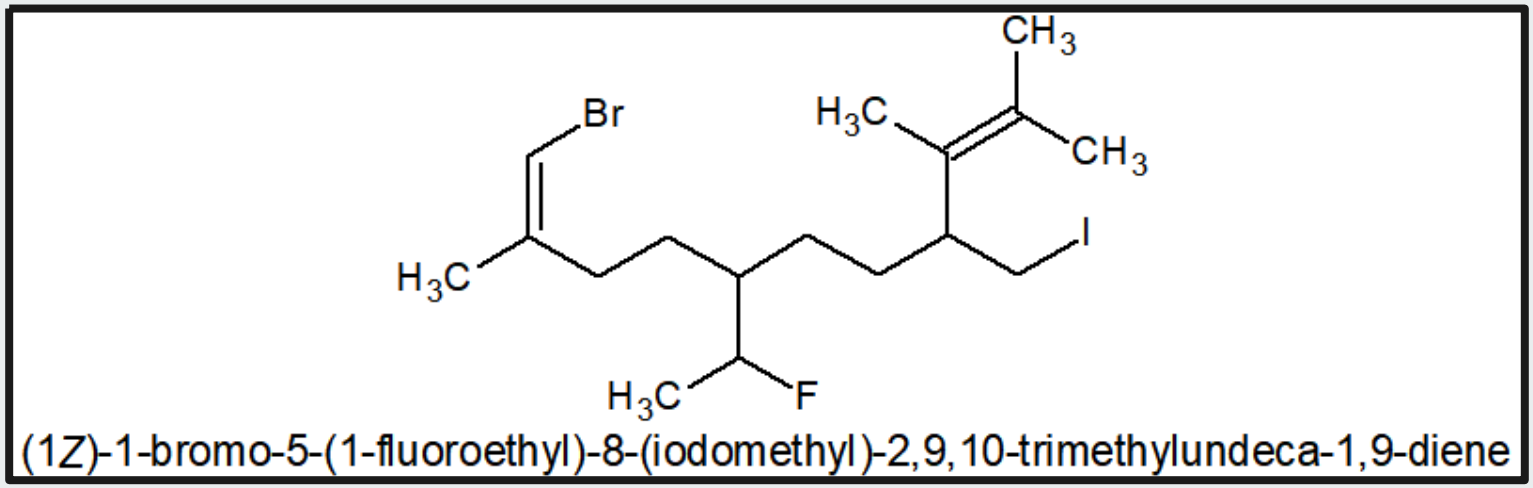
Organic Chemistry - Chapter 5 Nomenclature



(1*Z*)-1-bromo-5-(1-fluoroethyl)-8-(iodomethyl)-2,9,10-trimethylundeca-1,9-diene

The “art” of the IUPAC system in organic chemistry
Because doesn’t that look like fun?!?

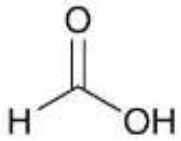
What is IUPAC and why do we “need” it?

- In 1892, as the number of known molecules grew, chemists decided that a SYSTEMATIC naming system was needed
- **IUPAC system** – International Union of Pure and Applied Chemistry
- We can learn the IUPAC system instead of having to memorize a common name for every molecule

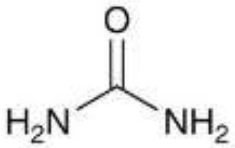
IUPAC

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

- Many organic compounds have common names

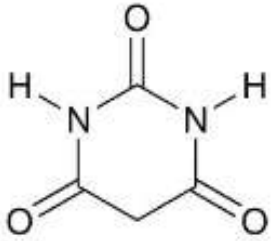


Formic acid
Isolated from ants and named after the Latin word for ant, *formica*



Urea
Isolated from urine

Morphine
A painkiller named after the Greek God of dreams, Morpheus



Barbituric acid
Adolf von Baeyer named this compound in honor of a woman named Barbara

- Some common names have been used for hundreds of years and are still frequently used.

How does it work?

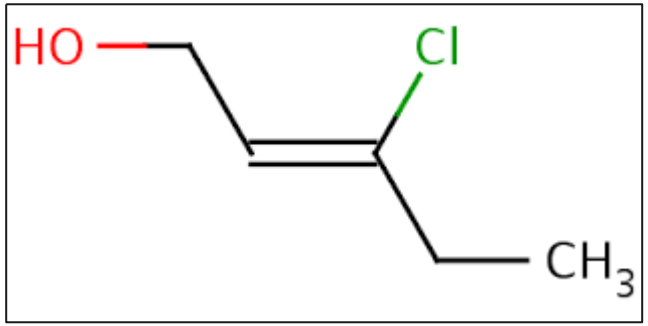
There are 5 parts to every name:

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

- ***Stereoisomerism*** - provides info about double bonds (cis/trans or E/Z) as well as stereocenters (R/S - learned later)
- ***Substituents*** - groups coming off of the main parent chain (like branches)
- ***Parent chain*** - the main chain of carbons
- ***Unsaturation*** - identifies all single bonds or if there are any double or triple bonds present
- ***Functional Group*** - the group of atoms for which the molecule is named

We will begin at the end of the name and work our way back through all 5 parts!
But first, let's see an example on the next slide

Example!



Imagine trying to name this compound so that EVERY time that name was used someone knew exactly what it was.

EX: “You know it’s got a double bond with a Cl and an OH”

That would not be very effective!

IUPAC Name: Z-3-chloropent-2-en-1-ol

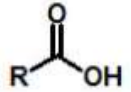
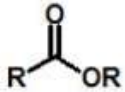
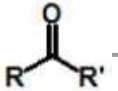
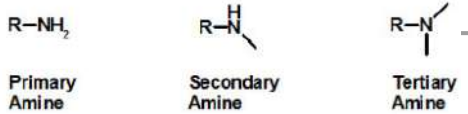
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups
Z	**3-chloro**	**pent**	**2-en**	**1-ol**

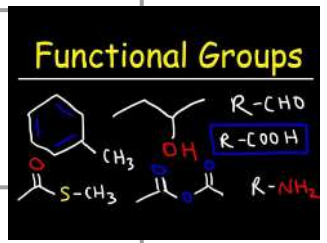
Section 5.1: Functional Groups

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

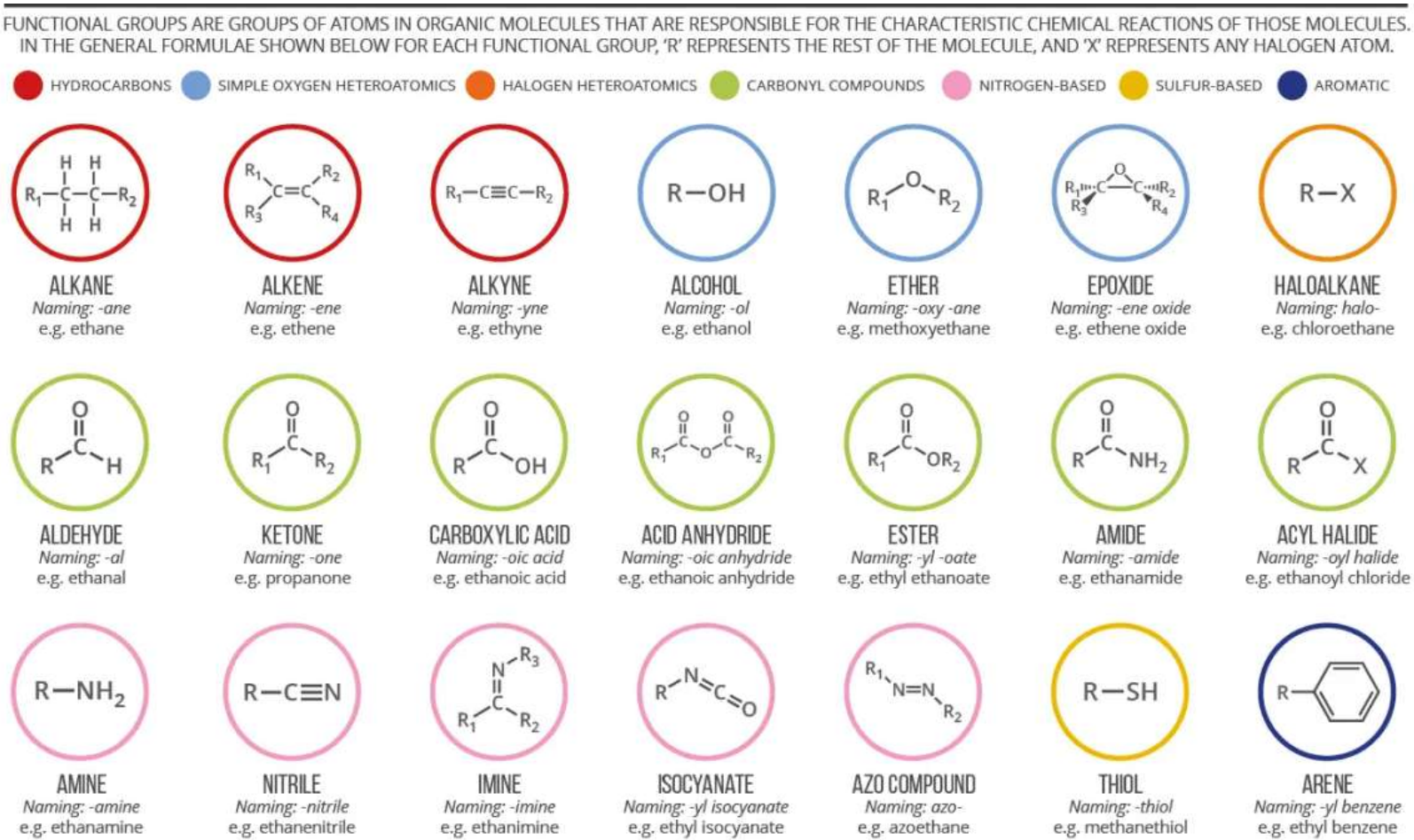
- **Functional group** - specific arrangements of atoms that have specific characteristics for reactivity
    - EX: - OH groups that are attached to a molecule all react similarly and are collectively called “alcohols”
    - Most textbooks are arranged according to functional groups so their common reactions can be studied
    - There are dozens of functional groups, but we will focus on 6 (and probably see some extras!)
- Each functional group has a specific suffix
- They occur in a hierarchy - only one functional group can get the “suffix” portion of the name
    - Additional functional groups are named in the substituent section of the name
    - Multiple functional groups: use di, tri, tetra, penta, hexa, etc… before suffix - **EX:** 2 alcohols = “-diol”

