-9}}{2.5 \times 10^{-7}} = 0.0060\]

An aromatic amine is mostly in the amine form in blood!
Carboxylic Acids & Amines Give Salts

\[
\text{Amine} \quad \text{Ethylmethylamine} \quad \text{Carboxylic Acid} \quad \text{Acetic Acid} \\
\text{100%} \\
\text{Ammonium Ion} \quad \text{Ethylmethylammonium} \quad \text{Carboxylate Anion} \quad \text{Acetate}
\]

Aminoacids exist *in vivo* only in their ionized form!

Tyrosine

isolectric form
What Products are Formed?
If No Reaction write – NR

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3 + \text{Cl}^- + \text{NaOH} \rightarrow \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{Cl}^- + \text{NaOH} \rightarrow \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3 + \text{Cl}^- + \text{HCl} \rightarrow \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{HCl} \rightarrow 
\]