Organic Naming Rules

AP Chemistry 439

For complete Rules go to:

http://www.acdlabs.com/iupac/nomenclature/

Organic Compounds

- Consist of mainly four elements
- Carbon
- Hydrogen
- Oxygen
- Nitrogen

Why Do We Need a Separate Set of Rules?

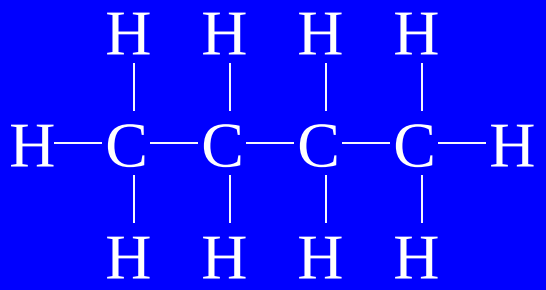
- Examine some typical organic compounds
- CH_4 Carbon tetrahydride
- C_2H_6 Dicarbon hexahydride
- Name these using typical covalent rules

So?

- That wasn't so bad, right?
- How about these:
- C_4H_{10} Tetracarbon decahydride
- C_5H_{12} Pentacarbon ??? hydride
- See my point?

Isomers

- If that's not enough, how about this one:

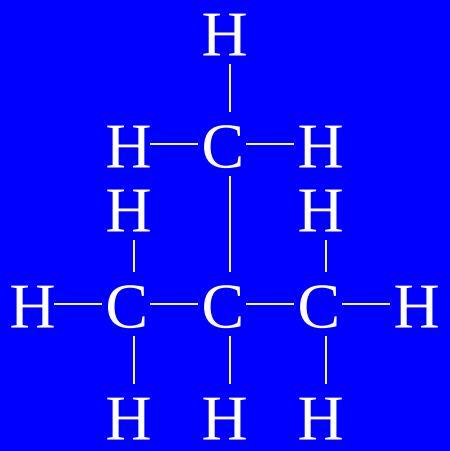


Formula?

C_4H_{10}

Different Structure

Same Formula



Formula?

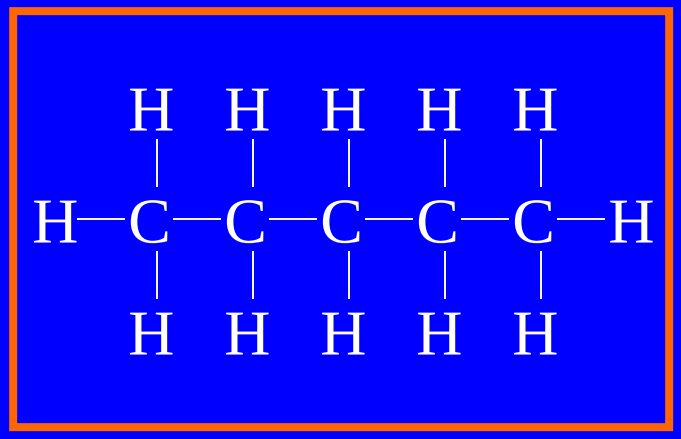
C_4H_{10}

Overall Problems

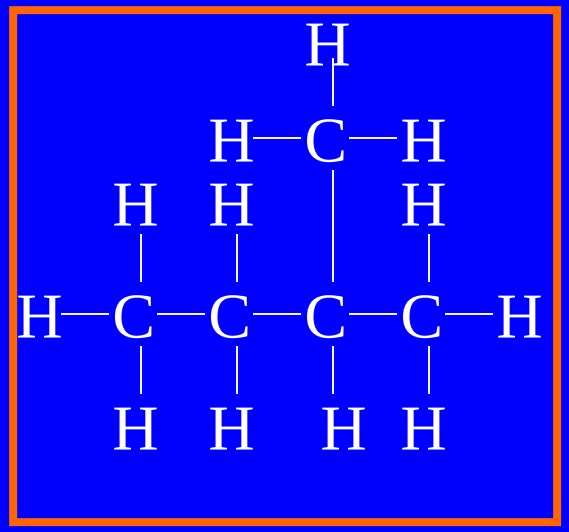
- Memorizing too many prefixes for large numbers
- Different chemicals having the same formulas
- Keep in mind that thus far we've only dealt with TWO different elements!

So what to do?

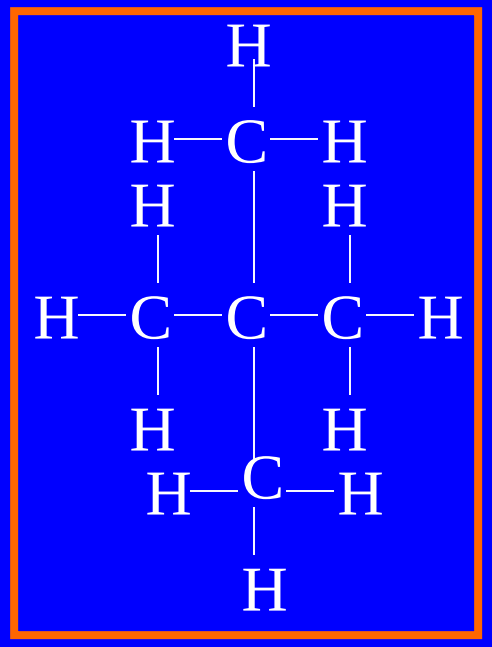
- Number of hydrogens is going to be the same, regardless of isomerism



C_5H_{12}



C_5H_{12}



C_5H_{12}

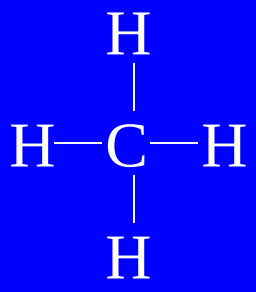
Solution

- Since number of hydrogens don't change with isomerism, why bother naming them?
- Name the molecule simply based on number of CARBONS
- We can always add prefixes or suffixes later for differentiation

Name based on number of Carbons

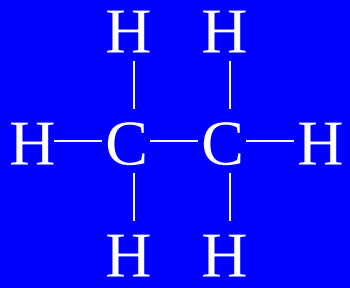
- 1 • Methane
- 2 • Ethane
- 3 • Propane
- 4 • Butane
- 5 • Pentane
- 6 • Hexane
- 7 • Heptane
- 8 • Octane
- 9 • Nonane
- 10 • Decane

Did that Really Help?



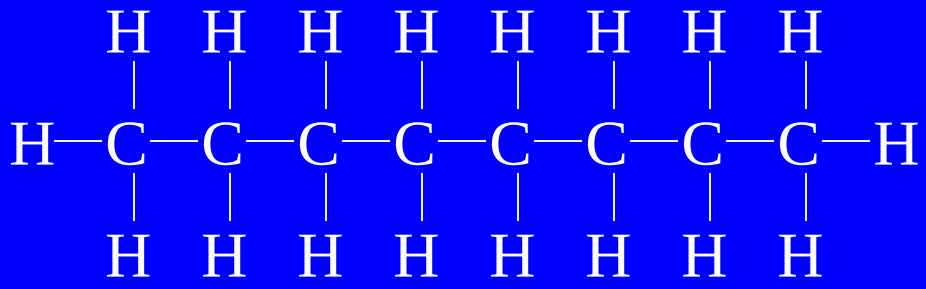
CH_4

Carbon tetrahydride becomes: Methane



C_2H_6

Dicarbon hexahydride becomes: Ethane



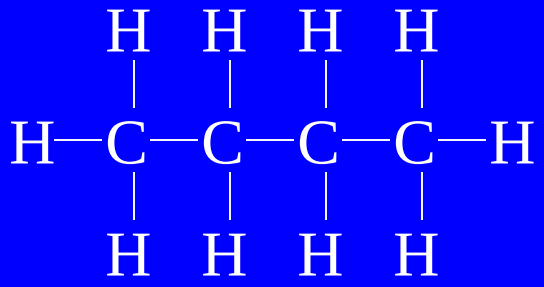
C_8H_{18}

Octacarbon ???hydride becomes:

