

ORGANIC CHEMISTRY NOMENCLATURE WORKBOOK



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Book: Organic Chemistry Nomenclature
Workbook (O'Donnell)

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CHAPTER OVERVIEW

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1.1: Unbranched Alkanes

Learning Objective

- Naming Unbranched Alkanes (Organic Chemistry)

An **alkane** is a type of **hydrocarbon** (a compound consisting of only carbon and hydrogen atoms). When the carbon-carbon backbone consists only of single bonds, the hydrocarbon contains as many hydrogen atoms as possible, and is therefore **saturated**. Alkanes are saturated hydrocarbons.

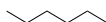


Figure 1.1.1. Hexane is an unbranched, saturated alkane containing six carbon atoms: Hexane

Below is a table of the names of unbranched, saturated alkanes containing up to ten carbons, with their condensed structural formulas, molecular formulas, and boiling points.

Alkane	Condensed Structural Formula	Molecular Formula	Boiling Point (degrees C)
Methane	CH ₄	CH ₄	-161
Ethane	CH ₃ CH ₃	C ₂ H ₆	-89
Propane	CH ₃ CH ₂ CH ₃	C ₃ H ₈	-42
Butane	CH ₃ CH ₂ CH ₂ CH ₃		-0.5
Pentane	CH ₃ (CH ₂) ₃ CH ₃		36
Hexane	CH ₃ (CH ₂) ₄ CH ₃		69
Heptane			98
Octane			126
Nonane			151
Decane			174

Table of names, condensed structural formulas, molecular formulas, and boiling points of unbranched saturated alkanes containing up to ten carbon atoms.

Practice Questions

- Fill in the blank spaces in the table.
- Draw the structures of these ten unbranched alkanes, using Figure 1.1.1 (hexane) as a model.
- What do the names of these molecules have in common?
- What is the relationship between the number of carbon atoms and the number of hydrogen atoms in an unbranched alkane? Provide a general formula (use *n* for the number of carbon atoms).
- Draw a graph of boiling points versus number of carbon atoms in unbranched alkanes.
- How do the boiling points vary with the number of carbons? Propose an explanation for this observation.

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1.2: Constitutional Isomers

Learning Objective

- Introduction to constitutional isomers using alkanes

Evaluate the two molecules below (Figure 1.2.1).

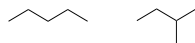


Figure 1.2.1. Two alkanes for comparison

- How are they the same?
- How are they different?

Two molecules which have the same molecular formula but different structural formulas, or bonding arrangements, are known as **constitutional isomers**.

Pentane is an alkane with five carbon atoms. It has three constitutional isomers, shown below.



Figure 1.2.2. Unbranched isomer of pentane



Figure 1.2.3. Branched constitutional isomer of pentane



Figure 1.2.4. Branched constitutional isomer of pentane

Practice Questions

1. Draw three constitutional isomers of heptane.
2. Circle the constitutional isomers of hexane in the figure below. Why are the remaining molecules not considered to be constitutional isomers of hexane?

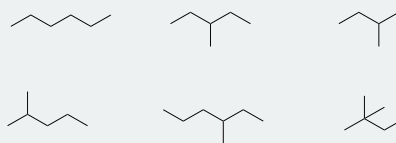


Figure 1.2.5

3. Draw the constitutional isomer of hexane that is missing.
4. What is the minimum number of carbons in the chain of an alkane to be able to have a constitutional isomer?

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1.3: Alkyl Substituents

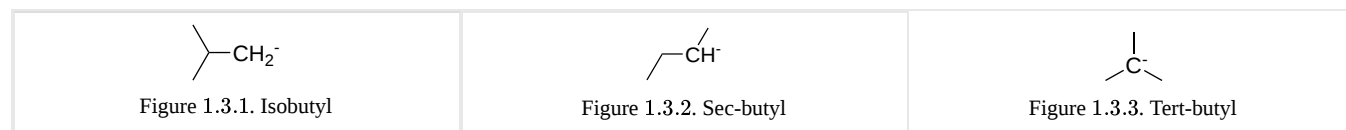
Learning Objective

- How to name organic molecules with alkyl substituents

An **alkane** can be appended onto an existing chain to create a branched molecule. This branched piece of the molecule is called a **substituent**. A substituent made from an alkane is called an **alkyl group**. Alkyl groups are named similarly to unbranched alkane chains.

