ORGANIC NOMENCLATURE

Organic compounds are named by using the IUPAC system.

Organic names have consistent structures composed of several parts. It is usually easiest to name compounds by working from back-to-front. Similarly it is usually easiest to convert a name to a structure by working back to front.

STRAIGHT CHAIN ALKANES

The names of these compounds have two parts. The prefix gives the number of carbons. The suffix gives the functional group (in this case an alkane).

To name a straight-chain alkane, first count the number of carbons. Then choose the prefix that matches the number of carbons in the chain.

Number of Carbons	Prefix	Number of Carbons	Prefix
1	meth	11	undec
2	eth	12	dodec
3	prop	13	tridec
4	but	14	tetradec
5	pent	15	pentadec
6	hex	16	hexadec
7	hept	17	heptadec
8	oct	18	octadec
9	non	19	nonadec
10	dec	20	eicos

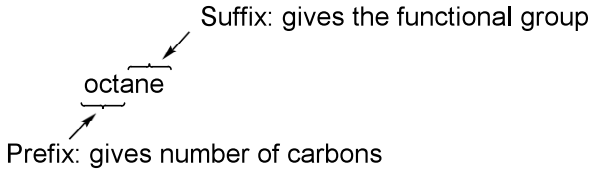
Now, add the suffix “ane”. This suffix designates the compound as an alkane.

Example:

$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

This compound contains 8 carbons in a linear chain. Choose the prefix “oct” for 8 carbons. Because the compound is an alkane, choose the suffix “ane”. Put these together to get the name.

octane

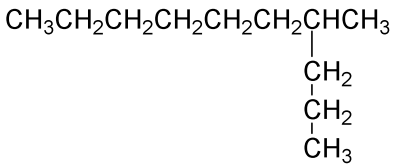


BRANCHED ALKANES:

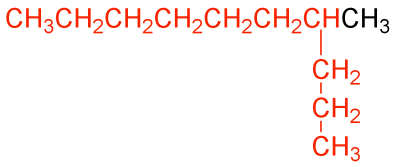
To start, identify the longest carbon chain, and count the number of carbons. This gives the prefix for the parent name of the compound. Add the suffix “ane” to identify the compound as an alkane.

Then, name each branch using the proper prefix to identify the number of carbons in the branch. Use the suffix "yl" to identify the chains as part of branches (substituents). Finally, identify the positions of the substituents using a number that indicates the carbons to which they are attached.

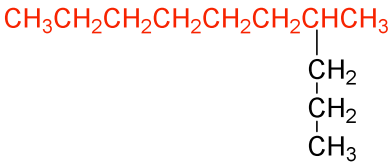
Example:



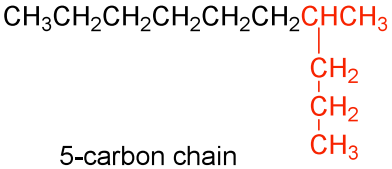
Start by identifying the parent chain. This is the longest continuous-chain (straight-chain) in the molecule.
Three possible straight chains can be identified in this structure (red). Count the number of carbons in each by starting at the end points and finishing at the other end points.



10-carbon chain

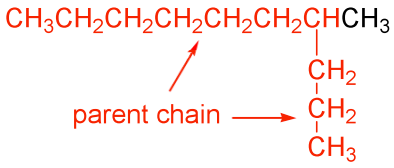


8-carbon chain



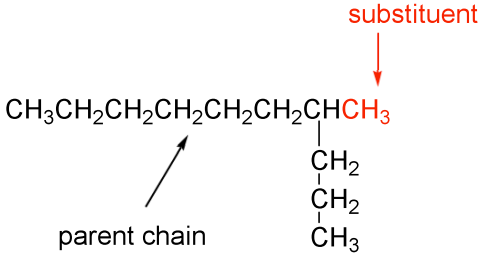
5-carbon chain

The longest chain has 10 carbons (in red below). This is the parent chain. For 10 carbons, use the prefix "dec". Add the suffix "ane" to indicate an alkane. The parent chain is
decane



decane

The remaining fragment that is un-named is called a substituent (shown in black above). Name the substituent using the same rules as the parent chain, using the suffix "yl" (instead of "ane") to identify the group as a substituent.