Functional Groups In Order

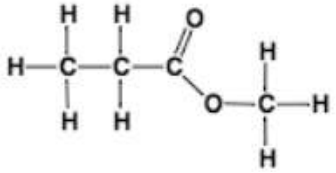
Hierarchy	Functional Group	Class of Compound	Suffix
1	Abbreviation: -COOH 	Carboxylic acid	-oic acid
2		Ester	-oate
3	Abbreviation: -CHO 	Aldehyde	-al
4		Ketone	-one *(pronounced"own")*
5		Alcohol	-ol
6	 Primary Amine Secondary Amine Tertiary Amine	Amine	-amine
NO Functional Group			-e

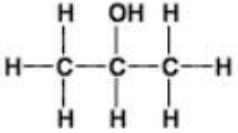


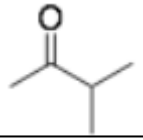
Additional "Functional" groups *(some on the image are not technically FG's)*

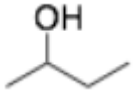


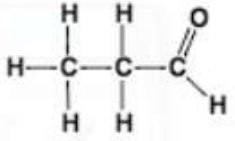
5.1 Practice - Identify the functional group and the suffix that would be used

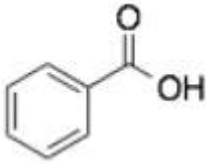


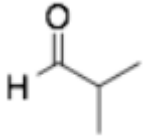


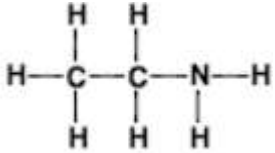


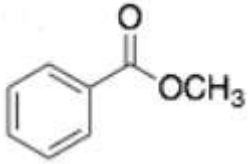








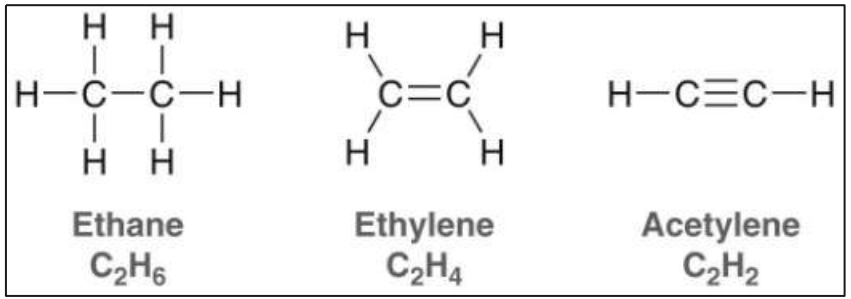




Section 5.2: Unsaturation

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

- **Unsaturation** - this region describes if there are any **carbon-carbon** double or triple bonds present in the molecule (or all single bonds)
  - Having multiple bonds means the carbons will be attached to fewer H atoms *(therefore the carbons are NOT "saturated")*
  - Formula "trick":
    - All single bonds: $C_xH_{(2x+2)}$
    - Double bond means 2 *fewer* H's: $C_xH_{(2x)}$
    - Triple bond means 4 *fewer* H's: $C_xH_{(2x-2)}$

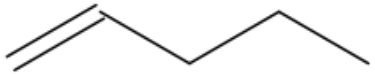


Note: *These multiple bonds are separate from ones we might see in functional groups! Those are not C-C multiple bonds and are already accounted for by using the functional group suffix!*

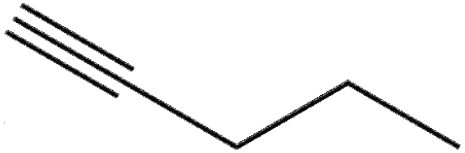
Section 5.2: Unsaturation

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Pentane



Pentene



Pentyne

What "Unsaturation" Tells Us:

- **All single bonds** = "an"
- **Double bond** = "en" *(pronounced "een")*
- **Triple bond** = "yn" *(pronounced "ine")*

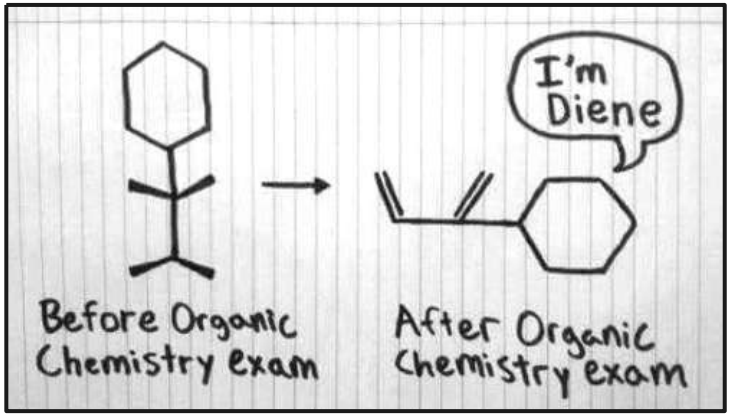
Things to notice:

1. They all have "pent"
2. They all end with "e"
3. Triple bonds are drawn linear
4. None have substituents
5. None have stereoisomerism

Section 5.2: Multiple double and/or triple bonds

- For multiple double or triple bonds we use these prefixes with the unsaturation term:
  - di = 2
  - tri = 3
  - tetra = 4
  - penta = 5
  - hexa = 6
  - (would continue with hepta, octa, nona, deca…)

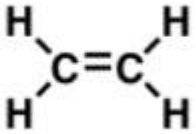
    - EXAMPLES:
      - two double bonds = “-dien-”
      - three double bonds = “-trien-”
      - five triple bonds = “-pentayn-”

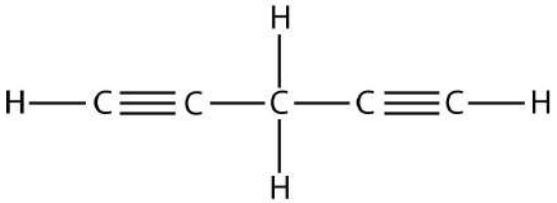


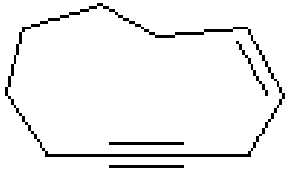
- **NOTE: double bonds always get listed first!** We must be explicit in addressing how many double and triple bonds are present. *(everything else is assumed to be single bonds)*

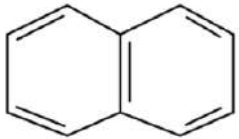
Section 5.2: Practice with Unsaturation

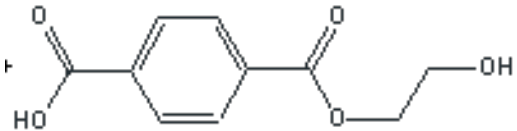
- Write the unsaturation portion of the name!