Octane

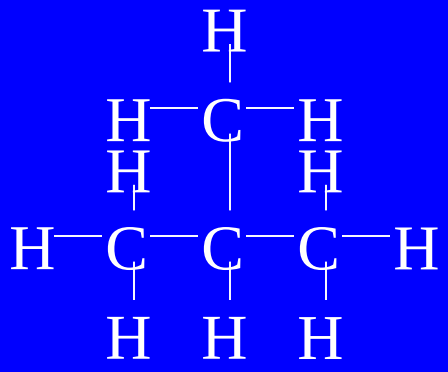
Branches

- Straight-chain alkanes (Just C & H with single bonds) are now easy



C_4H_{10} Butane

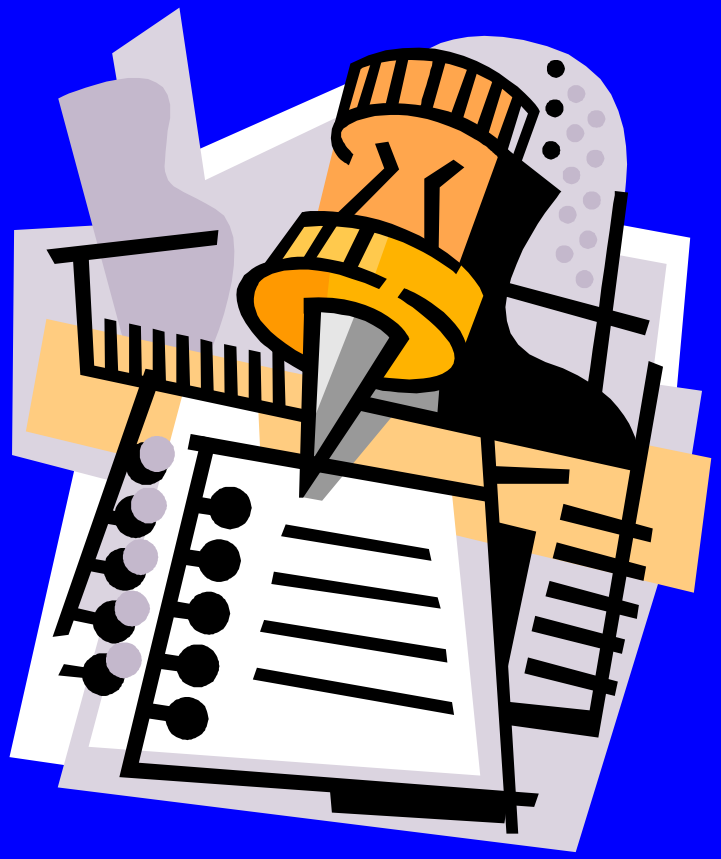
- But how do we deal with branches?



C_4H_{10} ????

Rules pt. 2

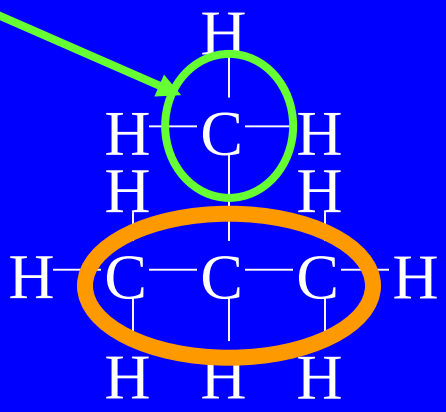
- Identify the longest unbranched chain of carbons
  - Name it as normal
  - Identify the branch
    - Name it but give it a “–yl” suffix
- Put the names of all branches first, then put name of longest chain



Example

Branch is one long

methyl

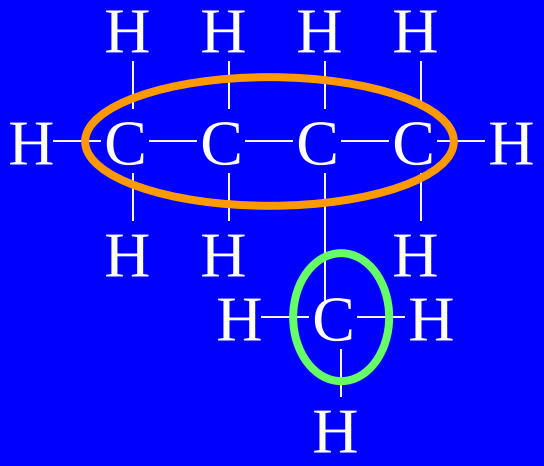


Longest unbranched chain of carbons is three long

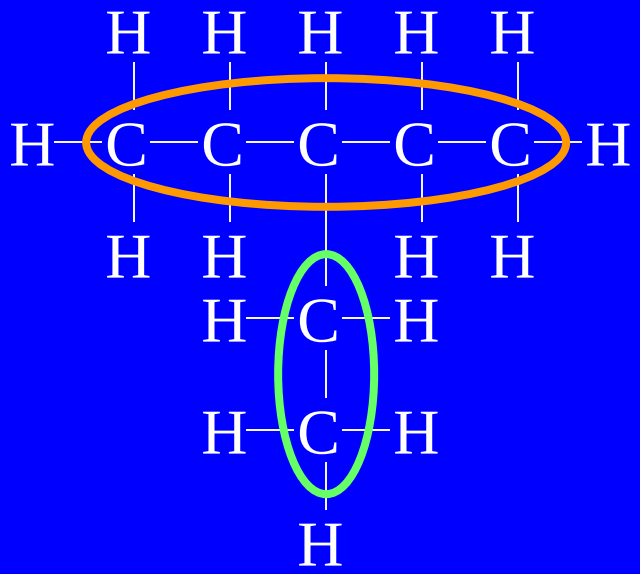
propane

Methyl Propane

Practice

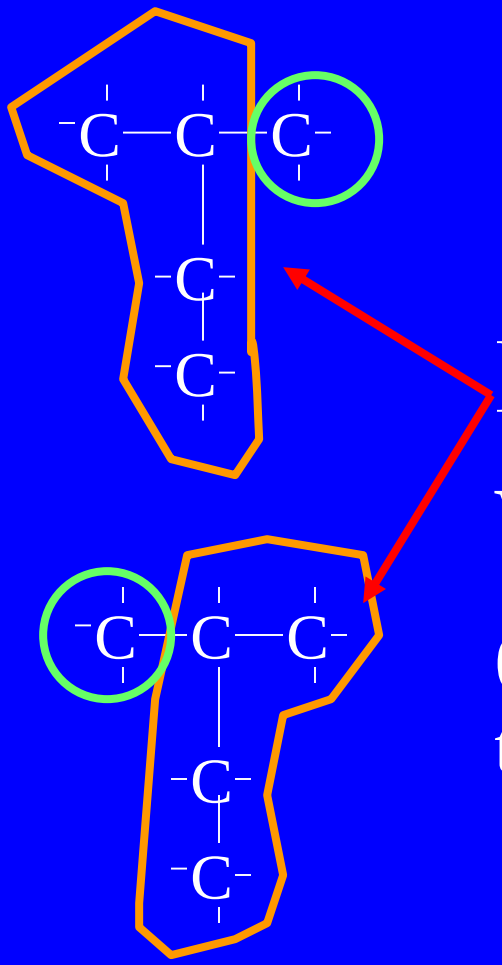


Methyl butane



Ethyl pentane

One More Practice

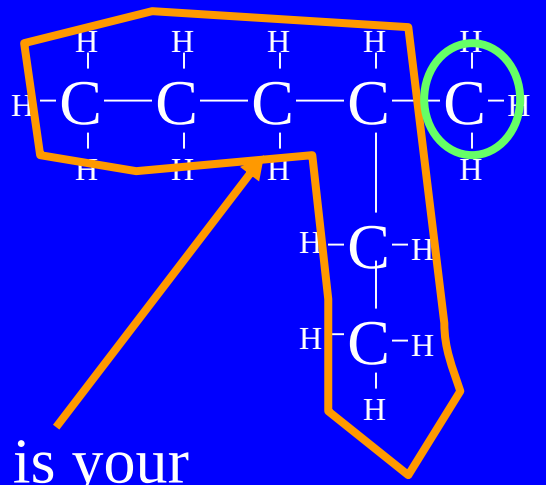


It doesn't matter which way you go!

(Provided you correctly pick the longest unbranched chain)

Methyl Butane

Be Careful



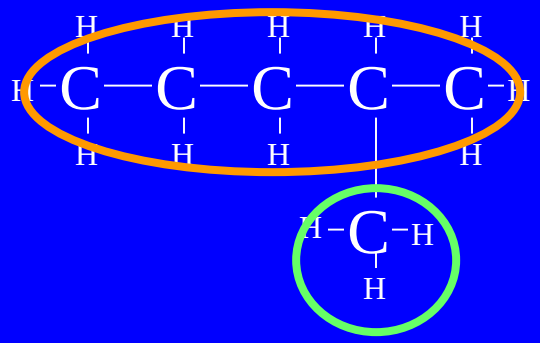
Methyl

This is your longest uninterrupted chain

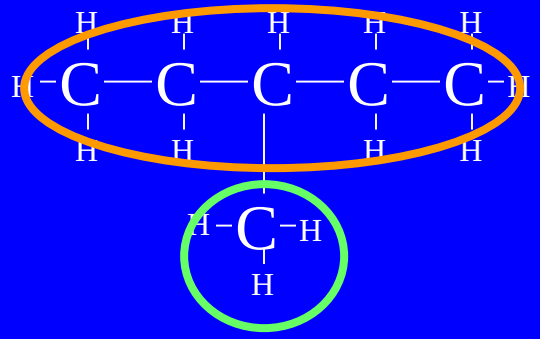
Hexane

Methyl Hexane

A Small Wrinkle



Methyl Pentane



Methyl Pentane

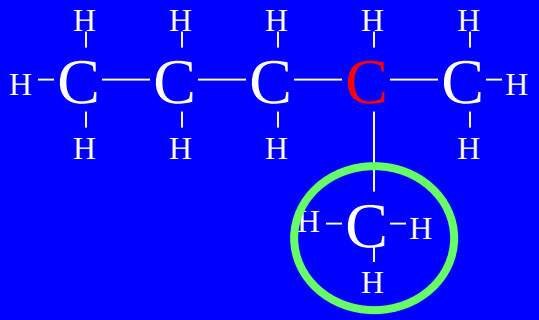
These are different molecules, though!!!