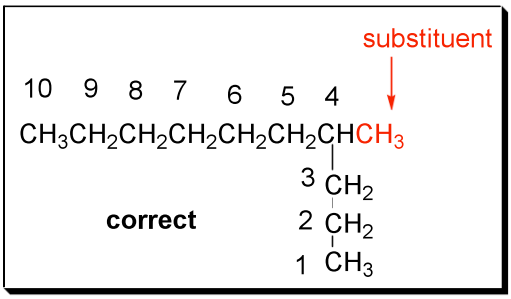


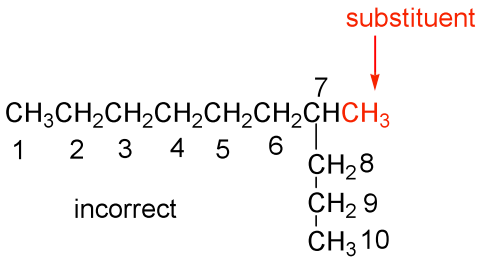
In this example, the substituent has 1 carbon (shown in red above). Use the prefix "meth" to indicate 1 carbon, add the suffix "yl" to indicate that it is a substituent.
methyl

The substituent name is added to the front of the parent chain name to give:
methyldecane

Note: do not separate the parts (no spaces or hyphens between the "methyl" and the "decane").

The last step is to identify the carbon on the parent chain that is attached to the substituent. To do this, number the carbons in the parent chain. Start numbering at the end of the parent chain that is *closest* to the substituent.



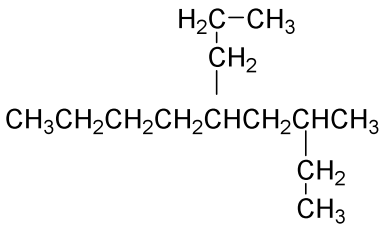


After numbering, we see that the substituent is attached to the parent chain at position 4. This number is placed in front of the substituent in the name, using a hyphen to separate the number from the rest of the name.
4-methyldecane.

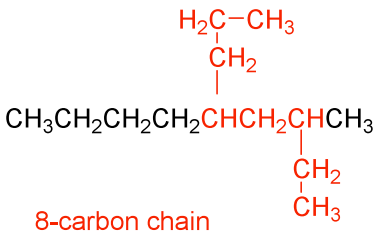
All chains and substituents have now been named, so this is the full name of the compound.

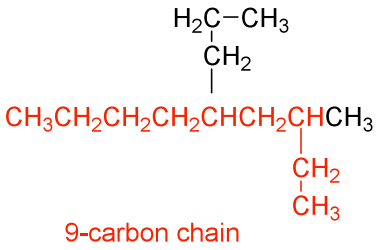
Follow the same procedure for compounds with more that one substituent. All you have to do is make sure you name all substituents. List the substituents in alphabetical order.

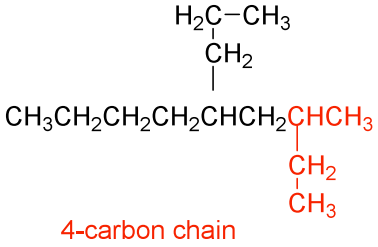
Example:

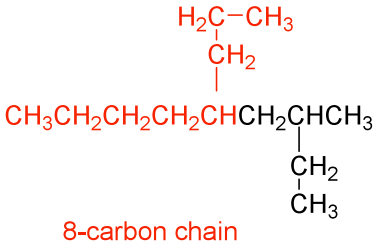


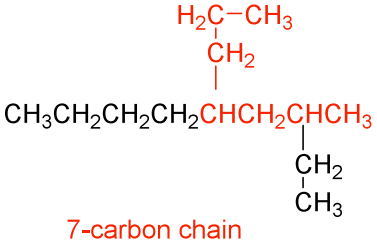
Begin by identifying the parent chain (longest chain). To do this, identify all chains and count the carbons in each.