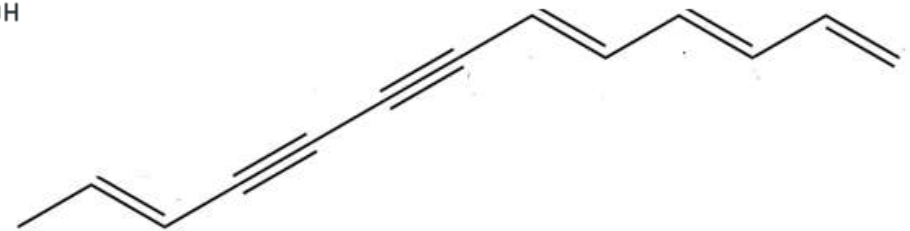








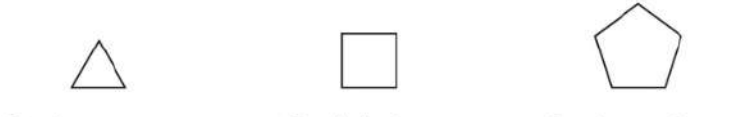




Section 5.3: Parent Chain

- **Parent Chain** - the root of the name that is based off of the longest *consecutive chain* of carbons, making sure to **include** the following groups, if present, **in this order**:
    1. Functional group
    2. Double bond
    3. Triple bond

Note: *if the carbon atoms are in a ring*, we add the term "cyclo"
EX: ring of 6 C's = "cyclohex"



Helpful Saying:
"My Evil Puppy Bites People Horribly Hard On Nasty Days!"

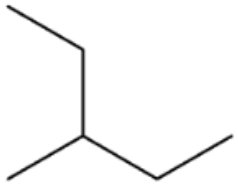
Longest Chain of C's	Parent Chain Name
1	meth
2	eth
3	prop
4	but
5	pent
6	hex
7	hept
8	oct
9	non
10	dec

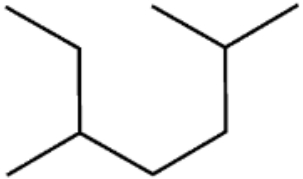
Section 5.3: How to find the Parent Chain (no FG)

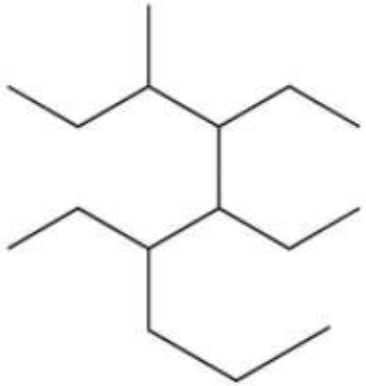
Pick a “starting” point and begin counting as many carbons in a row as you can (it can go L to R, down to up, the direction doesn’t matter!)

- Just don’t “backtrack” over a carbon
- **EX:** choose the parent chain for each

NUMBER OF CARBON ATOMS	PARENT
11	*undec*
12	*dodec*
13	*tridec*
14	*tetradec*





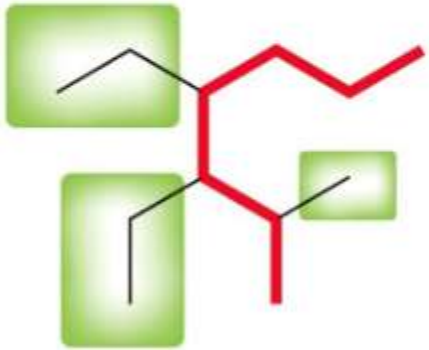


Section 5.3: What about ties?

– If there is more than one possible parent chain, choose the one with the most substituents attached

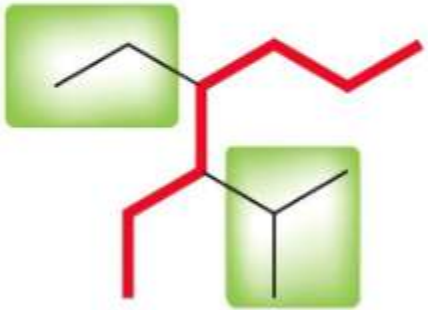
What is the parent name for this compound?

Correct
(3 substituents)



Parent has 7 carbon atoms

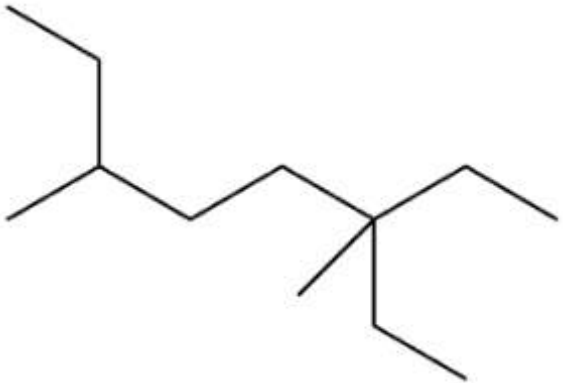
Incorrect
(2 substituents)

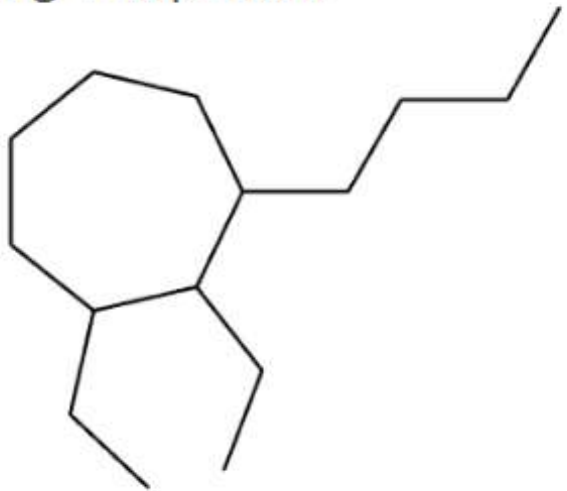


Parent has 7 carbon atoms

Section 5.3: How to find the Parent Chain (no FG)

- Give the parent name for the following compounds

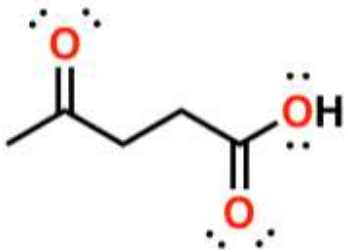


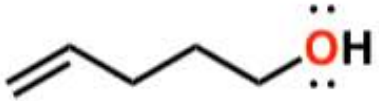


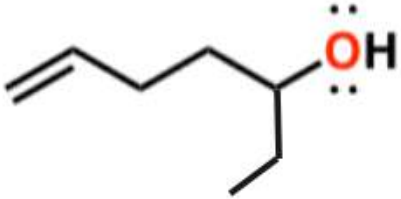
  - The parent name may <u>NOT</u> include carbons that are both in a ring and outside a ring.

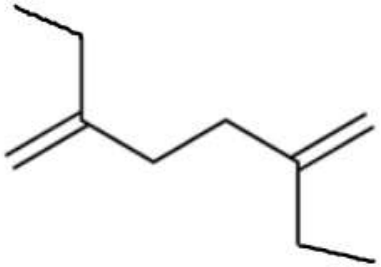
Section 5.3: Practice Finding the Parent Chain

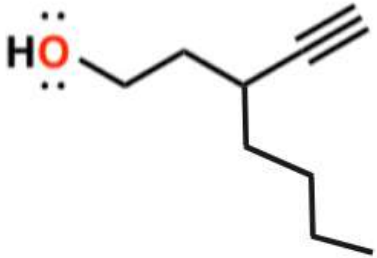
Make sure you parent chain includes **functional groups**, then **multiple bonds**, if present











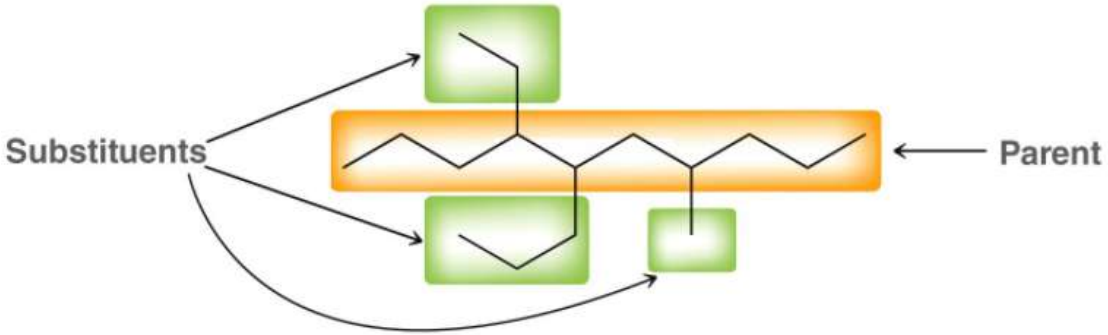
Section 5.4: Naming Substituents

Substituents: everything that is connected to the parent chain that is NOT covered under the main functional group suffix

Alkyl Substituents: these are branches of carbon groups (single bonded)

- **Add "yl"** to the same terminology we would use for the parent chain

EX:

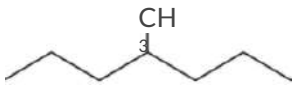


Number of C's in Sub.	Substituent name
1	methyl
2	ethyl
3	propyl
4	butyl
5	pentyl
6	hexyl
7	heptyl
8	octyl
9	nonyl
10	decyl

