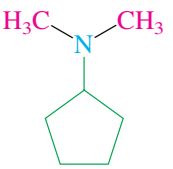
5.10 AMINES

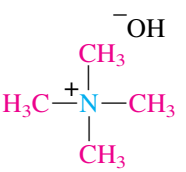
Amines can be considered as derivatives of ammonia in which one or more hydrogens have been replaced by alkyl or aryl groups. **Primary amines** have one alkyl or aryl group bonded to the nitrogen. **Secondary amines** have two groups on the nitrogen, **tertiary amines** have three, and **quaternary ammonium salts** have four. Note that the terms *primary, secondary,* and *tertiary* have different meanings here than they have with other functional groups. In the case of amines they refer to the number of carbon groups bonded to the *nitrogen.* In the case of alcohols and alkyl halides, however, they refer to the number of carbon groups bonded to the *carbon* that is bonded to the hydroxy or halogen substituent.

Butylamine
A primary amine

Diethylamine
A secondary amine



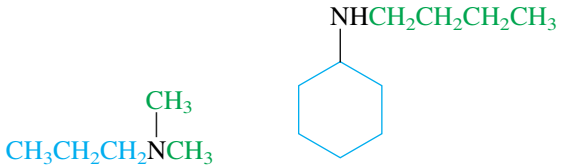
N,N-Dimethylcyclopentylamine
A tertiary amine



Tetramethylammonium hydroxide
A quaternary ammonium salt

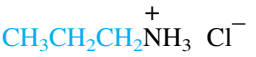
Common names are usually employed for simple amines. In these names, the suffix -amine is appended to the name of the alkyl group. The prefixes di-, tri- and tetra- are used when several identical groups are attached to the nitrogen. For secondary and tertiary amines with different groups attached to the nitrogen, the largest group is used with the -amine suffix. An *N*-, rather than a number, is used to indicate other groups that

are also attached to the nitrogen. Ionic compounds that are formed by the reaction of amines with acids are named as ammonium salts. Common names for some amines are shown in the preceding examples and in those that follow:



N,*N*-Dimethylpropylamine

N-Butylcyclohexylamine



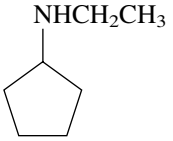
Propylammonium chloride

PROBLEM 5.21

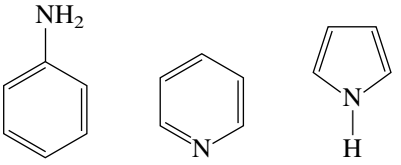
Name these compounds:

a) $CH_3CH_2CH_2NH_2$

b)

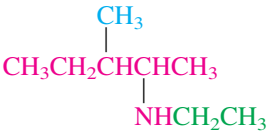


There are many trivial names for amines, especially those involving aromatic rings or where the nitrogen is part of a ring. Several important examples are the following:



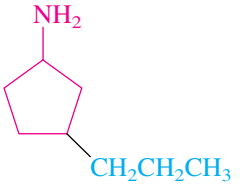
Aniline Pyridine Pyrrole

For more complex amines, systematic nomenclature is employed. Such names are constructed in a manner very similar to that employed to name alcohols. The largest chain attached to the nitrogen is chosen as the root, numbered so that the carbon attached to the nitrogen has the lower number, and the suffix -amine is attached. Other groups that are attached to the nitrogen are given the prefix *N*-.



N-Ethyl-3-methyl-2-pentanamine

(The longest chain containing a carbon attached to the nitrogen is chosen as the root and numbered from the end closer to the nitrogen. To show that the ethyl group is also attached to the nitrogen, it is given the prefix *N*-, rather than a number.)

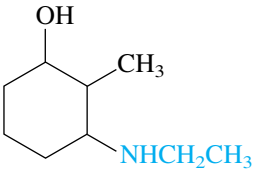


3-Propylcyclopentanamine

(Numbering begins at the carbon attached to the nitrogen.)