So Now What?

- Since two different molecules can't have the same name, we must differentiate
- If we look closely, though, the only difference between them is the position of the methyl group

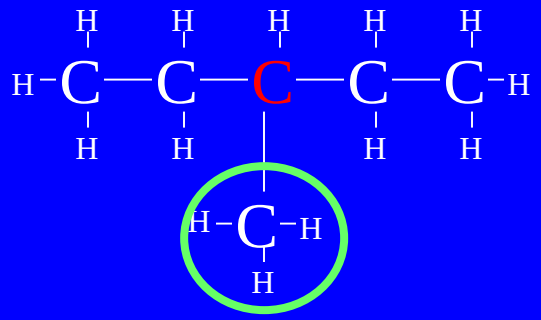
Positioning

2-Methyl Pentane



Here the methyl group is on the second carbon from the end

3-Methyl Pentane



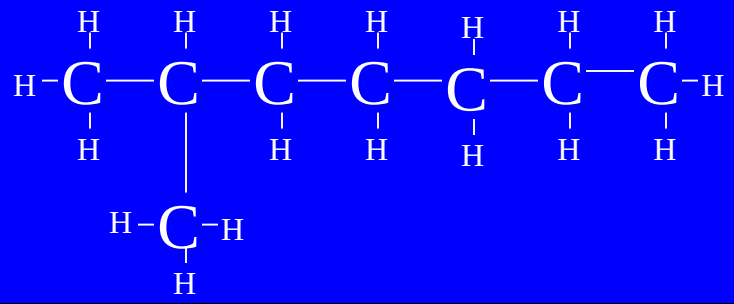
Here the methyl group is on the third carbon from the end

So…

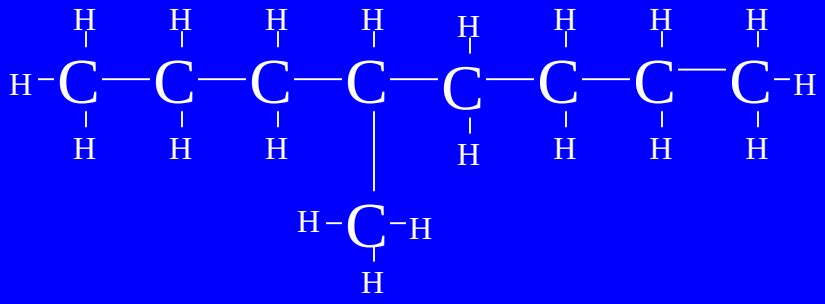
Rules pt. 3

- Identify the longest unbranched chain of carbons
  - Name it as normal
  - Identify the branch
- Name it but give it a "–yl" suffix
  - Put the names of all branches first, then put name of longest chain
- Put the number of the carbon the branch is on (start numbering from the closest single end)

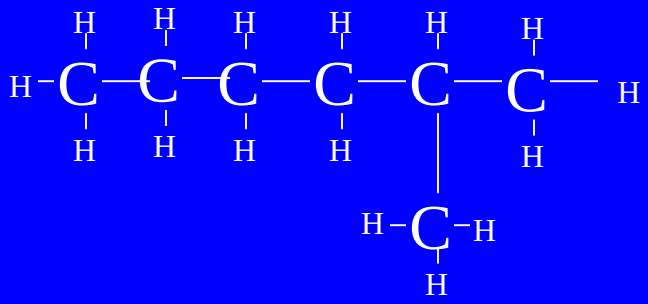
Practice



2-methyl heptane

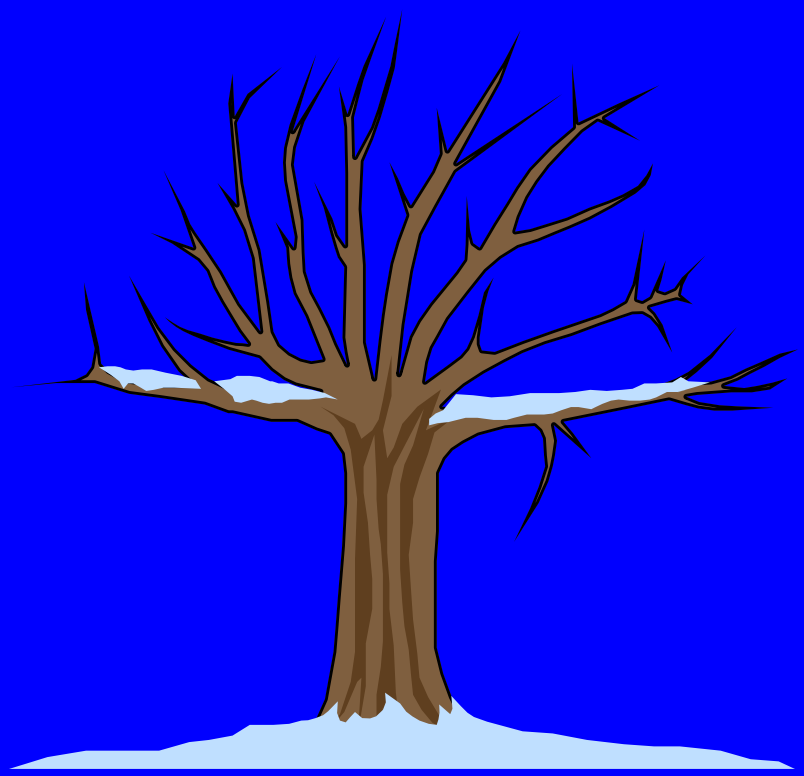


4-methyl octane



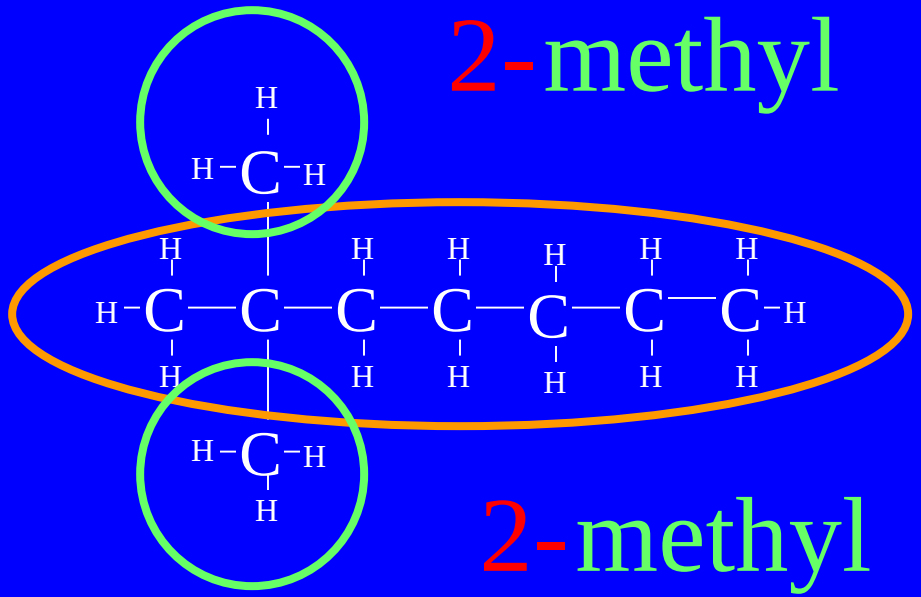
2-methyl hexane

Multiple Branches



- So far we've only had one branch
- What happens when there are multple branches?
- Just add a prefix to indicate the number of a particular type of branch