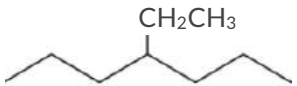
Section 5.4

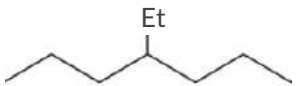
Alternative ways to list/show substituents:

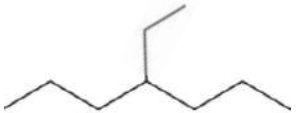
- **Methyl** groups can be shown as:
  - EX:



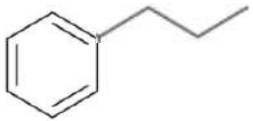
- **Ethyl** groups can be shown as:
  - EX:

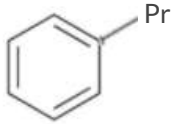






- **Propyl** groups are usually drawn out, but could be written as “-Pr”
  - EX:

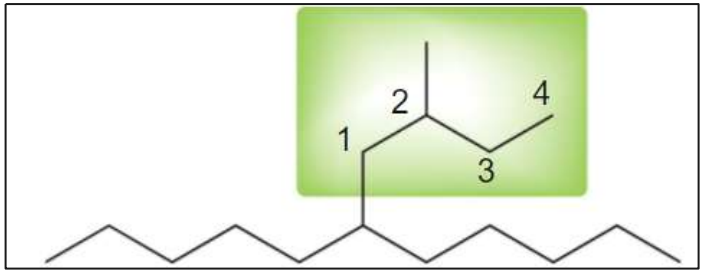




Section 5.4

How to name "Complex Branched" Substituents: *This is a little more than what we will get to in our HS organic course, but is most-definitely on the "college" plate! I just want you to have **seen** this!*

We will only use some of the "common names for branched substituents" from the following slide.



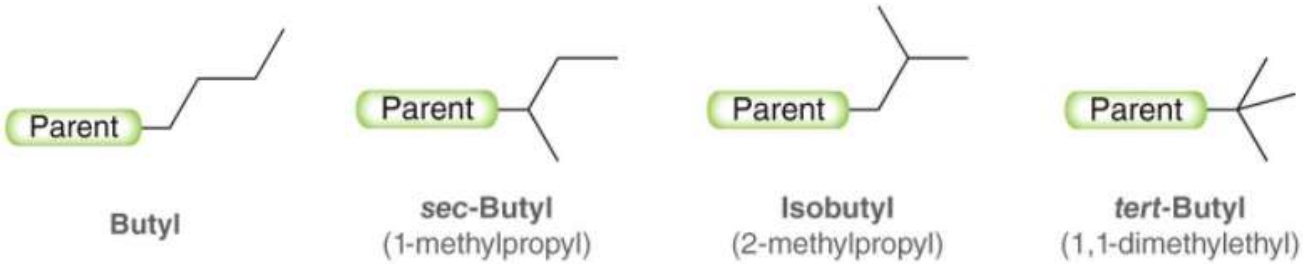
1. Number the longest carbon chain WITHIN the substituent. *Start with the carbon directly attached to the main chain*
2. Name the "parent chain" of the substituent *(in this case butyl)*
3. Name and Number the substituent's side group *(in this case 2-methyl)*
4. The name of the whole substituent is *(2-methylbutyl)*

Section 5.4

Common Names for "Branched" Substituents: You WILL need to know these common names!

- 3 Carbon Group Variations
  - EX:

- 4 Carbon Groups Variations
  - EX:



Section 5.4 - How to name functional groups as substituents

When a molecule has **more than one type of functional group, the lower-hierarchy functional group will be "picked up" in this portion of the name*

Functional Group Name	How it is Named as a Substituent
aldehyde	-aldo-
ketone	-keto-
alcohol	-hydroxy-
amine	-amino-

Section 5.4 - How to name Halogens as substituents

Halogens = group 17 elements

(Basically - add "o" to the end of the halogen's root name)

Halogen	How it is Named as a Substituent
F	-fluoro-
Cl	-chloro-
Br	-bromo-
I	-iodo-

Section 5.4 Final Points

- **For multiple substituents of the same kind we use the same prefixes as we did previously:**

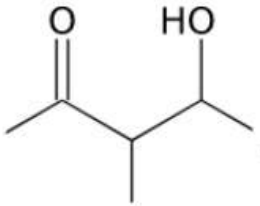
  di, tri, tetra, penta, hexa, hepta, etc...

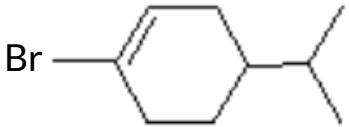
- **Each and every substituent needs to be numbered so that we know where it goes on the parent chain** *(more on that once we cover stereoisomerism)*
- **Substituents should be listed in ABC order** *(from the root of their name, more info later)*

Section 5.4 Practice

- **For each molecule, list out all of the info we have learned so far about it**

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups





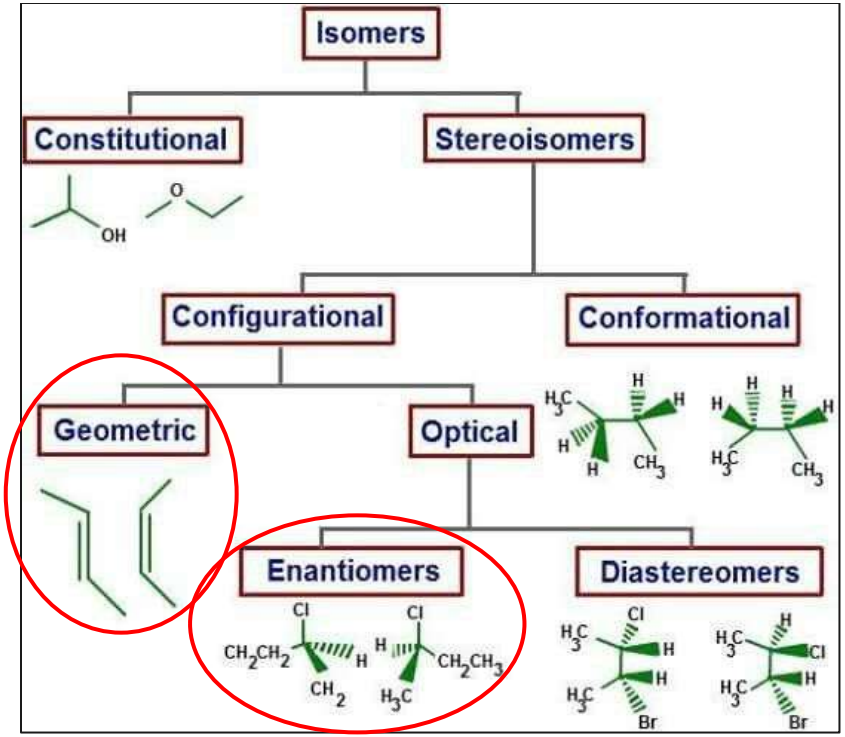
Section 5.5 Stereoisomerism

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Stereoisomerism is the first part of many names but may not always be present!
It describes the different spatial (3D) arrangements of the atoms in isomers

Isomers: atoms that have the same chemical formula (numbers & types of atoms) but are arranged differently

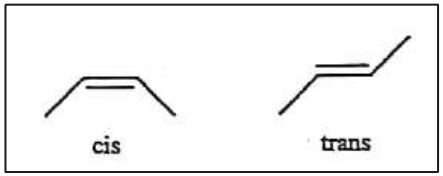
**Many different types, we will be looking at geometric isomers for double bonds and enantiomers*



Section 5.5 Stereoisomerism

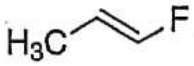
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

1. **Double bonds** can have alternate arrangements/configurations
   a. Due to overlapping p-orbitals "lock" the atoms in place *(unlike single bonds which can freely rotate)*
   b. To use **cis** or **trans**, they must have identical groups ***on either side*** of the double bond that can be compared



Examples:

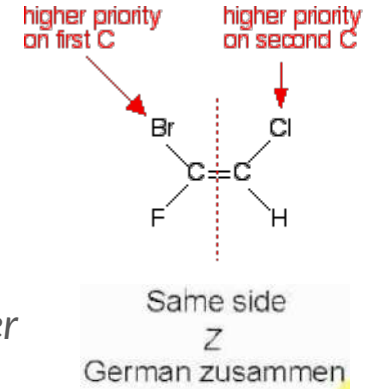
   c. The two groups **can** be hydrogen:

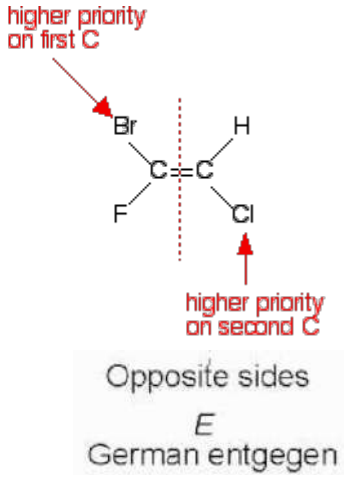


Section 5.5 Stereoisomerism

EXCEPTIONS to the cis/trans terminology:

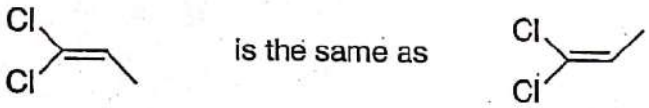
A. Cis/trans has limitations. What if you don't have 2 identical groups opposite of one another?
   - We use E for "**E**pposite side"
   - Or Z for "**Z**ame side" of groups.