Alkane	Condensed Structure	Alkyl Group	Condensed Structure
Methane	CH ₄	Methyl	CH ₃ -
Ethane	CH ₃ CH ₃	Ethyl	CH ₃ CH ₂ -
Propane	CH ₃ CH ₂ CH ₃	Propyl	CH ₃ CH ₂ CH ₂ -
Butane	CH ₃ CH ₂ CH ₂ CH ₃	Butyl	CH ₃ CH ₂ CH ₂ CH ₂ -

Alkyl groups can also be branched. For example, there are three constitutional isomers of the butyl substituent. In these diagrams, the negative charge on the carbon indicates the site of the bond from the substituent to the rest of the molecule.



When naming molecules according to the IUPAC system of substitutive nomenclature, remember **prefix-parent-suffix** (like un-believe-able).

- prefix:** what are the substituents?
- parent:** how many carbons in the parent chain?
- suffix:** what is the family of compounds?

In the case of an alkane, the suffix is **-ane**.

Practice Questions

- The name of this molecule is 2-methylhexane. Identify the alkyl group. Label the parent chain carbons from 1-6.

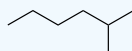


Figure 1.3.4: 2-methylhexane

- The name of this molecule is 3-methylheptane. Identify the alkyl group. Label the parent chain carbons from 1-7.

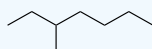


Figure 1.3.5: 3-methylheptane

- Identify the alkyl group in Molecule A. Label the parent chain carbons from 1-8. What is the name of this molecule?

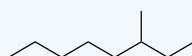


Figure 1.3.6: Molecule A

- Identify the alkyl group in Molecule B. Label the parent chain carbons. What is the name of this molecule?

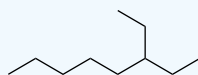


Figure 1.3.7: Molecule B

5. The name of this molecule is 2,3-dimethylpentane.

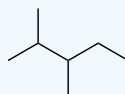


Figure 1.3.8: 2,3-dimethylpentane

What is the name of Molecule C?

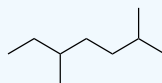


Figure 1.3.9: Molecule C

6. The name of this molecule is 4-ethyl-2-methyloctane.

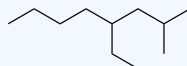


Figure 1.3.10: 4-ethyl-2-methyloctane

What is the name of Molecule D?

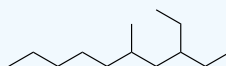


Figure 1.3.11: Molecule D

7. The name of this molecule is 4-isopropylnonane.

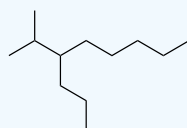


Figure 1.3.12: 4-isopropylnonane

What is the name of Molecule E?

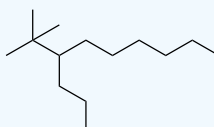


Figure 1.3.13: Molecule E

8. The name of this molecule is cyclobutane.



Figure 1.3.14: cyclobutane

What is the name of Molecule F?



Figure 1.3.15: Molecule F

9. The name of this molecule is methylcyclobutane.



Figure 1.3.16: methylcyclobutane

The name of this molecule is 1-ethyl-2-methylcyclohexane.

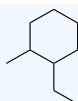


Figure 1.3.17: 1-ethyl-2-methylcyclohexane

What is the name of Molecule G?

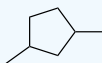


Figure 1.3.18: Molecule G

10. Write the steps that you use to name an alkane, in order, as instructions for a student who doesn't know how to do it.
11. Draw any alkane and go through the steps in naming your molecule.

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1.4: Alkenes and Alkynes

Learning Objective

- How to name alkenes and alkynes.

An **alkane** is a **saturated** hydrocarbon, meaning that the molecule contains all the possible hydrogen atoms because all the carbon-carbon bonds are single bonds. If one of those carbon-carbon bonds is a double bond, the resulting hydrocarbon is **unsaturated** and called an **alkene**.

This alkene is named propene.



Figure 1.4.1: propene

If one of the carbon-carbon bonds is a triple bond, the resulting hydrocarbon is called an **alkyne**.

Practice Question

- This alkyne is named ethyne.



Figure 1.4.2: ethyne

What is the name of Molecule A?