Practice



2-methyl

heptane

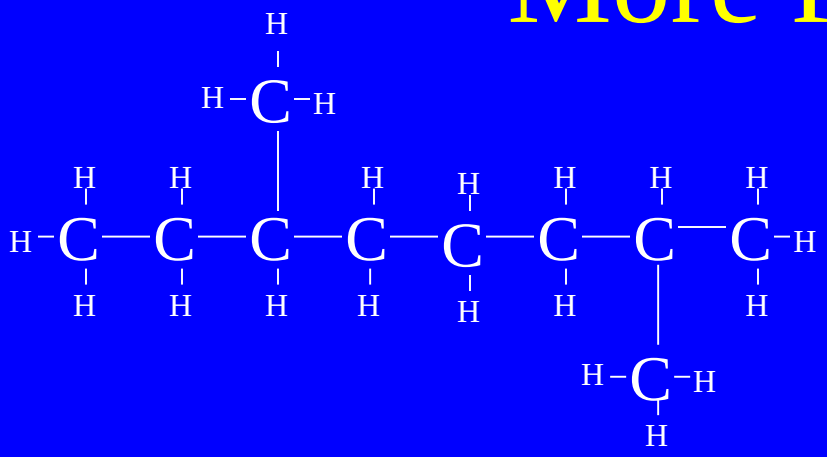
2-methyl

2-methyl, 2-methyl heptane

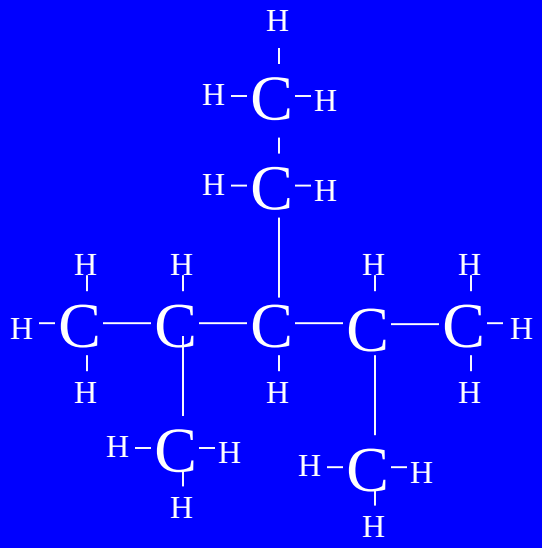
Sounds redundant

2,2 dimethyl heptane

More Practice



2, 6-dimethyl octane

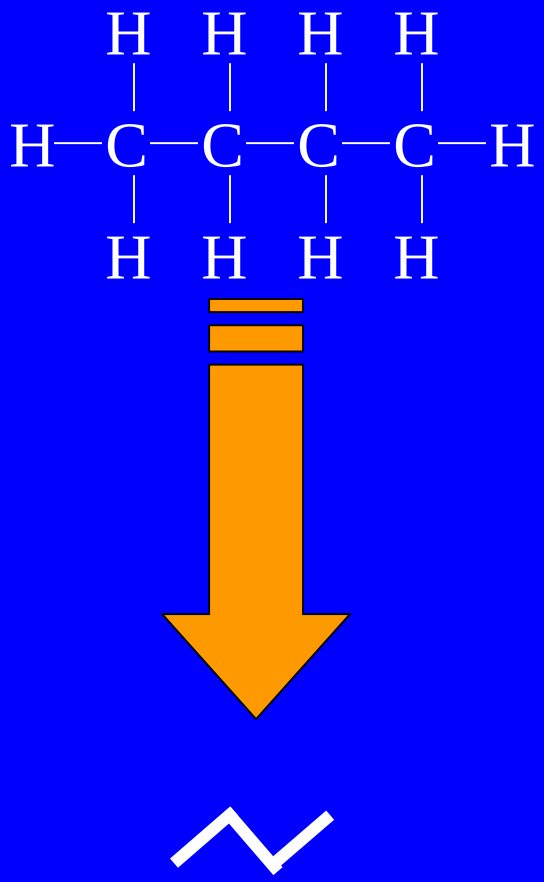


3 ethyl-2,4-dimethyl pentane

Is your arm sore yet?

- Are you sick to death of writing all those carbons?
- Even worse, are you sick of writing all those Hydrogens?
- How about this…

Shorthand notation



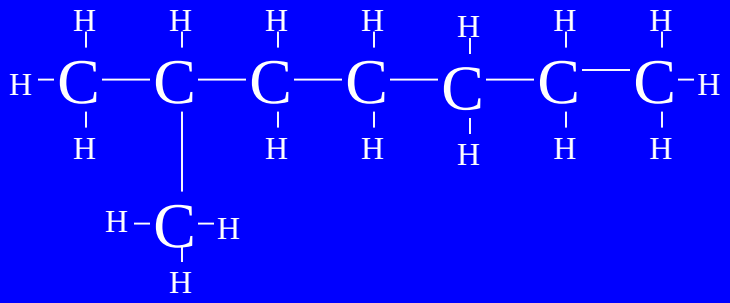
Keep in mind that we have been ignoring the hydrogens for a long time.

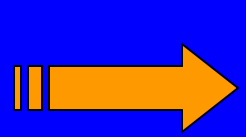
Our names have been based entirely on the positioning of the carbons.

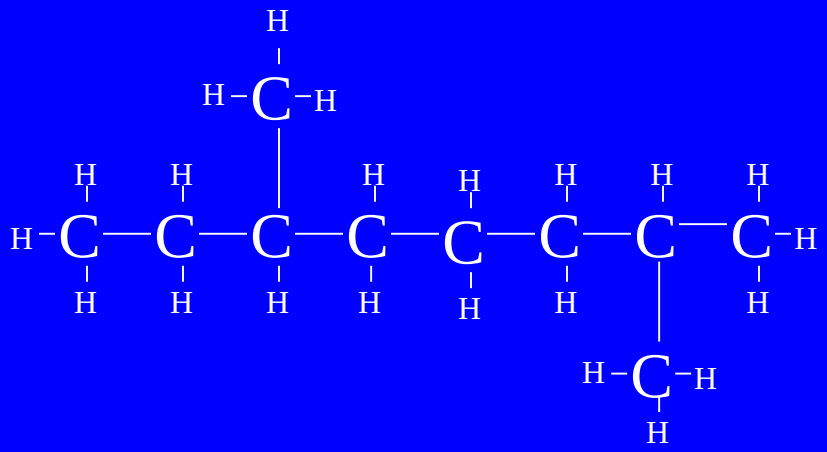
So lets now ignore the hydrogens

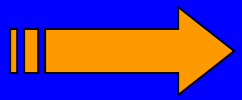
completely!

Is it that easy?

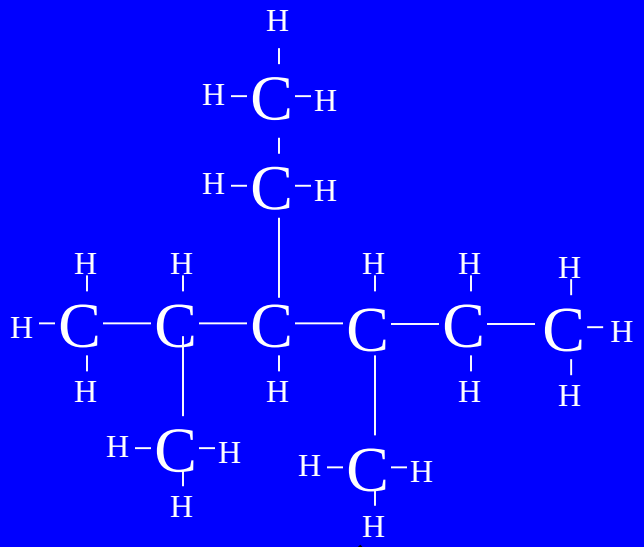




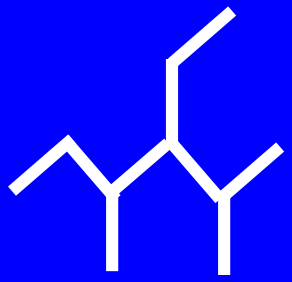




One More



Shorthand notation?



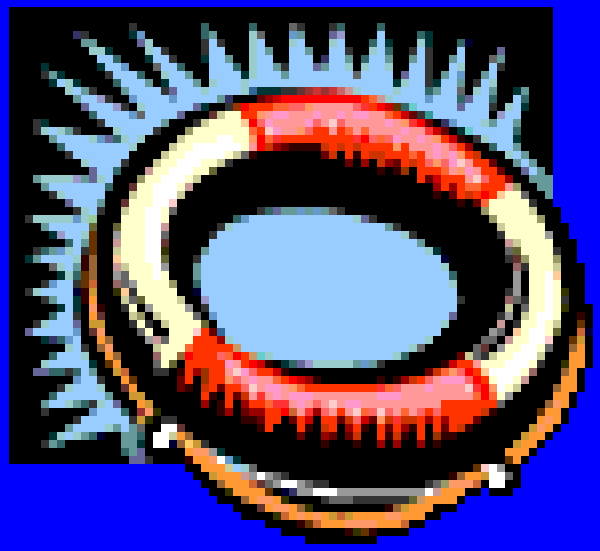
Name?

3-ethyl-2,4 dimethyl hexane

So is that it?

- Not even close!!
- There are literally millions of different organic compounds.
- What else can we do to make things more complicated?