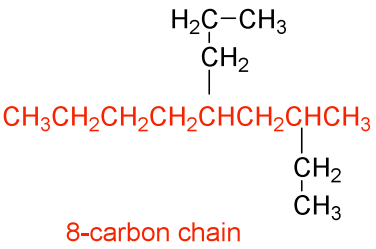








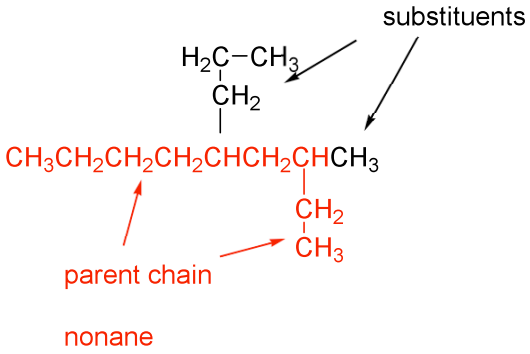




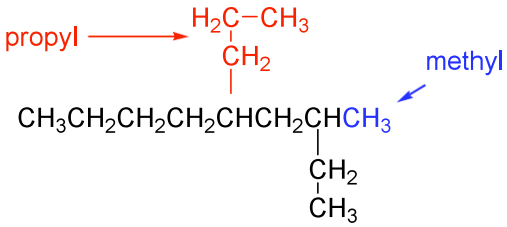
In this compound the longest chain has 9 carbons. The prefix for the parent chain is “non” for 9 carbons and the suffix is “ane” to indicate an alkane.

nonane

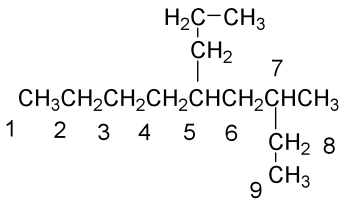
Now, name the other parts of the compound (substituents).



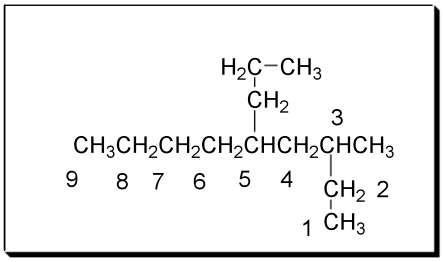
There are two substituents, one has 3 carbons, the other has 1 carbon. The first substituent is a “propyl” group, the prefix “prop” indicates 3 carbons, the suffix “yl” indicates a substituent. The second substituent is a “methyl” group (prefix “meth” + suffix “yl”).



Once the substituents are named, you must specify their positions. Number the carbons of the parent chain, staring at the end-carbon closest to a branch point. It does not matter which substituent is closer, choose the closest one.



the first branch point is at carbon 5
incorrect



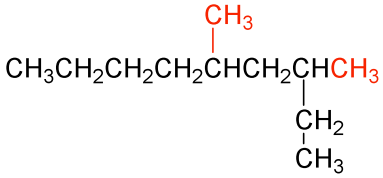
the first branch point is at carbon 3
this numbering gives a lower first-branch-point
correct

As shown above, the numbering on the right gives the first branch-point at a lower numbered carbon (3) than the numbering on the left (first group at position 5). Therefore use the numbering on the right.
This puts the methyl group at position 3, and the propyl group at position 5.
3-methyl
5-propyl

Add these, in alphabetical order, to the front of the parent chain name to get the full name of the compound. **Separate numbers from letters with hyphens.** Do not separate the parent-chain part of the name from the last substituent name.

3-methyl-5-propylnonane.
(Notice that there is no space or hyphen between "propyl" and "nonane".)

Example:



In this example, the two substituents are the same (methyl groups). If you use the same procedure described above, you should get the name:

3-methyl-5-methylnonane

Because the substituents are the same (methyl and methyl), instead of listing each group separately, list them once. Add a prefix to indicate how many methyl groups there are.

Number of identical substituents	prefix	Number of identical substituents	prefix
2	di	11	undeca
3	tri	12	dodeca
4	tetra	13	trideca
5	penta	14	tetradeca
6	hexa	15	pentadeca
7	hepta	16	hexadeca
8	octa	17	heptadeca
9	nona	18	octadeca
10	deca	19	nonadeca
		20	eicosa

Because there are two methyl groups, instead of naming the compound using “methyl-methyl” use the prefix “di” together with the substituent name “methyl”.

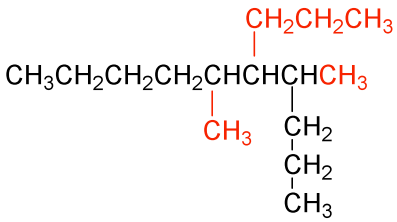
dimethyl

The position of each group still has to be specified, so provide this as a small list just before the substituent to which the numbers apply, using commas to separate the numbers in the list. List these numbers smallest-to-largest.

3,5-dimethylnonane

Note that the prefix “di”(or tri, tetra, etc), giving the number of groups, does *not* count when alphabetizing the substituents.

Example:



The longest chain (in black) is ten carbons long. The parent chain therefore has the prefix “dec” (for 10 carbons) and suffix “ane” (indicating an alkane).