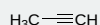


Figure 1.4.3: Molecule A

The double or triple bond is called a **functional group**, and is often the site where chemical reactions occur. Like a substituent, it is specified in the molecular name. When naming molecules according to the IUPAC system of nomenclature, remember **prefix-parent-suffix** (like un-believe-able).

prefix: what are the substituents?

parent: how many carbons? If there is a double or triple carbon-carbon bond in the molecule, both carbons in that bond must belong to the parent carbon chain, even if that chain does not have the greatest number of carbons.

suffix: what is the family of compounds?

Practice Questions

- This molecule is named 2-pentene.



Figure 1.4.4: 2-pentene

What is the name of Molecule B?



Figure 1.4.5: Molecule B

What is the name of Molecule C?



Figure 1.4.6: Molecule C

- This molecule is named 4-methyl-2-pentene.



Figure 1.4.7: 4-methyl-2-pentene

What is the name of Molecule D?

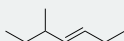


Figure 1.4.8: Molecule D

3. This molecule is named 3-isobutyl-1-octyne.

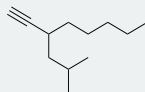


Figure 1.4.9: 3-isobutyl-1-octyne

What is the name of Molecule E?

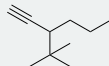


Figure 1.4.10: Molecule E

4. This molecule is named cyclohexene.



Figure 1.4.11: cyclohexene

What is the name of Molecule F?



Figure 1.4.12: Molecule F

5. This molecule is named 4-methylcyclohexene. Number the carbons.



Figure 1.4.13: 4-methylcyclohexene

What is the name of Molecule G?



Figure 1.4.14: Molecule G

6. This molecule is named 1,3-pentadiene.



Figure 1.4.15: 1,3-pentadiene

What is the name of Molecule H?

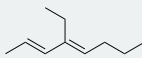


Figure 1.4.16: Molecule H

7. The location of substituents relative to the double bonds can lead to a type of constitutional isomer known as a **positional isomer**.

The name of this molecule is 5-methyl-1,3-cyclohexadiene.



Figure 1.4.17: 5-methyl-1,3-cyclohexadiene

What is the name of Molecule I?



Figure 1.4.18: Molecule I

Double or triple carbon-carbon bonds are rigid and planar. Since the carbons cannot rotate freely around the bond, **cis/trans isomers** are common, and the orientation may be important for chemical reactions.



Figure 1.4.19: cis-2-butene and trans-2-butene

 Practice Questions

1. Write the steps that you use to name an alkene and an alkyne, in order, as instructions for a student who doesn't know how to do it.
2. Draw any alkene or alkyne and go through the steps in naming your molecule.

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1.5: Halogens

Learning Objective

- How to name halogenated hydrocarbons

The **halogens** are elements belonging to Group 7A. **Fluorine, chlorine, bromine, and iodine** can be added to hydrocarbons through reactions with their **diatomic forms** or when bound to hydrogen as **hydrogen halides**.



Figure 1.5.1. where X is any halogen atom: Diatomic halogen vs halogen halide

When a halogen atom is bound to an otherwise saturated carbon atom, the molecule is known as an **alkyl halide**.

Substituent	Symbol	Name
Fluorine	F	fluoro-
Chlorine	Cl	chloro-
Bromine	Br	bromo-
Iodine	I	iodo-

When naming molecules according to the IUPAC system of nomenclature, remember **prefix-parent-suffix** (like un-believe-able).

- prefix:** what are the substituents?
- parent:** how many carbons?
- suffix:** what is the family of compounds?

Practice Questions

1. This molecule is named 2-chlorobutane.

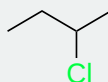


Figure 1.5.2: 2-chlorobutane

What is the name of Molecule A?

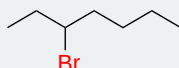


Figure 1.5.3: Molecule A

2. This molecule is named 2-fluoro-3-methylpentane.

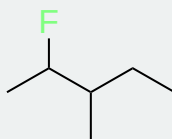


Figure 1.5.4: 2-fluoro-3-methylpentane

This molecule is named 4-iodo-2-methylhexane.

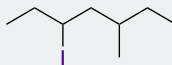


Figure 1.5.5: 4-iodo-2-methylhexane

What is the name of Molecule B?

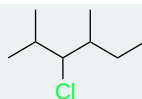


Figure 1.5.6: Molecule B

3. This molecule is named 1-chloro-2-butene.

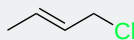


Figure 1.5.7: 1-chloro-2-butene

This molecule is named 5-fluoro-2-hexene.

