

12.2: Families of Organic Molecules - Functional Groups

Learning Objectives



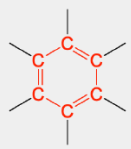
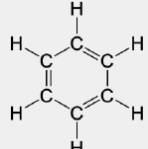


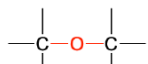
- Identify and describe functional groups in organic molecules.

Organic molecules can be classified into *families* based on structural similarities. Within a family, molecules have similar physical behavior and often have predictable chemical reactivity. The structural components differentiating different organic families involve specific arrangements of atoms or bonds, called **functional groups**. If you understand the behavior of a particular functional group, you can describe the general properties of that class of compounds.

The simplest organic compounds are in the **alkane** family and contain only carbon–carbon and carbon–hydrogen *single* bonds but do not have any specific functional group. Hydrocarbons containing at least one carbon–carbon double bond, (denoted C=C), are in the **alkene** family. **Alkynes** have at least one carbon–carbon triple bond (C≡C). Both carbon–carbon double bonds and triple bonds chemically react in specific ways that differ from reactions of alkanes and each other, making these specific functional groups.

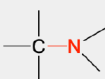



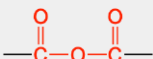
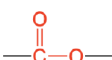
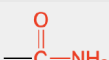

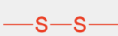

In the next few chapters, we will learn more about additional functional groups that are made up of atoms or groups of atoms attached to hydrocarbons. Being able to recognize different functional groups will help to understand and describe common medications and biomolecules such as amino acids, carbohydrates, and fats. Table 12.2.1 and Figure 12.2.1 below list several of the functional groups to become familiar with as you learn about organic chemistry.

Table 12.2.1 : Organic Families and Functional Groups

Family Name	Functional Structure	Group	Simple Example Structure	Simple Example Name	Name Suffix
alkane	none		CH ₃ CH ₂ CH ₃	propane	-ane
alkene			H ₂ C=CH ₂	ethene (ethylene)	-ene
alkyne			HC≡CH	ethyne (acetylene)	-yne
aromatic				benzene	none
alkyl halide	 (X = F, Cl, Br, I)		CH ₃ CH ₂ Cl	chloroethane	none
alcohol			CH ₃ CH ₂ OH	ethanol	-ol
ether			CH ₃ CH ₂ -O-CH ₂ CH ₃	diethyl ether	none*

Atoms and bonds in red indicate the functional group. Bonds not specified are attached to R groups (carbons and hydrogens).

*Ethers do not have a suffix in their common name; all ethers end with the word *ether*.

Family Name	Functional Structure	Group	Simple Example Structure	Simple Example Name	Name Suffix
amine			$\text{CH}_3\text{CH}_2\text{NH}_2$	ethylamine	<i>-amine</i>
aldehyde			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	ethanal	<i>-al</i>
ketone			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$	propanone (acetone)	<i>-one</i>
carboxylic acid			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	ethanoic acid (acetic acid)	<i>-oic acid</i>
anhydride			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$	acetic anhydride	none
ester			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{CH}_3$	methyl ethanoate (methyl acetate)	<i>-ate</i>
amide			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$	acetamide	<i>-amide</i>
thiol			$\text{CH}_3\text{CH}_2\text{SH}$	ethanethiol	<i>-thiol</i>
disulfide			$\text{CH}_3\text{S}-\text{SCH}_3$	dimethyl disulfide	none
sulfide			$\text{CH}_3\text{CH}_2\text{SCH}_3$	ethyl methyl sulfide	none

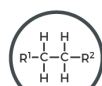
Atoms and bonds in red indicate the functional group. Bonds not specified are attached to R groups (carbons and hydrogens).

*Ethers do not have a suffix in their common name; all ethers end with the word *ether*.

FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

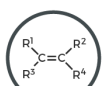
Functional groups are the characteristic groups in organic molecules that give them their reactivity. In the formulae below, R represents the rest of the molecule and X represents any halogen atom.