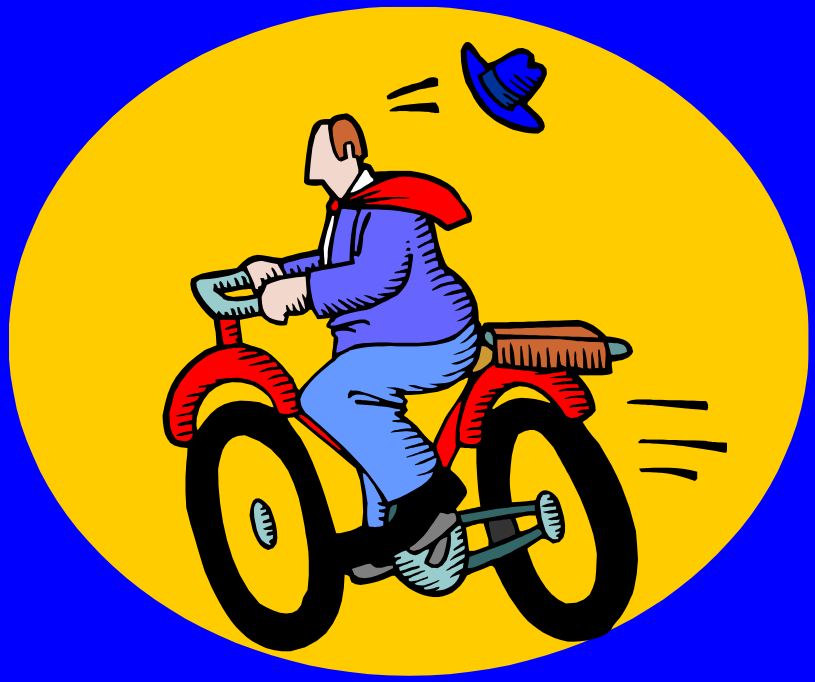
Rings



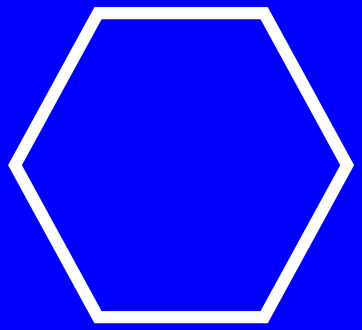
- Thus far we have dealt with chains that are straight or branched.
- If hydrocarbons are long enough, one end can wrap around and link up with itself!
- We call these cyclic hydrocarbons.

Cyclic Hydrocarbons

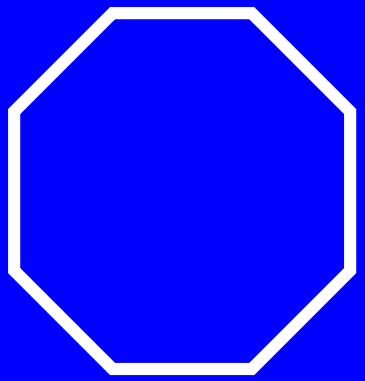
- Name the molecule as normal
- Add the prefix cyclo- to the front of the name of the longest chain
- Start numbering from the most “important” branch in the ring



Examples

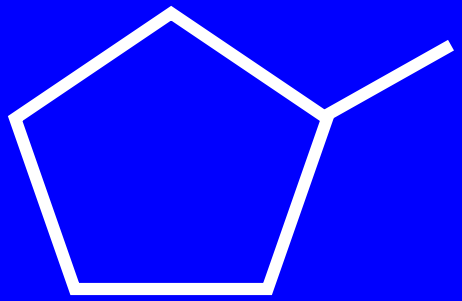


Cyclohexane

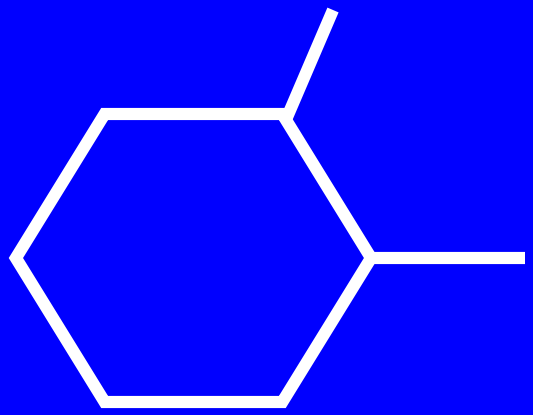


Cyclooctane

More Examples

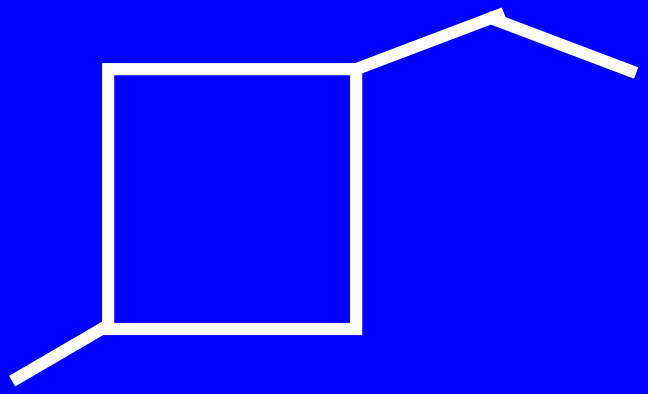


Methyl cyclopentane

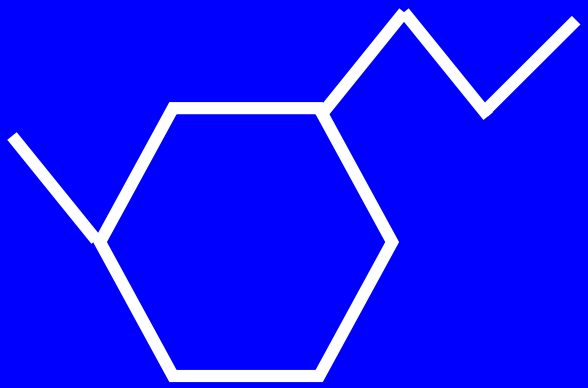


1,2 dimethyl cyclohexane

Try These



1 ethyl, 3 methyl cyclobutane

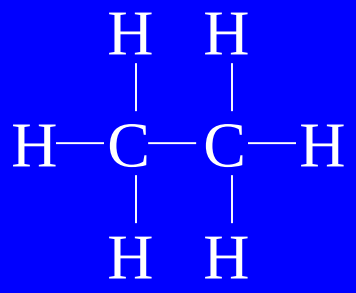


3 methyl, 1 propyl cylclohexane

Multiple Bonds

- So far, even with the cyclic structures we have dealt only with single bonds
- Carbon can make multiple bonds to another carbon
- This changes the name
- Why?

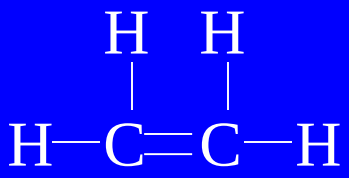
Examine Structures



C_2H_6

Ethane- notice that each carbon has four bonds

What will happen to the structure if we double bond the two carbons?



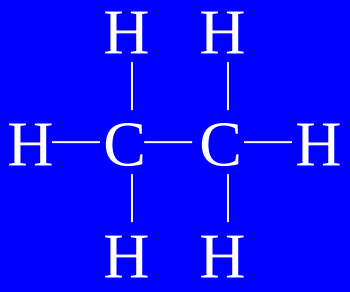
C_2H_4

Each carbon still has four bonds BUT now the hydrogens have changed!!

Naming molecules with multiple bonds

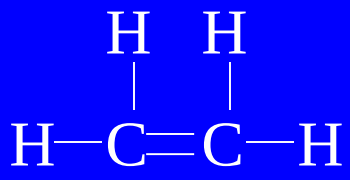
- Name the molecule as normal
- Change the suffix of the longest chain name
- Double bonds = ene
- Triple bonds = yne
- Use numbering and prefixes for positioning and multiple multiple bonds.

So….



C_2H_6

ethane



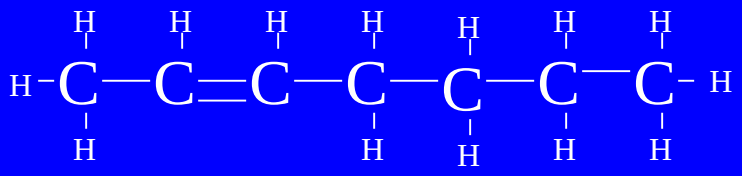
C_2H_4

ethene

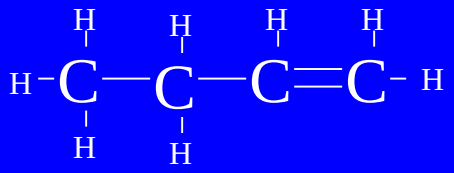
C_2H_2

ethyne

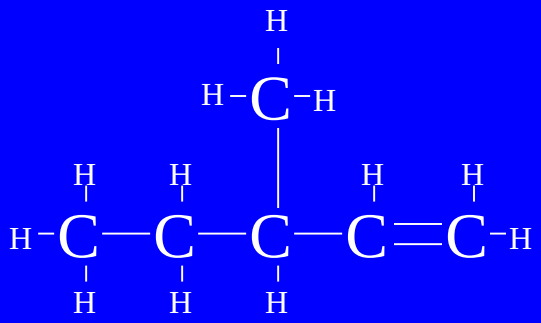
Practice



2-heptene

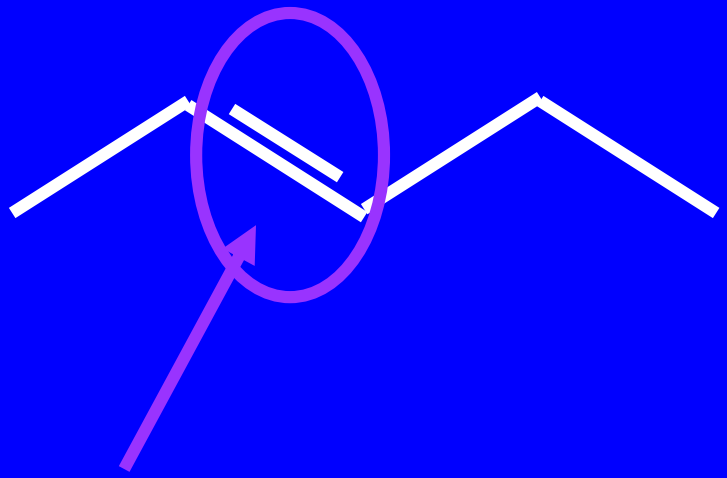


1-butene



3 methyl-1-pentene

How about in Shorthand?