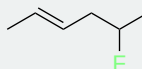


Figure 1.5.8: 5-fluoro-2-hexene

What is the name of Molecule C?

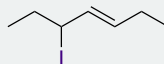


Figure 1.5.9: Molecule C

4. This molecule is named 5-fluoro-1,3-cyclohexadiene.

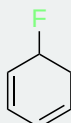


Figure 1.5.10: 5-fluoro-1,3-cyclohexadiene

What is the name of Molecule D?

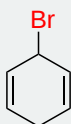


Figure 1.5.11: Molecule D

5. Write the steps that you use to name an alkyl halide, in order, as instructions for a student who doesn't know how to do it.

6. Draw any alkyl halide and go through the steps in naming your molecule.

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1.6: Benzene and Conjugation

Learning Objective

- Understanding and naming benzene derivatives.

Aromatic hydrocarbons, like this **benzene** ring, have unexpected chemistry.



Figure 1.6.1: benzene

We would expect to name this molecule 1,3,5-cyclohexatriene and see its double bonds react like other double bonds. However, these double bonds do not react in the same way as double bonds in a standard alkene. Observe the result of the below experiment under the appropriate reaction conditions.

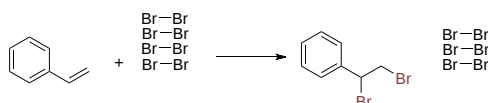


Figure 1.6.2.

This surprising stability of the double bonds in the benzene ring is not due to the cyclic arrangement of the carbon chain. Under the appropriate reaction conditions, we see the following results for adding hydrogen across the double bonds of the molecules below.

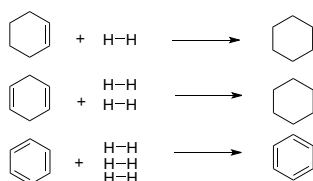


Figure 1.6.3.

Measuring the bond lengths gives the following result.

Bond Type	Bond Length (Angstroms)
Single	1.54
Double	1.34
Benzene	1.4

Therefore, the three “double bonds” of the benzene ring are not true double bonds. The electrons are shared across all of the carbons in the ring, an arrangement called **conjugation** which is better represented by the below structure.



Figure 1.6.4.

When depicting benzene rings using the double bond drawing, remember that the ring is a hybrid between two equally likely **resonance structures**.

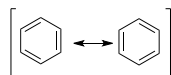


Figure 1.6.5.

Therefore both structures below would be named 1-chlorobenzene.

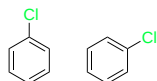


Figure 1.6.6: 1-chlorobenzene

When a benzene ring has two **substituents**, they are named based upon their position to each other rather than by numbers.



Figure 1.6.7. o is for ortho, with substituents at 1,2:o-dichlorobenzene



Figure 1.6.8. m is for meta, with substituents at 1,3:m-chloromethylbenzene

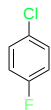


Figure 1.6.9. p is for para, with substituents at 1,4:p-chlorofluorobenzene

Practice Questions

1. What is the name of Molecule A?

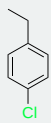


Figure 1.6.10: Molecule A

2. A benzene ring can be a substituent.

The name of this molecule is 2-phenyldecane.

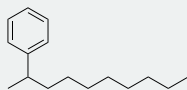


Figure 1.6.11: 2-phenyldecane

What is the name of Molecule B?

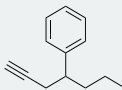


Figure 1.6.12: Molecule B

Conjugation is not limited to cyclic structures. One of the two molecules below does not react with halogen halides under standard reaction conditions. Which molecule do you predict is the more stable one? Why? What prediction would you make about the lengths of its carbon-carbon bonds?



Figure 1.6.13.

Practice Questions

- Write the steps that you use to name a benzene derivative or a molecule containing a benzene ring as a substituent, in order, as instructions for a student who doesn't know how to do it.
- Draw any benzene-containing molecule and go through the steps in naming your molecule.

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1.7: Alcohols

Learning Objective

- How to name alcohols and phenols.

In organic chemistry, any **alkyl group** can be abbreviated as **R**. An **alcohol**, in which a **hydroxy (-OH)** group is attached to a carbon of the alkyl group, can be abbreviated as **R-OH**.