In addition to carbon–carbon double and triple bonds, only one other functional group can be designated as a suffix in the name. For example, if a compound has both an alcohol and an amine functional group, only one of them can be designated with the suffix. The other must be named as a group, using a prefix. The alcohol functional group has higher priority than the amine functional group, so the nitrogen group is named as an amino- group (or an alkylamino- group) on the main chain of the alcohol. (The priorities and group names for other groups are listed in Table 12.3 on p. 492.) An example is provided by the following compound:

ORGANIC Chemistry Now™
Click *Coached Tutorial Problems* to practice **Drawing Structures of Alkyl Halides, Alcohols, Ethers, and Amines.**



3-Ethylamino-2-methylcyclohexanol

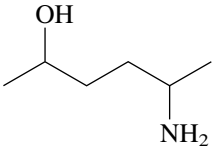
(The hydroxy group has higher priority than the amino group and is used to determine both the suffix and the numbering.)

PROBLEM 5.22

Name these compounds:

a) $CH_3CHCH_2CH_2CHCH_3$ (with CH_3 and $NHCH_3$ substituents)

b)



PROBLEM 5.23

Draw structures for these compounds:

a) Diethylammonium bromide

b) *N*-Methyl-3-(1-methylpropyl)-2-octanamine

Amines are polar compounds because of the presence of the nitrogen. Their melting and boiling points are higher than those of hydrocarbons of similar molecular mass. Like alcohols, primary and secondary amines are capable of forming hydrogen bonds, although the strength of the hydrogen bond is somewhat weaker in the case of an amine because nitrogen is less electronegative than oxygen. As a result, the boiling points of primary and secondary amines are somewhat lower than those of a similar alcohol. For example, butylamine boils at 78°C, and 1-butanol boils at 117°C. Because they have no hydrogens bonded to the nitrogen, the molecules of a tertiary amine do not form hydrogen bonds to each other, so the physical properties of tertiary amines resemble those of ethers. Amines of low molecular mass often have ammonia-like or fishy odors, and

some have quite unpleasant odors. Perhaps you can imagine the odors of cadaverine and putrescine:

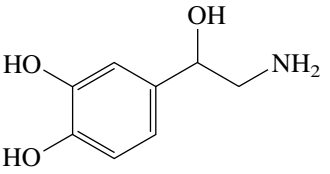
$NH_2CH_2CH_2CH_2CH_2NH_2$ $NH_2CH_2CH_2CH_2CH_2CH_2NH_2$

Putrescine Cadaverine

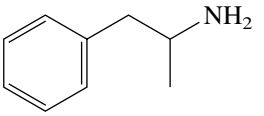
Amines occur widely in nature, both in plants and animals. Natural amines, such as epinephrine (adrenaline), are often physiologically active in animals, as are some synthetic amines, such as amphetamine. Those that occur in plants, such as nicotine and morphine, are called **alkaloids** because they are basic and can be isolated by extraction with acid. When plant matter is extracted with aqueous acid, the amines are protonated according to the following equation:

$$RNH_2 + HCl \rightleftharpoons RN\overset{+}{H}_3\ \overset{-}{Cl}$$

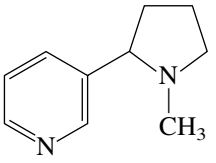
The resulting salts dissolve in the aqueous solution and can easily be separated from the rest of the plant material.



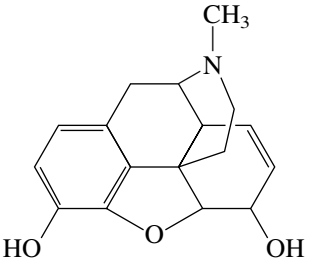
Epinephrine



Amphetamine



Nicotine



Morphine

Review of Mastery Goals

After completing this chapter, you should be able to:

- Provide the systematic (IUPAC) name for an alkane. (Problems 5.24 and 5.26)
- Draw the structure of an alkane whose name is provided. (Problem 5.25)
- Name a complex group. (Problem 5.30)
- Name a cycloalkane, an alkene, an alkyne, an alkyl halide, an alcohol, an ether, or an amine. (Problems 5.24, 5.29, 5.30, 5.33, 5.34, and 5.43)

ORGANIC Chemistry Now™
Click *Mastery Goal Quiz* to test how well you have met these goals.