   - **This method works for ALL double bonds**
   - **We learn the priorities of these in a later chapter*

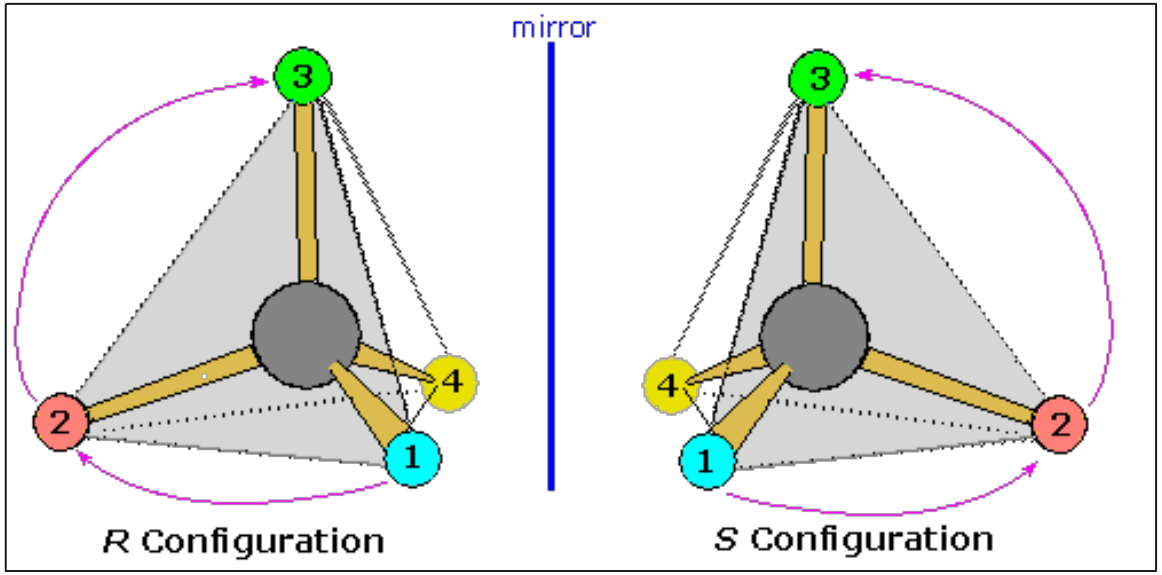
A. If there are 2 identical groups attached to the ***same C atom***
   - EX:



Section 5.5 Stereoisomerism

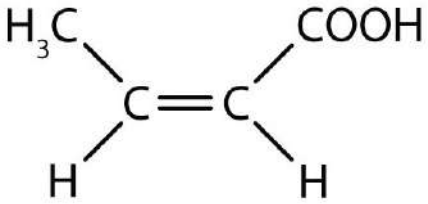
2. Stereocenters *(carbons attached to 4 diff. "things" - we will learn about this later. I'll tell you if it is R or S for now, just get the general idea of it below)*

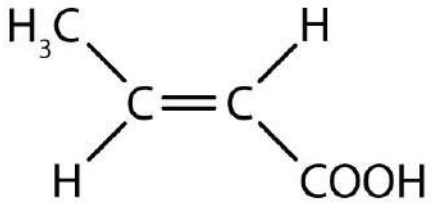
- Uses **R** for "right handed" rotation (clockwise)
- Uses **S** for "left handed" rotation (counter-clockwise)

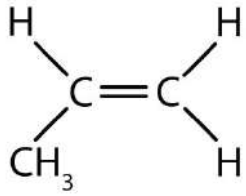


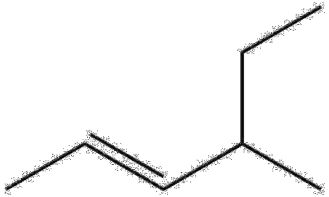
Section 5.5 Practice

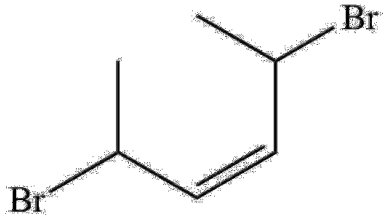
Determine if the double bonds are cis, trans, or neither







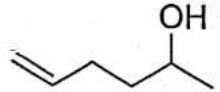


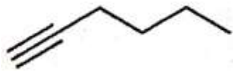


Section 5.6 Numbering

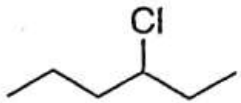
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

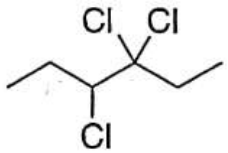
- Numbering applies to ALL parts of the name!
- When numbering the parent chain, we use the same hierarchy as we did to pick it:
  - Functional group
  - Double bond
  - Triple bond
- Make sure the “lower number” option give priority in the order above

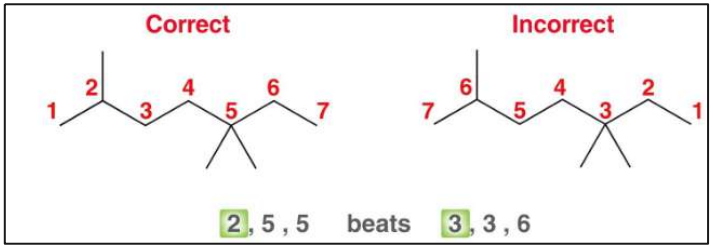




- **If NONE of them are present, simply number so that the total of the substituents has the lowest value*

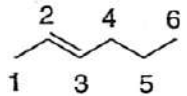






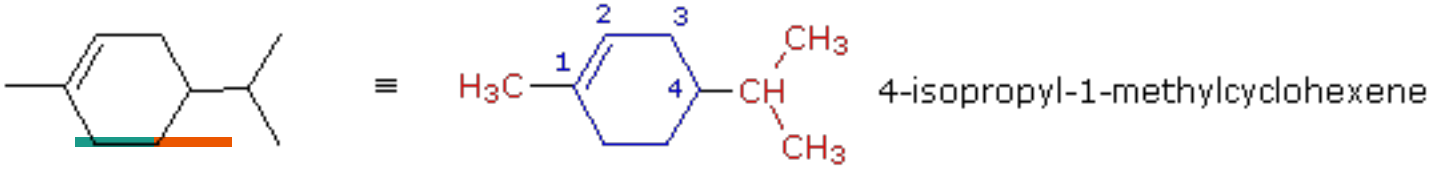
Section 5.6 How to place numbers in names

- **General Number "Rules"**
  - Everything needs numbered!
    - *Except a functional group or double bond if it is on the **first carbon only***
    - If you have multiples of a part of the name, then EACH needs numbered
      - EX: "-2,4,6-trimethyl"
  - Use **-** (hyphen)between #'s and letters
  - Use **,** (comma) between multiple numbers

- ***Functional Group*** - place the number in front of the suffix
- ***Unsaturation*** - use only the lower of the carbon's number on the parent chain
  - EX: 

- ***Substituents*** - place directly in front of each substituent
- ***Stereoisomerism*** - if more than one double bond we have to indicate each with a number. If there is only one double bond we can just put *cis* or *trans* / E or Z out front. Stereocenters, (R or S) are placed in parentheses.