Practice Questions

1. The name of this molecule is ethanol.



Figure 1.7.1: ethanol

What is the name of Molecule A?

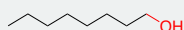


Figure 1.7.2: Molecule A

2. This molecule is named 2-butanol.



Figure 1.7.3: 2-butanol

This molecule is named 6-isopropyl-5-nonanol. Number the carbons.

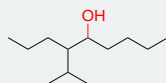


Figure 1.7.4: 6-isopropyl-5-nonanol

Number the carbons. What is the name of Molecule B?

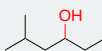


Figure 1.7.5: Molecule B

3. The name of this molecule is 3-propyl-2-octanol. Number the carbons.

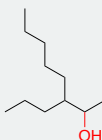


Figure 1.7.6: 3-propyl-2-octanol

4. Number the carbons. What is the name of molecule C?

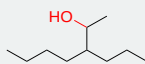


Figure 1.7.7: Molecule C

5. This molecule is named 3-fluorocyclohexanol. Number the carbons.



Figure 1.7.8: 3-fluorocyclohexanol

6. Number the carbons. What is the name of Molecule D?

Molecule D

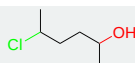


Figure 1.7.9.

7. This molecule is named 4-hexen-2-ol. Number the carbons.

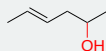


Figure 1.7.10: 4-hexen-2-ol

8. Number the carbons. What is the name of Molecule E?



Figure 1.7.11: Molecule E

9. This molecule is named 2,3-pentanediol.



Figure 1.7.12: 2,3-pentanediol

What is the name of Molecule F?

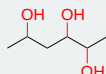


Figure 1.7.13: Molecule F

If a **hydroxy (-OH)** group is attached to an aromatic ring system, it is called a **phenol**.

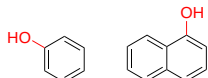


Figure 1.7.14: Two phenols

This molecule is named 2-chlorophenol or o-chlorophenol.



Figure 1.7.15: 2-chlorophenol / o-chlorophenol

Practice Questions

1. Name Molecule G using 1) numbers and 2) the o/m/p nomenclature.

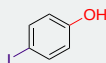


Figure 1.7.16: Molecule G

2. What additions do we make to our existing naming rules to name alcohols?
3. Write the steps that you use to name an alcohol in order, as instructions for a student who doesn't know how to do it.
4. Draw any alcohol and go through the steps in naming your molecule.

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1.8: Ethers

Learning Objective

- How to name ethers.

In organic chemistry, any **alkyl group** can be abbreviated as **R**. An **ether**, in which the carbons of two alkyl groups are linked to the same oxygen, can be abbreviated as **R-O-R**.

This molecule is often referred to simply as “ether”. Its common name is diethyl ether, and its IUPAC name is ethoxyethane.



Figure 1.8.1: ethoxyethane

The common name of this molecule is ethyl methyl ether, and its IUPAC name is methoxyethane.



Figure 1.8.2: methoxyethane

Practice Questions

- What are the common and IUPAC names of Molecule A?



Figure 1.8.3: Molecule A

- The name of this molecule is 2-methoxy-3-methylbutane. Number the carbons.



Figure 1.8.4: 2-methoxy-3-methylbutane

- Number the carbons. What is the name of Molecule B?

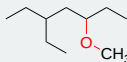


Figure 1.8.5: Molecule B

- The name of this molecule is 4-butoxy-2-butanol. Number the carbons.

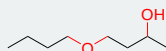


Figure 1.8.6: 4-butoxy-2-butanol

- Number the carbons. What is the name of Molecule C?

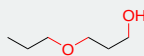


Figure 1.8.7: Molecule C

- What additions do we make to our existing naming rules to name ethers?
- Write the steps that you use to name an ether in order, as instructions for a student who doesn't know how to do it.
- Draw any ether and go through the steps in naming your molecule.

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1.9: Aldehydes and Ketones

Learning Objective

- How to name aldehydes and ketones.

A **carbonyl group** consists of a carbon atom double-bonded to an oxygen atom, written as **C=O**. **Aldehydes** and **ketones** are two compounds which contain the **carbonyl group**.



Figure 1.9.1. The R group can also be a hydrogen: **aldehyde**



Figure 1.9.2. The R groups can be the same or different: ketone

Aldehydes and **ketones** are **constitutional isomers**. For example, the aldehyde and ketone below both have the molecular formula C_3H_6O .