Parent chain: **decane**

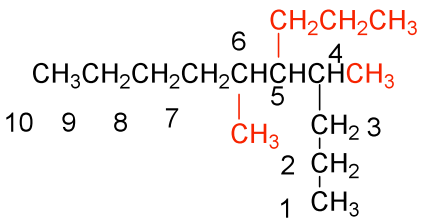
There are three substituents, a three-carbon substituent that has the prefix “prop” and suffix “yl”.

propyl

there are also two one-carbon substituents that each have the prefix “meth” and suffix “yl”. Because there are two of these methyl groups, we apply the prefix “di” (two substituents) before the group name

dimethyl

The last task is to identify the positions of the substituents along the parent chain. The following numbering is best (numbering started closest to the first branch point).



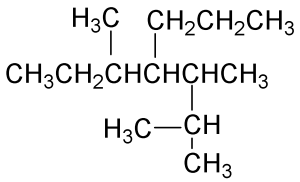
According to the numbering, the propyl group is at position 5, the methyl groups are at positions 4 and 6

5-propyl
4,6-dimethyl

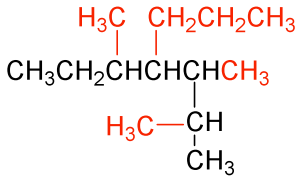
Alphabetically, methyl is before propyl (remember the "di" prefix is *not* considered when alphabetizing). Separate the numbers from the letters with hyphens; do not separate the last substituent from the parent-chain part of the name.

4,6-dimethyl-5-propyldecane.

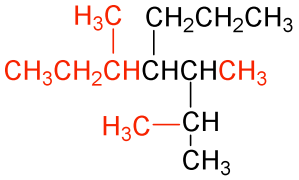
Example:



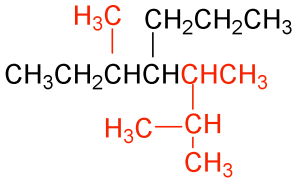
In this example, there are three longest chains (black below) that each have 7 carbons. Choose the chain that has the most substituents attached (left-most in this case) as the parent chain.



this parent chain (black) holds 4 substituents



this parent chain (black) holds 3 substituents

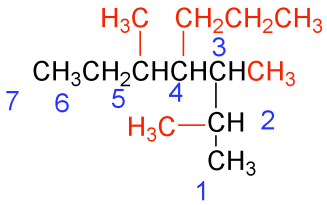


this parent chain (black) holds 2 substituents

The parent chain has 7 carbons and is therefore a **heptane** ("hept" prefix for 7 carbons, "ane" suffix for an alkane).

There are four substituents (red below). One has three carbons (**propyl**). The three other groups have one carbon each (methyl) that are therefore grouped together using the prefix "tri" (**trimethyl**).

Number the parent chain, starting at the end closest to the first branch-point.



List the substituents, in alphabetical order (ignoring the "tri" prefix), adding numbers to indicate the positions of the branching groups on the chain.

2,3,5-trimethyl-4-propylheptane

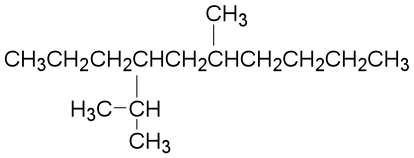
BRANCHED ALKYL SUBSTITUENTS:

Some substituents are branched. These groups are named exactly the way you would name a full-sized alkane; however there are two small differences.

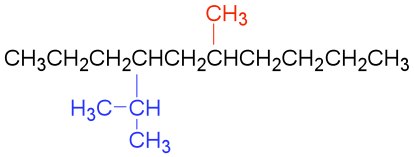
1) use the suffix "yl" to indicate a substituent
2) begin numbering at the carbon closest to the carbon that attaches the group to the main chain

The full name of the branched substituent (including the positional numbers) is placed within parentheses. A number and hyphen are placed in front of the opening parenthesis to indicate the position of the branched group along the main chain.

Example:

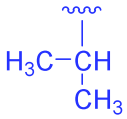


Start by identifying the longest chain.



The longest carbon chain has 10 carbons (in black above). This is a **decane**.