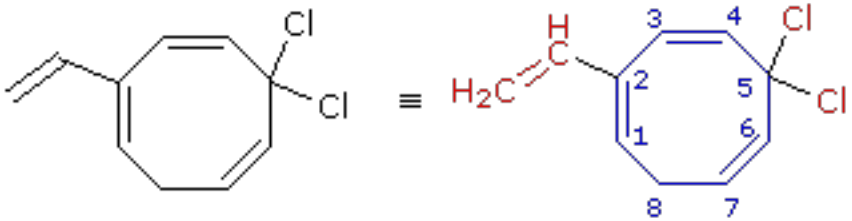
Worked-out Examples to reference



4-isopropyl-1-methylcyclohexene

1-cyclobutyl-3-methyl-1-butyne

1-cyclodecen-4-yne

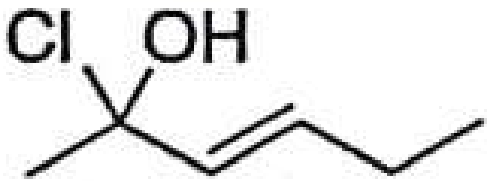


5,5-dichloro-2-vinyl-1,3,6-cyclooctatriene

Section 5.6 Practice - Putting it all together

1. **Name the molecule!**

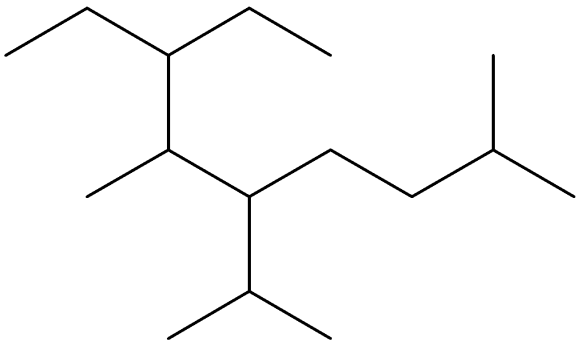
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

2. Name the molecule!

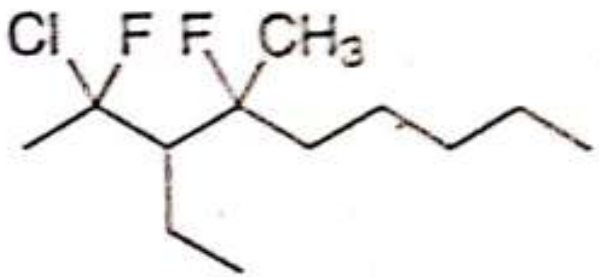
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

3. Name the molecule!

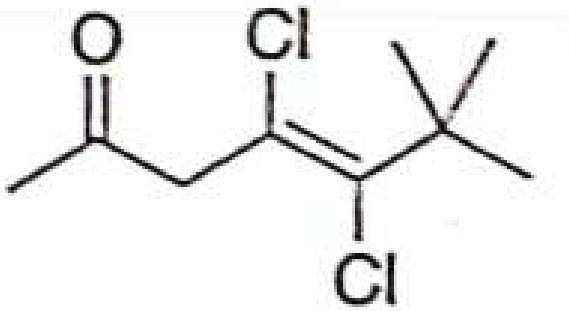
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

4. Name the molecule!

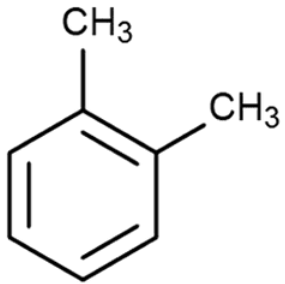
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

5. Name the molecule!

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

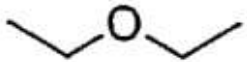


Practice with “rings” of carbons!

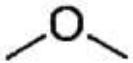
Section 5.7 Common Names

- Most of these names are so common, you may never hear anyone use their IUPAC name! It is important to familiarize yourself with them.

- SPECIAL NOTE ON ETHERS:
  - The common way to name ethers is to place the group on "either" side of the O is named as a substituent before the term "ether"

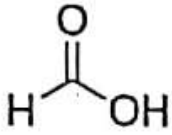


Diethyl ether
(also just ethyl ether)

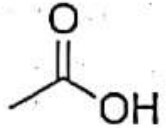


Dimethyl ether

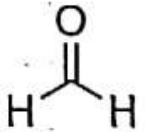
  - The IUPAC method would be to treat the O like a C and use the term -oxa. So diethyl ether would be 3-oxapentane *(but no one calls it that!)*



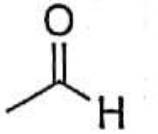
IUPAC name: methanoic acid
Common name: formic acid



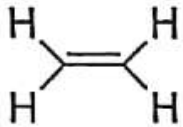
IUPAC name: ethanoic acid
Common name: acetic acid



IUPAC name: methanal
Common name: formaldehyde



IUPAC name: ethanal
Common name: acetaldehyde



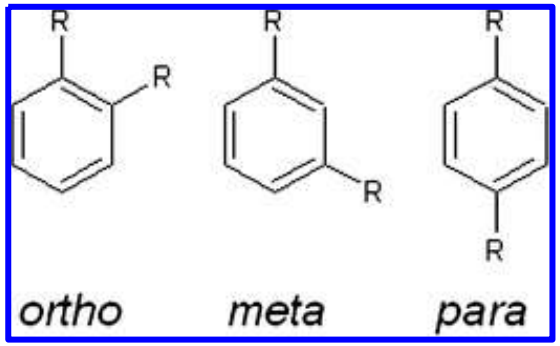
IUPAC name: ethene
Common name: ethylene

IUPAC name: ethyne
Common name: acetylene

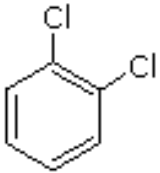
5.7 Common names of “di-substituted” Rings!

Sometimes Rings use some special terminology. *You are not required to know this for HS O-Chem, but you will for college!*

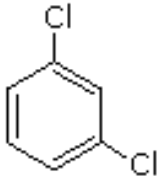
**You may see this on Nomenclature WS #5*



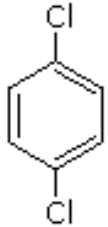
Conjugated double bond cyclohexanes are also called ***benzene*** *rings*



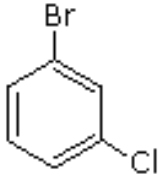
1,2-dichlorobenzene
ortho-dichlorobenzene
o-dichlorobenzene



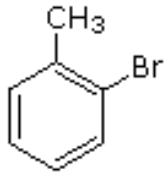
1,3-dichlorobenzene
meta-dichlorobenzene
m-dichlorobenzene



1,4-dichlorobenzene
para-dichlorobenzene
p-dichlorobenzene



1-bromo-3-chlorobenzene
meta-chlorobromobenzene
m-chlorobromobenzene



2-bromotoluene
ortho-bromotoluene
o-bromotoluene

Section 5.8 Going from a Name to a Structure

Draw out the molecule! (MUCH EASIER!)

1. 2,4-dimethylcyclopent-1-ene **Note you could also see:* 2,4-dimethylcyclopentene

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Section 5.8 Going from a Name to a Structure

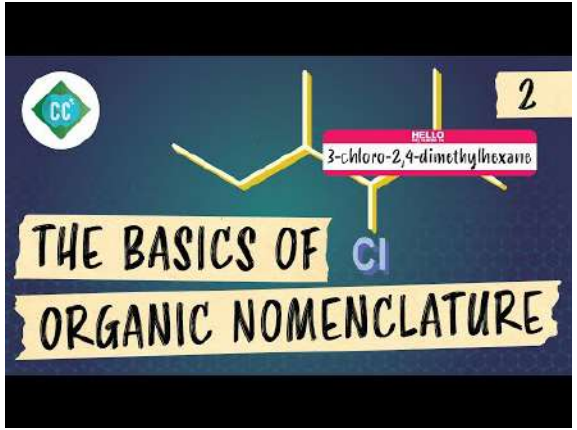
Draw out the molecule! (MUCH EASIER!)

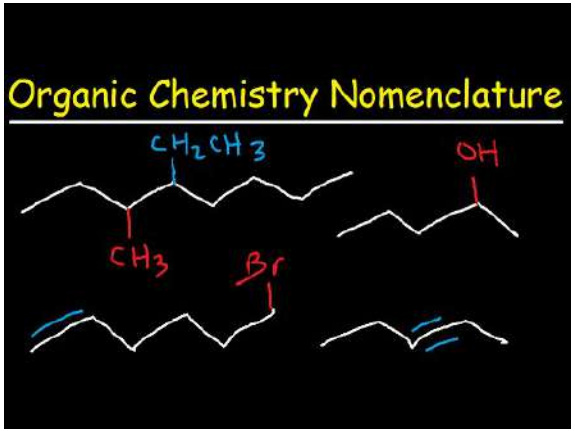
2. *trans*- 6-hydroxy-3,4-dimethyloct-3-enal

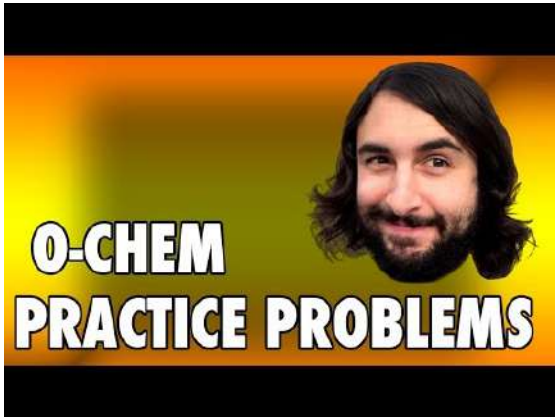
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

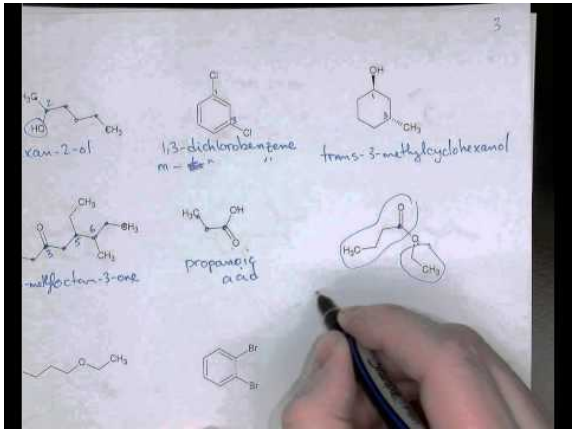
Helpful Video Resources!