● Hydrocarbons ● Halogen-containing groups ● Oxygen-containing groups ● Nitrogen-containing groups ● Sulfur-containing groups ● Phosphorus-containing groups



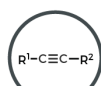
ALKANE

Naming: -ane
e.g. ethane



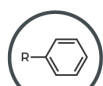
ALKENE

Naming: -ene
e.g. ethene



ALKYNE

Naming: -yne
e.g. ethyne



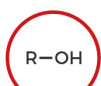
ARENE

Naming: -yl benzene
e.g. ethyl benzene



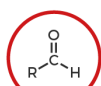
HALOALKANE

Naming: halo-
e.g. chloroethane



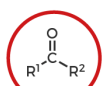
ALCOHOL

Naming: -ol
e.g. ethanol



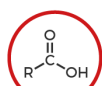
ALDEHYDE

Naming: -al
e.g. ethanal



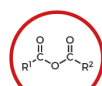
KETONE

Naming: -one
e.g. propanone



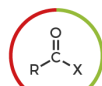
CARBOXYLIC ACID

Naming: -oic acid
e.g. ethanoic acid



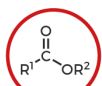
ACID ANHYDRIDE

Naming: -oic anhydride
e.g. ethanoic anhydride



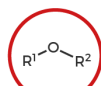
ACYL HALIDE

Naming: -oyl halide
e.g. ethanoyl chloride



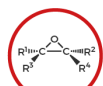
ESTER

Naming: -yl -oate
e.g. ethyl ethanoate



ETHER

Naming: -oxy -ane
e.g. methoxyethane



EPOXIDE

Naming: -ene oxide
e.g. ethene oxide



AMINE

Naming: -amine
e.g. ethanamine



AMIDE

Naming: -amide
e.g. ethanamide



NITRATE

Naming: -yl nitrate
e.g. ethyl nitrate



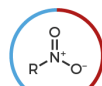
NITRITE

Naming: -yl nitrite
e.g. ethyl nitrite



NITRILE

Naming: -nitrile
e.g. ethanenitrile



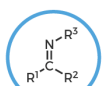
NITRO

Naming: nitro-
e.g. nitromethane



NITROSO

Naming: nitroso-
e.g. nitrosoethane



IMINE

Naming: -imine
e.g. ethanimine



IMIDE

Naming: -imide
e.g. succinimide



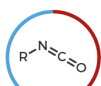
AZIDE

Naming: -yl azide
e.g. phenylazide



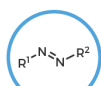
CYANATE

Naming: -yl cyanate
e.g. methyl cyanate



ISOCYANATE

Naming: -yl isocyanate
e.g. methyl isocyanate



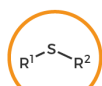
AZO COMPOUND

Naming: azo-
e.g. azoethane



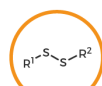
THIOL

Naming: -thiol
e.g. methanethiol



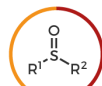
SULFIDE

Naming: sulfide
e.g. dimethyl sulfide



DISULFIDE

Naming: disulfide
e.g. dimethyl disulfide



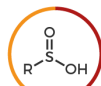
SULFOXIDE

Naming: sulfoxide
e.g. dimethyl sulfoxide



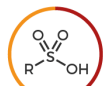
SULFONE

Naming: sulfone
e.g. dimethyl sulfone



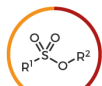
SULFINIC ACID

Naming: -sulfinic acid
e.g. benzenesulfonic acid



SULFONIC ACID

Naming: -sulfonic acid
e.g. benzenesulfonic acid



SULFONATE ESTER

Naming: -yl sulfonate
e.g. methylmethanesulfonate



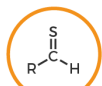
THIOCYANATE

Naming: thiocyanate
e.g. ethyl thiocyanate



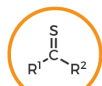
ISOTHIOCYANATE

Naming: isothiocyanate
e.g. ethyl isothiocyanate



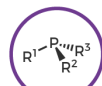
THIAL

Naming: -thial
e.g. ethanethial



THIOKETONE

Naming: -thione
e.g. propanethione



PHOSPHINE

Naming: phosphine
e.g. methylphosphane



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Figure 12.2.1: Functional groups in organic chemistry. (CC BY-NC-ND, CompoundChem.com).

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