Figure 1.9.3: C_3H_6O

The simplest **aldehyde** is methanal, commonly known as formaldehyde, and used as a preservative.



Figure 1.9.4: methanal

The name of this molecule is butanal.



Figure 1.9.5: butanal

Practice Questions

1. What is the name of Molecule A?

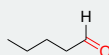


Figure 1.9.6: Molecule A

2. This molecule is named 5-methylhexanal. Number the carbons.

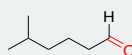


Figure 1.9.7: 5-methylhexanal

3. Number the carbons. What is the name of Molecule B?



Figure 1.9.8: Molecule B

4. This molecule is named 3-ethyl-4-methylhexanal. Number the carbons.

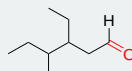


Figure 1.9.9: 3-ethyl-4-methylhexanal

5. Number the carbons. What is the name of Molecule C?

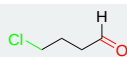


Figure 1.9.10: Molecule C

6. This molecule is named 3-pentenal. Number the carbons.

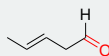


Figure 1.9.11: 3-pentenal

7. Number the carbons. What is the name of Molecule D?

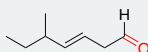


Figure 1.9.12: Molecule D

8. A well-known **ketone** is 2-propanone, commonly known as acetone, and used as a nail polish remover.



Figure 1.9.13: 2-propanone

This molecule is named 2-pentanone.



Figure 1.9.14: 2-pentanone

What is the name of Molecule E?

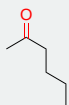


Figure 1.9.15: Molecule E

9. The name of this molecule is 5-ethyl-2-heptanone. Number the carbons.

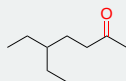


Figure 1.9.16: 5-ethyl-2-heptanone

10. Number the carbons. What is the name of Molecule F?



Figure 1.9.17: Molecule F

11. This molecule is named 6-chloro-4-ethyl-3-heptanone. Number the carbons.

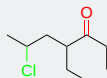


Figure 1.9.18: 6-chloro-4-ethyl-3-heptanone

12. Number the carbons. What is the name of Molecule G?

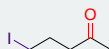


Figure 1.9.19: Molecule G

13. The name of this molecule is 3-bromocyclohexanone. Number the carbons.



Figure 1.9.20: 3-bromocyclohexanone

14. Number the carbons. What is the name of Molecule H?

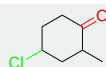


Figure 1.9.21: Molecule H

15. The name of this molecule is 4-hydroxy-2-butanone. Number the carbons.

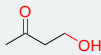


Figure 1.9.22: 4-hydroxy-2-butanone

16. Number the carbons. What is the name of Molecule I?

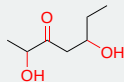


Figure 1.9.23: Molecule I

17. This molecule is named 5-chloro-4-oxohexanal. Number the carbons.

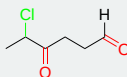


Figure 1.9.24: 5-chloro-4-oxohexanal

18. Number the carbons. What is the name of Molecule J?

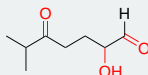


Figure 1.9.25: Molecule J

19. What additions do we make to our existing naming rules to name aldehydes and ketones?

20. Write the steps that you use to name an aldehyde or ketone in order, as instructions for a student who doesn't know how to do it.

21. Draw any aldehyde or ketone and go through the steps in naming your molecule.

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1.10: Carboxylic acids and Esters

Learning Objective

- How to name carboxylic acids and esters.

A **carbonyl group** consists of a carbon atom double-bonded to an oxygen atom, written as $C=O$. When a **hydroxy (-OH) group** is also bound to the carbonyl carbon, the resulting group is known as a **carboxy group**. **Carboxylic acids** contain the **carboxy group**, and one type of carboxylic acid derivative is an **ester**.



Figure 1.10.1: carboxylic acid



Figure 1.10.2: ester

Carboxylic acids are often abbreviated as **R-COOH** or **R-CO₂H**. Some simple carboxylic acids, such as acetic acid and benzoic acid, are referred to primarily by their common names.

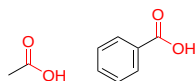


Figure 1.10.3: acetic acid and benzoic acid

The common name of this molecule is valeric acid. Its formal name is pentanoic acid.