Professor Dave Explain has MANY videos on his playlist for various parts of organic nomenclature. CLICK HERE to check out the list!

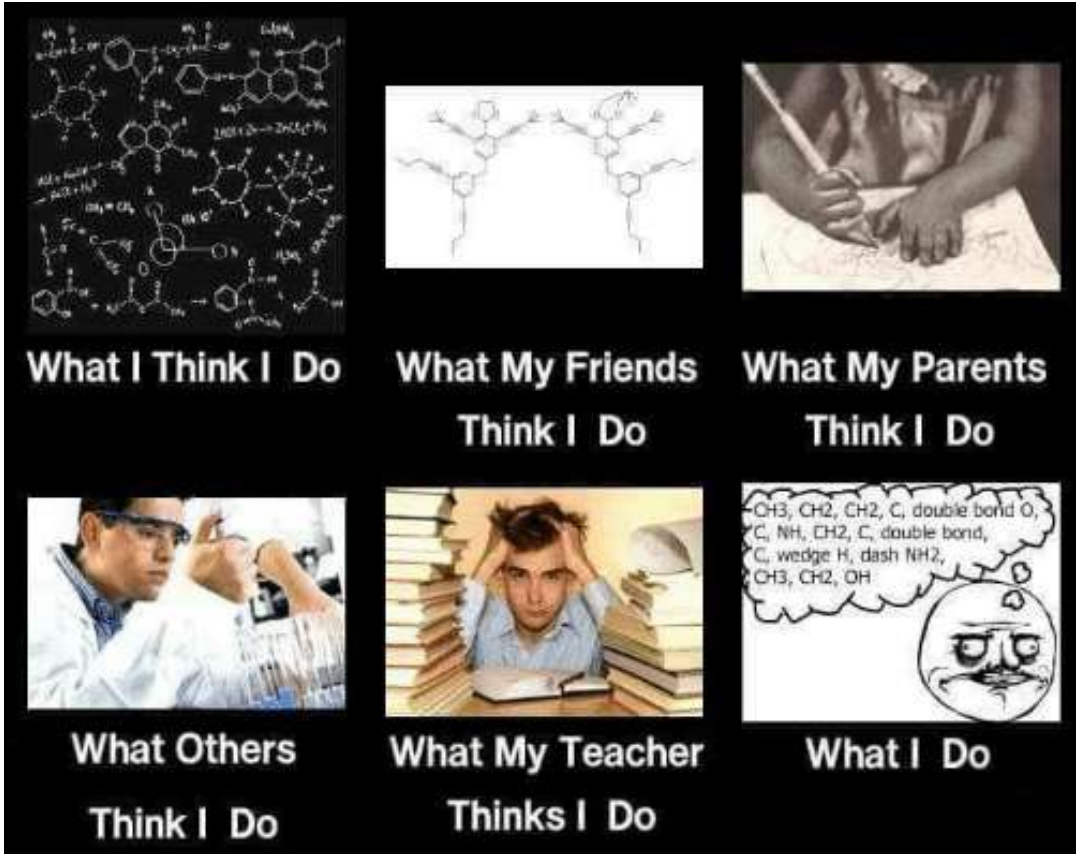








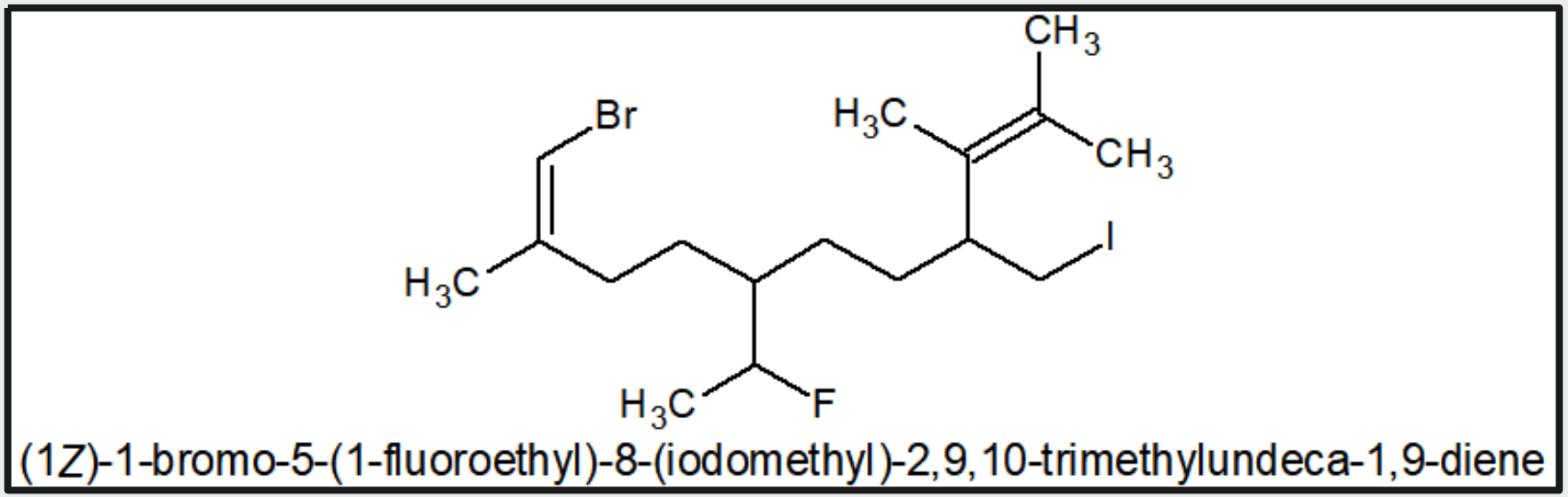
CONGRATULATIONS! YOU HAVE REACHED THE END OF CHAPTER 5!!!!!



Student Version of Slides to Follow

Organic Chemistry
Chapter 5 - Nomenclature Notes

Name: _____



(1*Z*)-1-bromo-5-(1-fluoroethyl)-8-(iodomethyl)-2,9,10-trimethylundeca-1,9-diene

The "art" of the IUPAC system in organic chemistry
Because doesn't that look like fun?!?

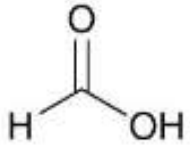
What is IUPAC and why do we “need” it?

- In [ ] as the number of known molecules grew, chemists decided that a [ ] naming system was needed
- **IUPAC system** – [ ]
  [ ]
- We can learn the IUPAC system instead of having to memorize a common name for every molecule

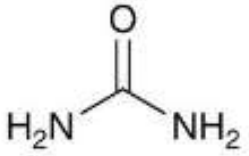
IUPAC

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

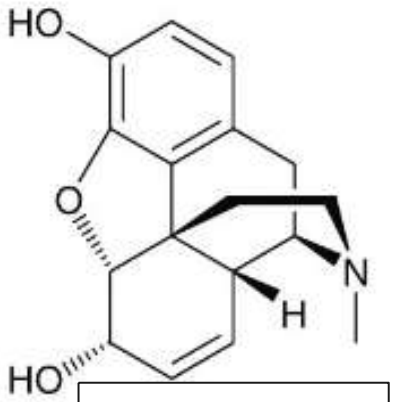
- Many organic compounds have common names



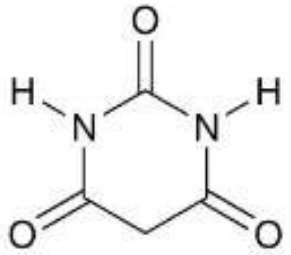
Isolated from ants and named after the Latin word for ant, *formica*



Isolated from urine



A painkiller named after the Greek God of dreams, Morpheus



Adolf von Baeyer named this compound in honor of a woman named Barbara

- Some common names have been used for hundreds of years and are still frequently used.

How does it work?