There are two substituents on the parent chain. The red substituent has one carbon and is therefore a **methyl** group. The blue substituent is branched, and so we name it in the following way:



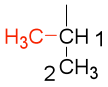
Identify the longest linear chain of the substituent, for this group, the longest chain has two carbons, use the prefix "eth" (2 carbons) and suffix "yl" (substituent). This gives the parent chain name of the *substituent*.

ethyl

There is a 1-carbon substituents on this group. This is named as **methyl** ("meth" indicates 1 carbon, "yl" indicates a substituent). The full name of the entire substituent is therefore:

methylethyl

Number the carbons on the parent chain of the group, starting at the attachment point to the main chain.



The methyl substituent is attached to the ethyl chain at position 1. Add this number in front of the group it refers to (**methyl**)

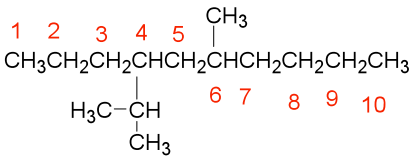
1-methylethyl

Place the name of this substituent in parentheses before adding it to the parent-chain name:

methyl-(1-methylethyl)decane

Note: Do not use a space or hyphen after the last parenthesis)

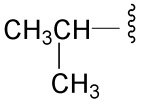
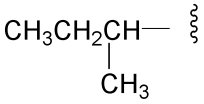
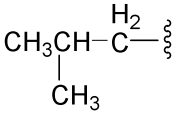
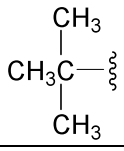
To identify the position of each substituent on the main chain, number the main chain starting at the end closest to a branch-point. Then add the positions of each group to the full compound name to get the final name.



We can see that the methyl group is at position 6, while the (1-methylethyl) group is at position 4.

6-methyl-4-(1-methylethyl)decane

Some groups have a trivial name. Trivial names are names that were applied to similar alkanes over 100 years ago, and that have stayed in the system. They are still commonly used so you need to know them.

Group	Trivial name(s)	Abbreviation
	*iso*-propyl	*i*-Pr
	*sec*-butyl	*s*-Bu
	*iso*-butyl	*i*-Bu
	*tert*-butyl	*t*-Bu

Using this system, the compound shown in the example above could have been given the name:

6-methyl-4-(*iso*-propyl)decane

CYCLIC ALKANES

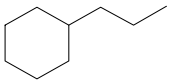
To name a cyclic compound, or a compound that contains a ring, use the prefix “cyclo” before name of the alkane.

Example:

This compound contains a ring, with six carbons in the chain making up the ring. Because there are 6 carbons in the chain, we name the chain as a **hexane** (“hex” + “ane”). Add the prefix “cyclo” to indicate that the 6 carbons of the chain are in a ring.

cyclohexane

Example:

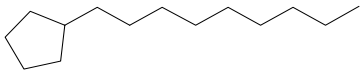


This compound has two parts, a ring containing 6 carbons, and a straight chain containing 3 carbons. As with other examples, the parent chain is the one with the most carbons. In this case it is the ring (6 carbons). Thus, the parent chain is a **cyclohexane**.

The three carbon chain attached to the ring is a substituent. Name this using the same procedure as the other alkanes. A three-carbon substituent is a “propyl” group (“prop” indicates three carbons; “yl” indicates a substituent). Because there is only one substituent, a position number is optional (this applies ONLY to rings).

propylcyclohexane or **1-propylcyclohexane**

Example:



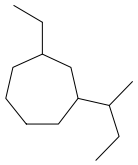
This compound has two parts, a ring containing 5 carbons, and a straight chain containing 9 carbons. As with other examples, the parent chain is the one with the most carbons. In this case it is the straight-chain (9 carbons). The parent chain is a **nonane**.

The substituent is a ring containing 5 carbons. The name of this substituent is made by adding “cyclo” + “pent” + “yl”, **cyclopentyl**.

cyclopentylnonane or **1-cyclopentylnonane**

Because the substituent is attached to position 1 of the nonane chain, we do not need to provide a number (it is optional)

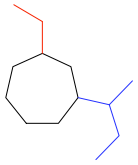
Example:



In this compound, the longest chain is a ring with 7 carbons. The parent chain is named by adding "cyclo" + "hept" + "ane".

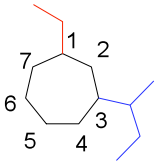
cycloheptane

There are two substituents. Shown below, the red group is an **ethyl** group (2 carbons, "eth" + "yl").



The blue group is a branched substituents. The longest chain in this group has 3 carbons ("prop" + "yl" **propyl**). There is a 1-carbon branch ("meth" + "yl" **methyl**) at position 1 of this group. This entire group is a **1-methylpropyl** group. Note that we could also use the trivial name ***sec*-butyl**.