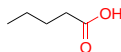


Figure 1.10.4: pentanoic acid

Practice Questions

- The common name of Molecule A is caprylic acid. What is the formal name of Molecule A?

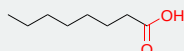


Figure 1.10.5: Molecule A

- The name of this molecule is hexanedioic acid.

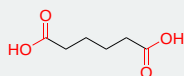


Figure 1.10.6: hexanedioic acid

What is the name of Molecule B?

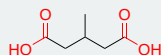


Figure 1.10.7: Molecule B

- The name of this molecule is cyclohexanecarboxylic acid.

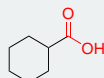


Figure 1.10.8: cyclohexanecarboxylic acid

What is the name of Molecule C?



Figure 1.10.9: Molecule C

4. The name of this molecule is 1,2-benzenedicarboxylic acid.

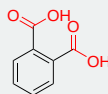


Figure 1.10.10: 1,2-benzenedicarboxylic acid

What is the name of Molecule D?

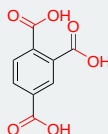


Figure 1.10.11: Molecule D

5. The name of this molecule is 4-bromopentanoic acid. Number the carbons.

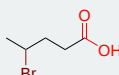


Figure 1.10.12: 4-bromopentanoic acid

6. Number the carbons. What is the name of Molecule E?

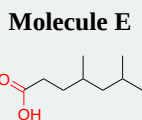


Figure 1.10.13.

7. This molecule is named 2-hydroxybutanoic acid (also known as lactic acid).

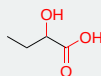


Figure 1.10.14: 2-hydroxybutanoic acid

What is the name of Molecule F?

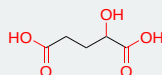


Figure 1.10.15: Molecule F

8. This molecule is named 3,6-dioxo-4-hydroxyhexanoic acid.

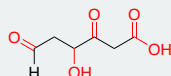


Figure 1.10.16: 3,6-dioxo-4-hydroxyhexanoic acid

What is the name of Molecule G?

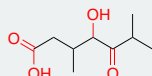


Figure 1.10.17: Molecule G

Esters are often manufactured to provide fragrance. One example is isobutyl methanoate, which smells like raspberries.

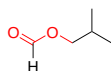


Figure 1.10.18: isobutyl methanoate

The process of **esterification** involves adding an alcohol to a carboxylic acid in the presence of hydrogen ions.

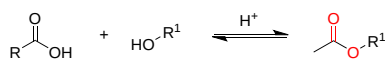


Figure 1.10.19: esterification

To name an ester, first we name the alcohol used, and then the carboxylic acid. Below is shown the esterification reaction of ethanol and propanoic acid to create ethyl propanoate.

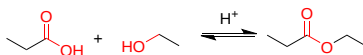


Figure 1.10.20: synthesis of ethyl propanoate

Practice Questions

1. What is the name of Molecule H?



Figure 1.10.21: Molecule H

2. What is the name of Molecule I?

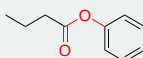


Figure 1.10.22: Molecule I

3. This molecule is named dimethylbutanedioate.

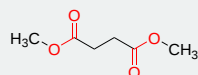


Figure 1.10.23: dimethylbutanedioate

What is the name of Molecule J?

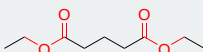


Figure 1.10.24: Molecule J

4. This molecule is named 2-chloroethyl propanoate.

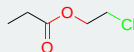


Figure 1.10.25: 2-chloroethyl propanoate

What is the name of Molecule K?

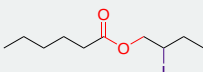


Figure 1.10.26: Molecule K

5. This molecule is named 2-bromopropyl 4-chlorobutanoate. Number the carbons.

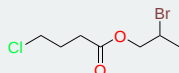


Figure 1.10.27: 2-bromopropyl 4-chlorobutanoate

6. Number the carbons. What is the name of Molecule L?

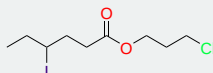


Figure 1.10.28: Molecule L

7. What additions do we make to our existing naming rules to name carboxylic acids and esters?

8. Write the steps that you use to name a carboxylic acid in order, as instructions for a student who doesn't know how to do it.

9. Draw any carboxylic acid and go through the steps in naming your molecule.

10. Write the steps that you use to name an ester in order, as instructions for a student who doesn't know how to do it.
11. Draw any ester and go through the steps in naming your molecule.