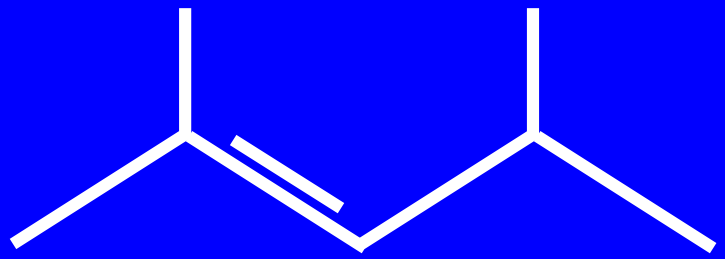


Notice the two lines means the double bond is there!

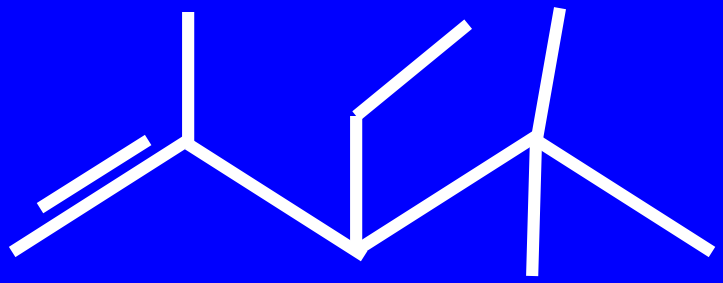
2 pentene

Practice!

Methyl propene

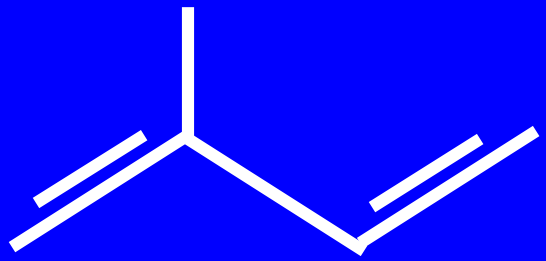


2,4-dimethyl-2-pentene

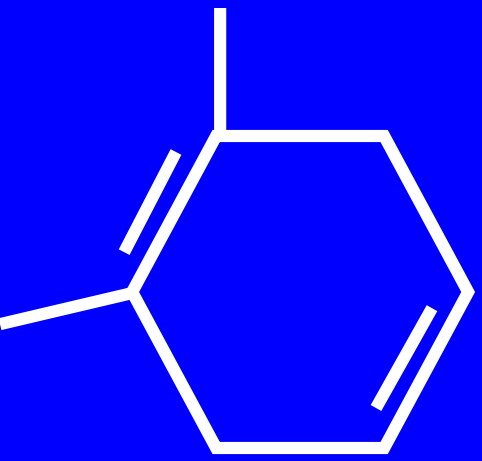


3-ethyl-2,4,4-trimethyl-1-pentene

Tough Ones

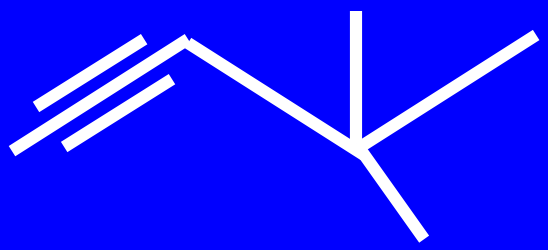


2 methyl 1,3 butadiene

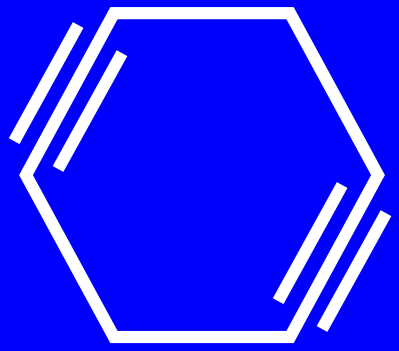


1,2 dimethyl-1,4 cyclohexadiene

Triples?



3, 3-dimethyl-1-butyne



1,4 cyclohexadiyne

So that's it, right?

- Not even close, bud.
- All this….all this was just for two elements, carbon and hydrogen!!
- We haven't even dealt with any of the others, yet.

Wait!! Don’t jump!!

- Get off that bridge.
- It’s not that bad provided we arrange things in an organized fashion!

Functional Groups

- Nature has done us a favor.
- There are many common groups that we can organized or file into different categories.
- Then we can name them based on these categories.

Functional Groups

- A group of atoms that, when added to a hydrocarbon chain, alter the chemical properties of the chain.
- Just a few different functional groups to know…

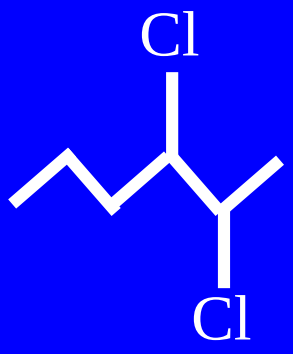
Functional Groups

• Halogens	• R-F, R-Cl, R-Br, R-I
• Alcohols	• R-OH
• Ethers	• R-O-R
• Aldehydes	• R-COH
• Ketones	• R-CO-R
• Carboxylic Acids	• R-COOH
• Esters	• R-COO-R
• Amines	• $R\text{-}NH_2$

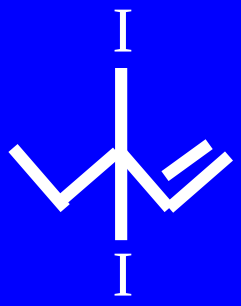
Halides

- Fluorides, Chlorides, Bromides, and Iodides
- Simply name the molecule as normal but add the prefix Fluoro, Chloro, Bromo, or Iodo as necessary