To establish the positions of the groups on the ring, number the carbons of the ring starting from the substituent that is first alphabetically (ethyl in this case). Number the ring in the direction that will give the lowest number for the first branch-point. In this case, you should number in a clockwise direction to place the (1-methylpropyl) group at position 3.

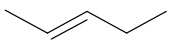


1-ethyl-3-(1-methylpropyl)cyclohexane or **1-ethyl-3-(*sec*-butyl)cyclohexane**

ALKENES:

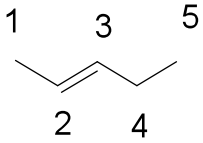
Alkenes are named using the same system. Because the functional group has changed (alkene) we use a different suffix. To indicate an alkene, use the suffix "ene". To properly name an alkene, you must also indicate the position of the double bond. Do this by giving the position of the carbon of the double bond that is closest to the end of the chain.
You must also specify the stereochemistry of the double bond. This is done by using *E* or *Z* (as appropriate), placed in parentheses at the beginning of the name.

Example.



This compound has one continuous straight-carbon chain with 5 carbons. The compound contains a double bond, and therefore is classed as an alkene.
The name is constructed by coupling the prefix "pent" (5 carbons) with the suffix "ene" (alkene).
pentene

To specify the position of the double bond, number the chain starting at the end closest to the double bond.



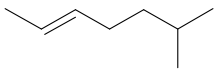
The double bond starts at carbon 2. Only the starting number of the double bond is required. This number is placed between the prefix (indicating number of carbons) and suffix (indicating the functional group).
pent-2-ene

The double bond is an *E* bond. To show this, the *E* is written in parentheses at the beginning of the name. If there is only one double bond, no positional number is necessary.
(*E*)-pent-2-ene

It is permitted to place the number designating the position of the functional group at the beginning of the parent-chain portion of the name. be careful when doing this. The number is understood to refer to the last suffix listed.

(*E*)-2-pentene

Example:



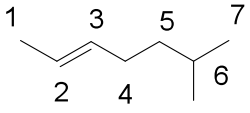
Alkenes with substituents are named as with alkanes (remember the "ene" suffix for the parent chain). For numbering purposes, the main chain is numbered starting at the end closest to the *double bond*.

The parent chain here has 7 carbons and contains an alkene. The parent chain is named by combining "hept" (7 carbons) with "ene" (alkene): **heptene**.

There is one substituent that has one carbon. It is named by combining "meth" (1 carbon) with "yl" (substituent): **methyl**

methylheptene

The chain is numbered starting at the end closest to the *double bond.*



The double bond starts at carbon 2

methylhept-2-ene

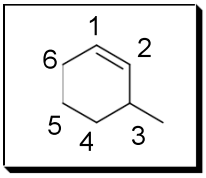
The methyl group is on carbon 6

6-methylhept-2-ene

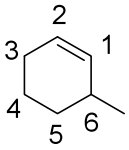
Finally, the double bond is an *E* double bond. Add this to the beginning of the name.

(*E*)-6-methylhept-2-ene

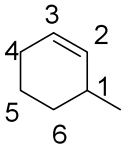
When double bonds are located in a ring, the compounds are named normally, however numbering begins at one carbon of the double bond, and proceeds in the direction of the double bond. When substituents are present, the numbers should proceed, across the double bond, in the direction towards the nearest substituent, as shown below:



correct



incorrect

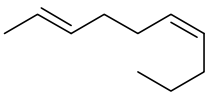


incorrect

HIGHER-ORDER ALKENES.

Compounds containing more than one double bond require a prefix to indicate the number of double bonds. The prefixes are the same as those used to indicate numbers of identical substituents. Add this prefix (di, tri, tetra etc.) just before the "ene" suffix. List the positions of the double bonds by giving a list of the starting carbons just before the functional group suffix.

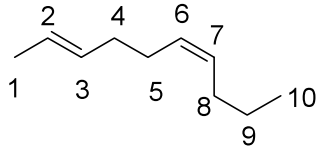
Example:



This compound has 10 carbons in the main linear chain, use the prefix "dec". The suffix is "ene" because the compound contains double bonds as the functional group. There are two double bonds, so apply the prefix "di" before the suffix "ene". The "di" prefix is separated from the "dec" prefix with an "a".

decadiene

The positions of the double bonds are obtained by numbering the chain, starting at the end closest to a double bond.