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1.11: Amines and Amides

Learning Objective

- How to name amines and amides.

An **amino group** consists of a nitrogen atom bonded to two hydrogen atoms, written as -NH_2 . If the hydrogens are replaced by R groups, the group is referred to as a **substituted amino group**. **Amines** and **amides** are two compounds which contain **amino or substituted amino groups**.

Amines are designated as **primary, secondary, or tertiary amines** based upon the degree of substitution of the amino group. For example, an amine in which all three of the potential nitrogen bonds are with R groups instead of hydrogens is called a tertiary amine (see the right-most molecule below).

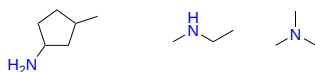


Figure 1.11.1: primary, secondary, and tertiary amines

Despite the complexity of the below molecule, because the nitrogen is directly bound to two hydrogens and only one R group, it is a primary amine.

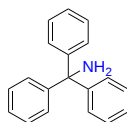


Figure 1.11.2: an enormous primary amine

There are multiple substitutive nomenclatures for naming amines, with the two most common being IUPAC and Chemical Abstract Service. Both will be described below.

This molecule is named 2-pentanamine (CAS) or 2-aminopentane (IUPAC).

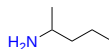


Figure 1.11.3: 2-pentanamine (CAS) / 2-aminopentane (IUPAC)

Practice Questions

1. What are the names of Molecule A?

Molecule A

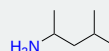


Figure 1.11.4.

2. This molecule is named 1,6-hexanediamine (CAS) or 1,6-diaminohexane (IUPAC).

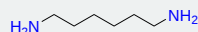


Figure 1.11.5: 1,6-hexanediamine (CAS) / 1,6-diaminohexane (IUPAC)

What are the names of Molecule B?

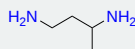


Figure 1.11.6: Molecule B

3. This molecule is named N,N-dimethylethanamine (CAS) or dimethylaminoethane (IUPAC).

N,N-dimethylethanamine (CAS) / dimethylaminoethane (IUPAC)



Figure 1.11.7.

What are the names of Molecule C?

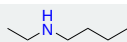


Figure 1.11.8: Molecule C

4. This molecule is named 4-amino-2-pentanone (CAS) or 4-aminopentan-2-one (IUPAC). Number the carbons.



Figure 1.11.9: 4-amino-2-pentanone (CAS) / 4-aminopentane-2-one (IUPAC)

5. Number the carbons. What are the names of Molecule D?



Figure 1.11.10: Molecule D

6. This molecule is named 2-(N-methylamino)ethanol (CAS) or 2-methylaminoethanol (IUPAC). Number the carbons.

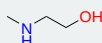


Figure 1.11.11: 2-(N-methylamino)ethanol (CAS) / 2-methylaminoethanol (IUPAC)

7. Number the carbons. What are the names of Molecule E?

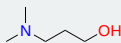


Figure 1.11.12: Molecule E

An **amide** is a **carboxylic acid derivative** in which the **carboxyl -OH** has been replaced with an **amino or substituted amino group**. Amides are also described as primary, secondary, or tertiary depending on the number of R groups bound directly to the nitrogen.

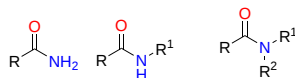


Figure 1.11.13: primary, secondary, and tertiary amides

The naming of simple amides is based on the carboxylic acid nomenclature, and keeps the same name in the CAS and IUPAC systems.

The name of this molecule is 3-methylbutanamide.

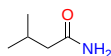


Figure 1.11.14: 3-methylbutanamide

Practice Questions

1. What is the name of Molecule F?

Molecule F

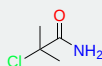


Figure 1.11.15.

2. The name of this molecule is N-methylbenzamide.

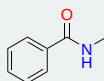


Figure 1.11.16: N-methylbenzamide

What is the name of Molecule G?

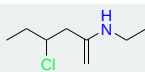


Figure 1.11.17: Molecule G

3. What additions do we make to our existing naming rules to name amines and amides, in the substitutive naming system that you use?
4. Write the steps that you use to name an amine in order, as instructions for a student who doesn't know how to do it.
5. Draw any amine and go through the steps in naming your molecule.
6. Write the steps that you use to name an amide in order, as instructions for a student who doesn't know how to do it.
7. Draw any amide and go through the steps in naming your molecule.

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