Halides



2, 3 dichlorohexane

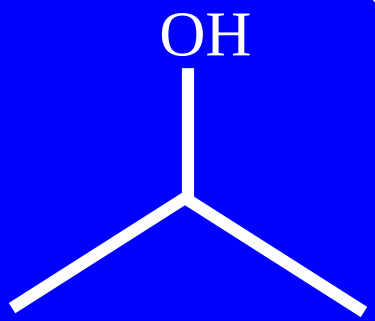


3, 3 diiodo-1-pentene

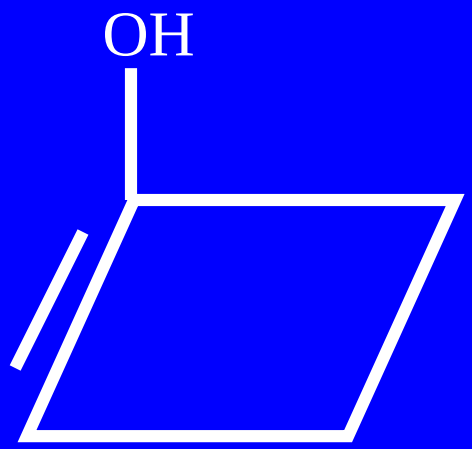
Alcohols

- R-OH
- Name like normal except add an –ol suffix

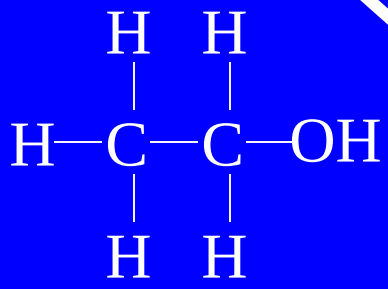
Alcohols



2 propanol



1cyclobutenol

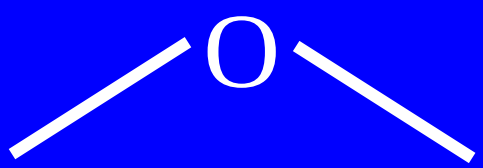


ethanol

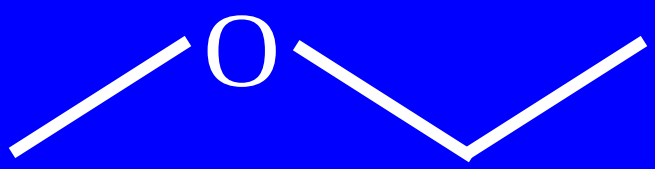
Ethers

- R-O-R
- Name two “R” groups with –yl endings
- End name in ether

Ethers



Dimethyl ether

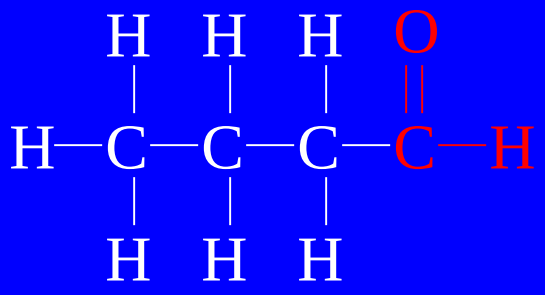


Ethyl methyl ether

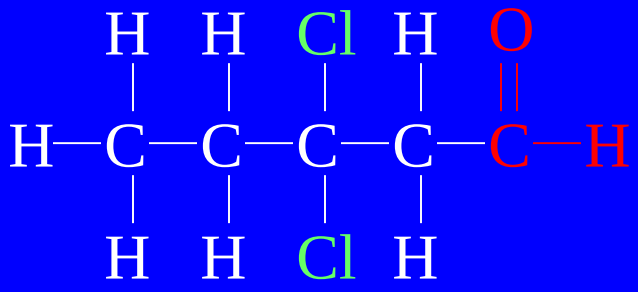
Aldehyde

- R-COH
- This is a carbon to oxygen double bond with a hydrogen at the end.
- Name as normal except use a “-al” suffix

Aldehydes

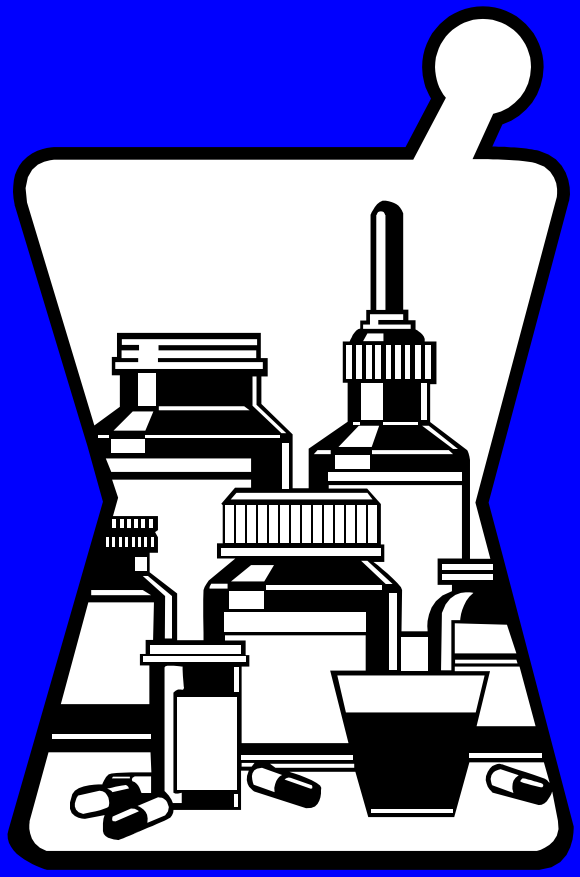


butanal



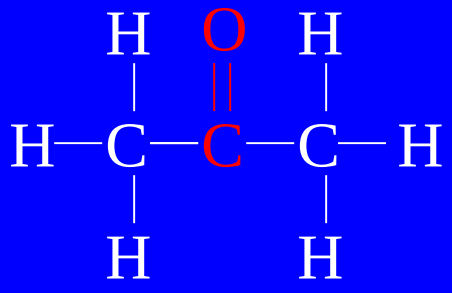
3,3 dichloropentanal

Ketones

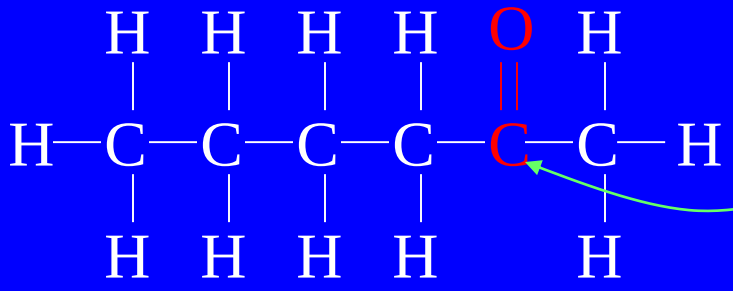


- R-CO-R
- This is a carbon to oxygen double bond but in the center of a hydrocarbon chain rather than the end
- Name as normal but give it a “-one” suffix

Ketones



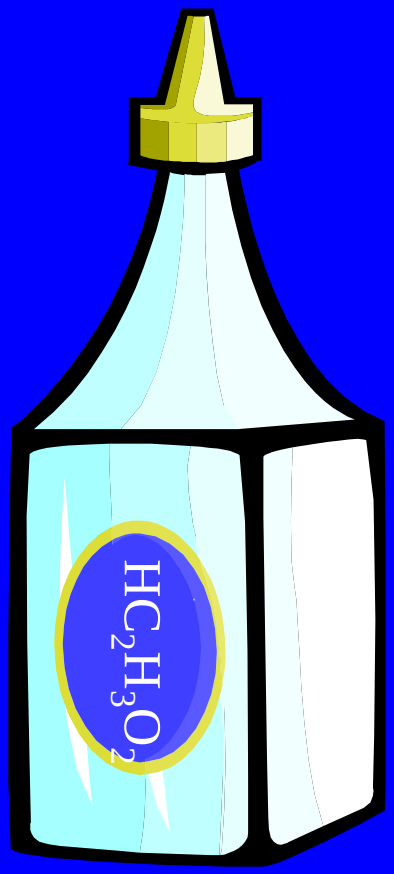
propanone



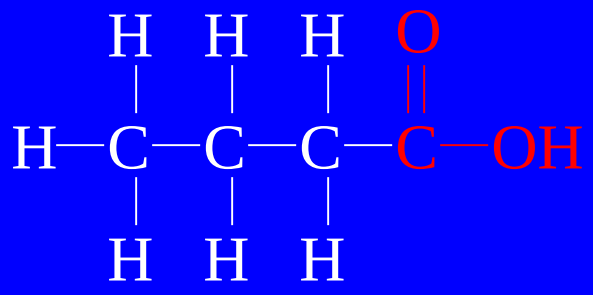
2 hexanone

Carboxylic Acids

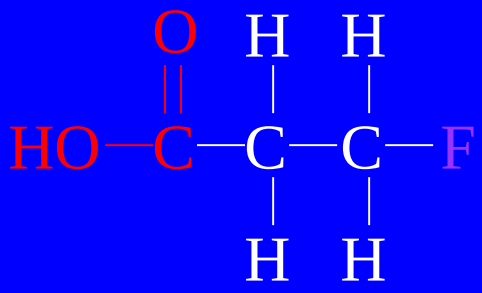
- R-COOH or R-CO_2H
- This is a carbon to oxygn double bond with the same carbon single-bonded to an OH group.
- Name as normal except give it the suffix “-anoic acid”.