One of the double bonds starts at position 2, the other starts at position 6. Add these numbers as a short list "2,6" immediately after the "deca", separated from the "diene" with hyphens.

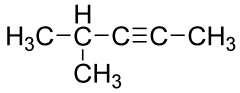
deca-2,6-diene

Now use the E,Z nomenclature to identify the configurations of the double bonds:

(2*E*,6*Z*)-deca-2,6-diene

ALKYNES.

Compounds containing triple bonds are called alkynes. They are named the same way as alkenes, using the suffix "yne" to indicate the functional group is an alkyne.

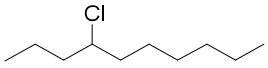


4-methylpent-2-yne

HALIDES.

These are named as substituents to a chain using the designations "fluoro", "chloro", "bromo" or "iodo" as appropriate.

Example:



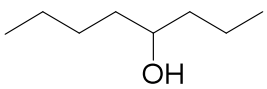
This **decane** has a chlorine atom at position 4 (numbered closest to the Cl branch point). The name is therefore

4-chlorodecane

ALCOHOLS

Alcohols are indicated by adding the suffix "ol" to the end of the name, removing the last "e" from the alkane (ane), alkene (ene), or alkyne (yne) designator just before it. Indicate the position of the alcohol function by adding the position number just before the "ol". When the alcohol is located on carbon 1, adding the number is optional unless the compound is cyclic.

Example:



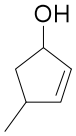
There is only one chain here, that has 8 carbons, use the prefix "oct" (8). The chain has only sp^3 carbons (alkane), so attach the suffix "ane". There is also a functional group here that is normally listed last. This group is an alcohol, so use the suffix "ol", removing the last "e" from the "ane" that immediately precedes it.

octanol

The OH group is located on carbon 4 (start numbering from the right as OH is closest to that end). Add the "4", using hyphens, between the "octan" and the "ol".

octan-4-ol

Example:



The longest chain in this compound has 5 carbons, is in a ring, and contains a double bond. Name this chain by combining "cyclo" + "pent" + "ene".
cyclopentene

The compound contains an alcohol. This functional group is the key functional group of the molecule, and so the descriptor for this is placed at the end of the name. Add the suffix "ol" to the end, removing the terminal "e".
cyclopentenol

There is also a substituent that has one carbon. Combine "meth" and "yl" to get the substituent name. Add this to the beginning of the name.
methylcyclohexenol

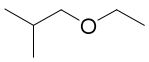
The next step is to add numbers to indicate the positions of the various groups. To set position numbers, begin at the end of the name, and work right-to-left. The "ol" is the principal functional group, so begin numbering at the carbon holding the OH group. The "en" is next, so continue numbering towards the double bond. This puts the first carbon of the double bond at position 2, and the methyl group at position 4. Place the numbers before the appropriate group.

4-methylcyclohex-2-en-1-ol or **4-methylcyclohex-2-enol** (position 1 for the OH is implied)

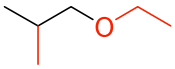
ETHERS:

This is a class of compound that has two carbon chains separated by an oxygen. The parent chain of the compound is the longest chain. It is named as if the shorter chain, together with the oxygen, is a substituent. Add the suffix "oxy" to the end of the substituent name (instead of "yl") to generate the name.
Numbering on the main chain should begin at the carbon attached to the ether oxygen.

Example:



The longest carbon chain has 3 carbons (black).



propane

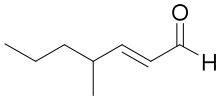
This chain has two substituents, a methyl group at position 2, and an oxygen attached to an ethyl group at position 1. To get the name of the second substituent, combine the prefix "eth" with the suffix "oxy" to produce an "ethoxy" group. Place the substituents, in alphabetical order, before the main chain name.

1-ethoxy-2-methylpropane

ALDEHYDES:

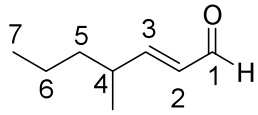
Aldehydes are named using the same method as alcohols. Use the suffix "al" to indicate the principal group is an aldehyde. Note for these compounds, that the carbon of the aldehyde groups is normally carbon 1 of the main chain.