Carboxylic Acids

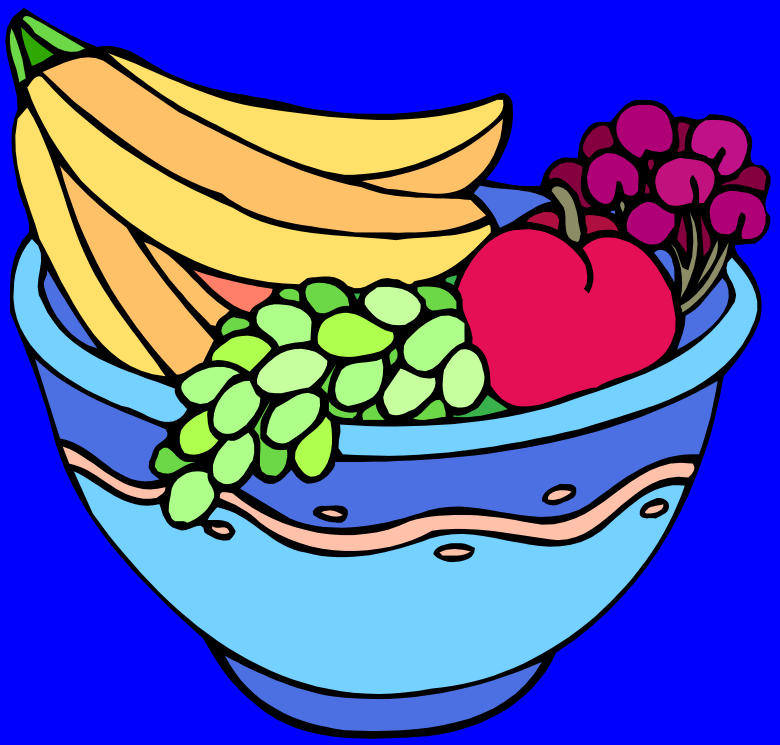


But**anoic acid**



3-Fluoroprop**anoic acid**

Esters

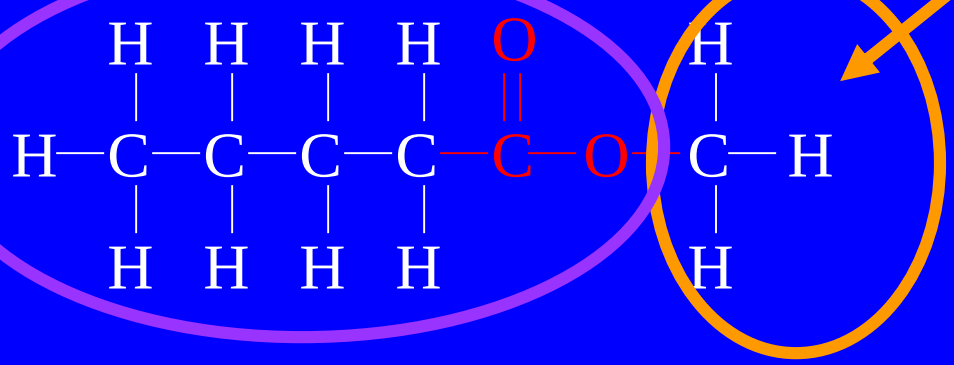


- R-COO-R
- This is a carbon to oxygen double bond with a carbon to oxygen single bonded to another single bonded carbon
- Name by given secondary branch “-yl” suffix and main branch “-anoate” suffix.

Esters

Main Branch

Secondary Branch

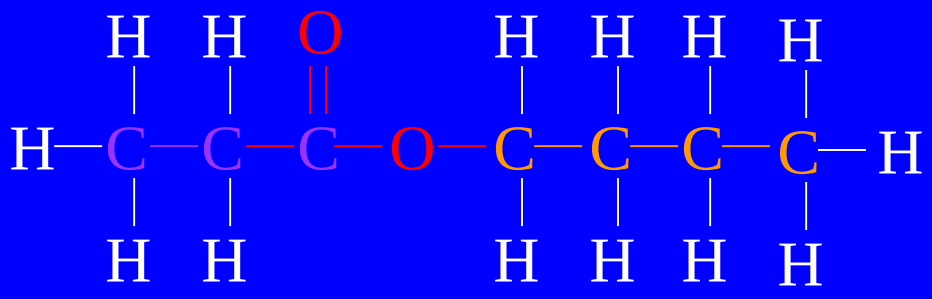


pentanoate

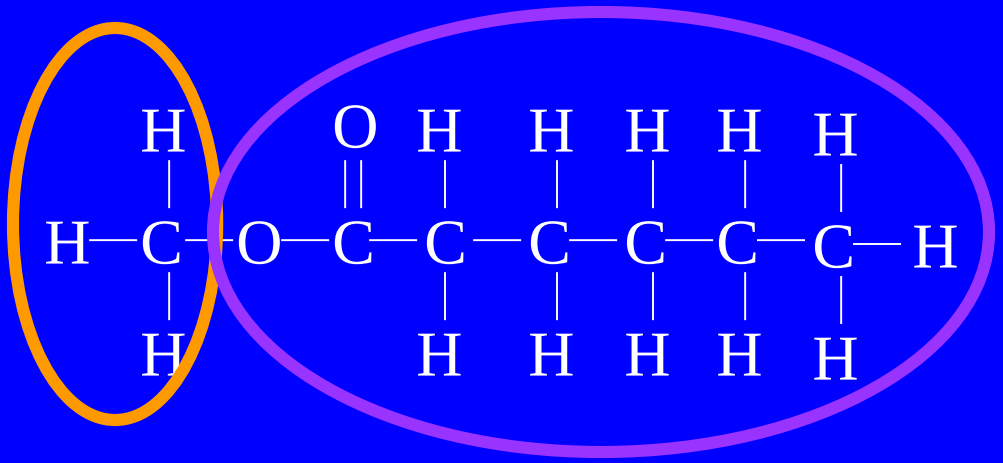
methyl

Methyl Pentanoate

Esters

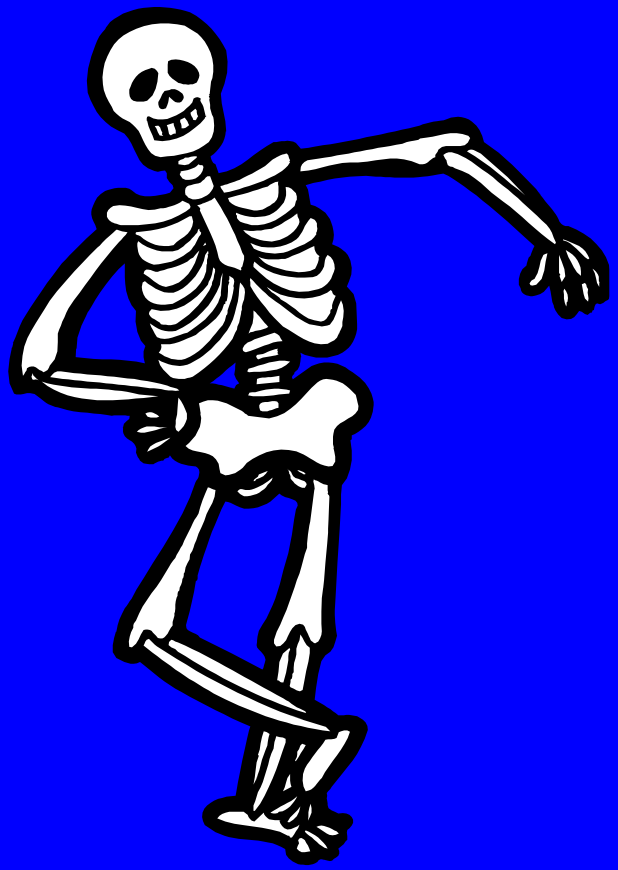


Butyl propanoate



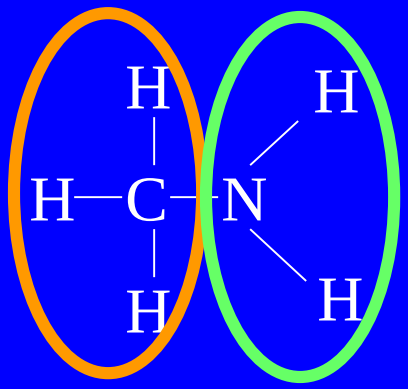
Methyl hexanoate

Amines

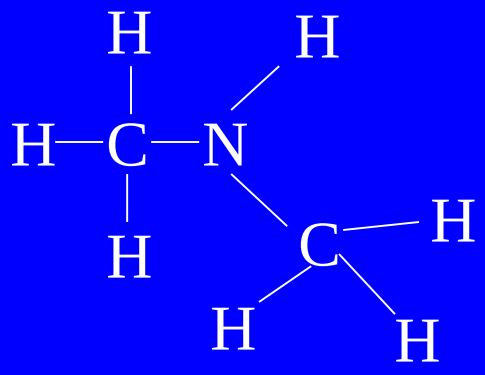


- $R\text{-}NH_2$
- Name the “R” group or groups with “-yl” endings
- Add the word “amine”

Amines



Methyl amine



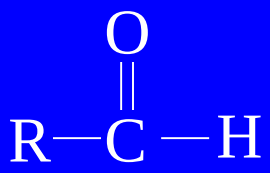
Dimethyl amine

Summary

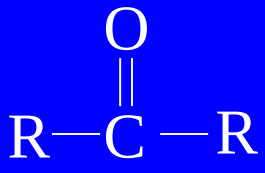
Halide

Alcohol

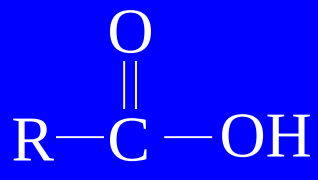
Ether



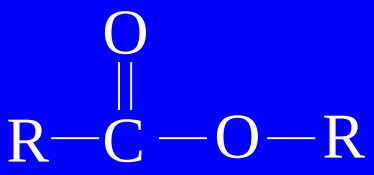
Aldehyde



Ketone



Carboxylic Acid



Ester

Amine

Summary

• Alkanes	• -	“-ane”
• Alkenes	• =	“-ene”
• Alkynes	• ≡	“-yne”
• Halides	• R-X	“-o”
• Alcohols	• R-OH	“-ol”
• Ethers	• R-O-R	“-yl ether”
• Aldehydes	• R-COH	“-al”
• Ketones	• R-CO-R	“-one”
• Carboxylic Acids	• R-COOH	“-anoic acid”
• Esters	• R-COO-R	“-yl” “-anoate”
• Amines	• R-NH_2	“-yl amine”

Can You Do This?

- YES!
- It takes:
- Memorization
- Practice
- Practice
- Practice
- Practice
- And, oh yes…
- Practice!