Example:



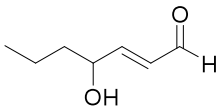
The longest chain has 7 carbons, use the prefix "hept". The compound contains a double bond, add the suffix "en". Finally, the compound is an aldehyde, add the suffix "al"
heptenal

There is a methyl substituent at position 4 (numbering begins at the aldehyde carbon). The double bond begins at carbon 2.



4-methylhept-2-enal

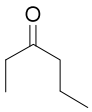
Example:



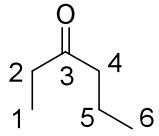
This compound contains an alcohol and aldehyde functional group. The parent name should normally be that of the functional group with the highest oxidation state—consult the list on the last page for full details. The alcohol will therefore be a substituent. Name it as "hydroxy".
4-hydroxyhept-2-enal

KETONES:

To identify a ketone, use the suffix “one”.



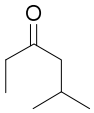
The longest carbon chain has 6 carbons. Use the prefix “hex”. The chain is an alkane (except for the ketone) so add the suffix “ane”. Finally, there is a ketone functional group. Use the suffix “one”, removing the final “e” from the “ane” suffix. Identify the position of the carbonyl functional group (C=O) by adding the position of the *carbonyl carbon* before the “one” suffix.



hexan-3-one

In the case of branching, the main chain should be numbered beginning at the terminal carbon closest to the ketone functional group (listed last in the name).

Example:

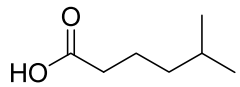


5-methylhexan-3-one

CARBOXYLIC ACIDS:

Carboxylic acids are named using the suffix “oic acid”. Numbering of the chain begins at the carbonyl of the carboxylic acid. It is normally unnecessary to indicate the number of the carboxylic acid functional group as this is normally position 1.

Example:

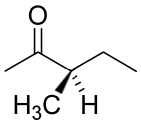


5-methylhexanoic acid

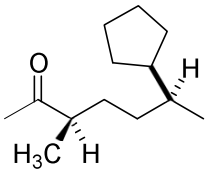
CHIRALITY:

When chiral centers are present in a molecule, add the absolute configuration of the chiral centre (R or S) in parentheses at the beginning of the name (similar to E/Z). If there is more than one chiral center, indicate the position of each center by adding the carbon number just before the R or S. When typed, these letters should be italicized.

Examples:



(*R*)-3-methylpentan-2-one



(3*R*,6*S*)-3-methyl-6-cyclopentylheptan-2-one

When more than one functionality is present, the principal group (the last suffix) is assigned according to the following priorities:

Carboxylic acid > anhydride > ester > acid halide > amide > nitrile > aldehyde > ketone > alcohol/phenol > thiol > amine
These groups normally all have higher priority that alkenes and alkynes.

When in doubt, the principal group is normally the group with the highest oxidation state.

Prefixes indicating numbers of carbons in a chain:

Number of Carbons	Prefix	Number of Carbons	Prefix
1	meth	11	undec
2	eth	12	dodec
3	prop	13	tridec
4	but	14	tetradec
5	pent	15	pentadec
6	hex	16	hexadec
7	hept	17	heptadec
8	oct	18	octadec
9	non	19	nonadec
10	dec	20	eicos

Prefixes indicating numbers of substituents:

Number of identical substituents	prefix	Number of identical substituents	prefix
2	di	11	undeca
3	tri	12	dodeca
4	tetra	13	trideca
5	penta	14	tetradeca
6	hexa	15	pentadeca
7	hepta	16	hexadeca
8	octa	17	heptadeca
9	nona	18	octadeca
10	deca	19	nonadeca
		20	eicosa

Common Substituents:

Substituent	suffix or identifier	Substituent	identifier
$C_nH_{(2n+1)}$	yl	Br	bromo
$C_nH_{(2n-1)}$ *contains double bond*	enyl	I	iodo
$C_nH_{(2n-3)}$ *contains triple bond*	ynyl	OH	hydroxy
F	fluoro	OR	Alkoxy (alk = prefix for number of carbons)
Cl	chloro	NH_2	amino

Suffixes for common functional groups:

Functional Group	Suffix	Functional Group	Suffix
Alkane	ane	Ketone	one
Alkene	ene	Carboxylic acid	oic acid
Alkyne	yne	Ester	oate
Alcohol	ol	Amide	amide
Aldehyde	al	Acid halide	oyl halide (halide = chloride, bromide etc.)

When combining suffixes ("ane" + "ol" for example), remove the trailing "e" from the first suffix ("ane" + "ol" makes "anol" and not "aneol").