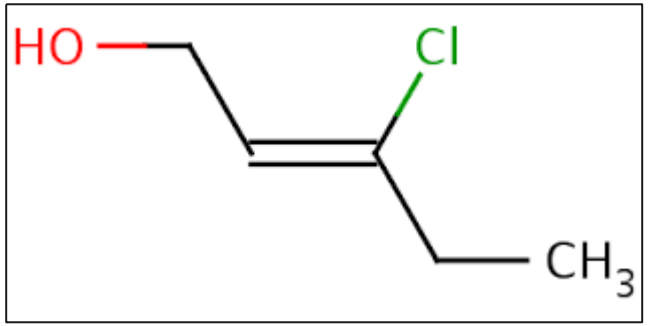
There are 5 parts to every name:

- ***Stereoisomerism*** - provides info about _____ (cis/trans or E/Z) as well as _____ (R/S - learned later)
- ***Substituents*** - g_____(like branches)
- ***Parent chain*** - the _____
- ***Unsaturation*** - identifies all _____ bonds or if there are any _____ or _____ bonds present
- ***Functional Group*** - the _____ of _____ for which the molecule is named

We will begin at the _____ of the name and work our way back through all 5 parts!

But first, let's see an example on the next slide

Example!



Imagine trying to name this compound so that EVERY time that name was used someone knew exactly what it was.

EX: “You know it’s got a double bond with a Cl and an OH”

That would not be very effective!

IUPAC Name: Z-2-chloropent-2-en-1-ol

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Section 5.1: Functional Groups

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

- _____ - specific arrangements of atoms that have specific characteristics for reactivity
    - EX: - OH groups that are attached to a molecule all react similarly and are collectively called “alcohols”
    - Most textbooks are arranged according to functional groups so their common reactions can be studied
    - There are dozens of functional groups, but we will focus on 6 (and probably see some extras!)
- Each functional group has a specific _____
- They occur in a _____ - only one functional group can get the “suffix” portion of the name
    - Additional functional groups are named in the _____ section of the name
    - Multiple functional groups: use _____, _____, _____, _____, _____, etc… before suffix -
        - **EX:** 2 alcohols = “-diol”

Functional Groups In Order

Hierarchy	Functional Group	Class of Compound	Suffix
1	Abbreviation: -COOH		
2			
3	Abbreviation: -CHO		
4			*(pronounced“own”)*
5			
6			
NO Functional Group			

Additional "Functional" groups *(some on the image are not technically FG's)*

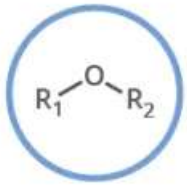
HYDROCARBONS · SIMPLE OXYGEN HETEROATOMICS · HALOGEN HETEROATOMICS · CARBONYL COMPOUNDS · NITROGEN-BASED · SULFUR-BASED · AROMATIC

ALKANE
Naming: -ane
e.g. ethane

ALKENE
Naming: -ene
e.g. ethene

ALKYNE
Naming: -yne
e.g. ethyne

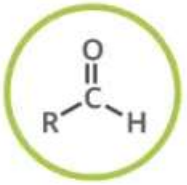
ALCOHOL
Naming: -ol
e.g. ethanol



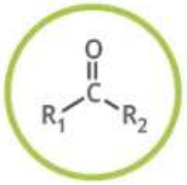
ETHER
Naming: -oxy -ane
e.g. methoxyethane

EPOXIDE
Naming: -ene oxide
e.g. ethene oxide

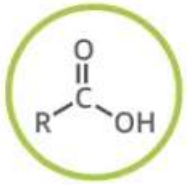
HALOALKANE
Naming: halo-
e.g. chloroethane



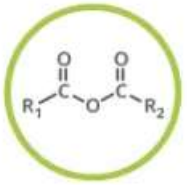
ALDEHYDE
Naming: -al
e.g. ethanal



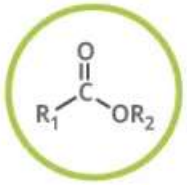
KETONE
Naming: -one
e.g. propanone



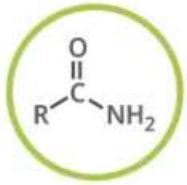
CARBOXYLIC ACID
Naming: -oic acid
e.g. ethanoic acid



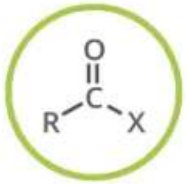
ACID ANHYDRIDE
Naming: -oic anhydride
e.g. ethanoic anhydride



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



AMIDE
Naming: -amide
e.g. ethanamide



ACYL HALIDE
Naming: -oyl halide
e.g. ethanoyl chloride

AMINE
Naming: -amine
e.g. ethanamine

NITRILE
Naming: -nitrile
e.g. ethanenitrile

IMINE
Naming: -imine
e.g. ethanimine

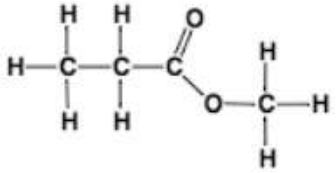
ISOCYANATE
Naming: -yl isocyanate
e.g. ethyl isocyanate

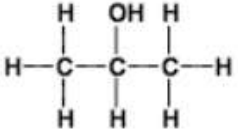
AZO COMPOUND
Naming: azo-
e.g. azoethane

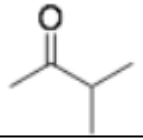
THIOL
Naming: -thiol
e.g. methanethiol

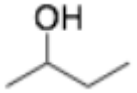
ARENE
Naming: -yl benzene
e.g. ethyl benzene

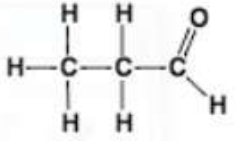
5.1 Practice - Identify the functional group and the suffix that would be used

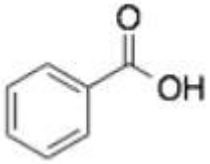


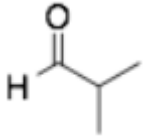


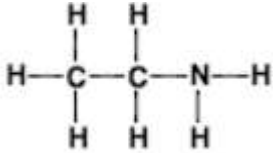


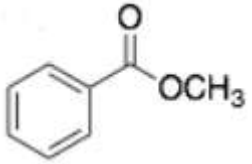








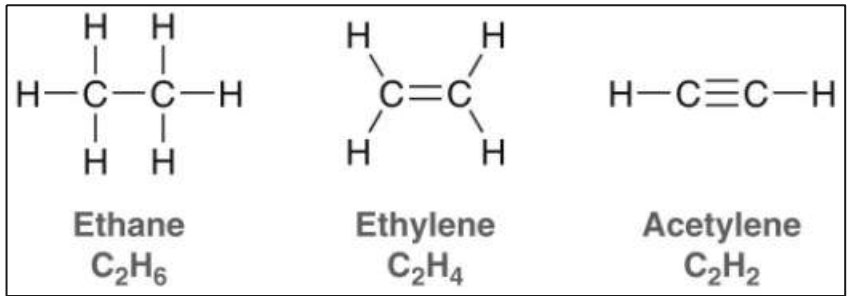




Section 5.2: Unsaturation

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

- _____ - this region describes if there are any _____-_____ double or triple bonds present in the molecule (or all single bonds)
  - Having multiple bonds means the carbons will be attached to fewer H atoms *(therefore the carbons are NOT "saturated")*
  - **Formula "trick":**
    - All single bonds: $C_xH_{(2x+2)}$
    - Double bond means 2 *fewer* H's: $C_xH_{(2x)}$
    - Triple bond means 4 *fewer* H's: $C_xH_{(2x-2)}$

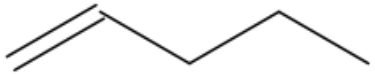


Note: *These multiple bonds are separate from ones we might see in functional groups! Those are not C-C multiple bonds and are already accounted for by using the functional group suffix!*

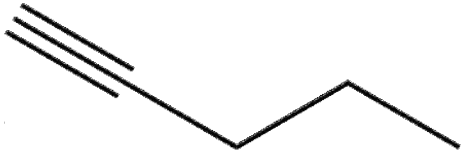
Section 5.2: Unsaturation

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Pent**an**e



Pent**en**e



Pent**yn**e

What "Unsaturation" Tells Us:

- **All single bonds** = "_____"
- **Double bond** = "_____" *(pronounced "een")*
- **Triple bond** = "_____" *(pronounced "ine")*

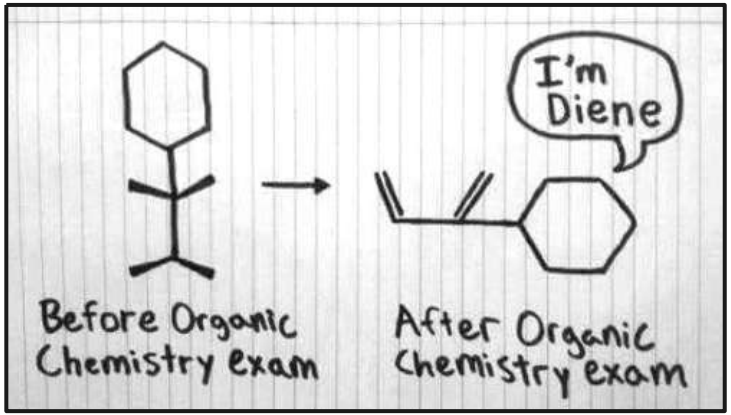
Things to notice:

1. They all have "pent"
2. They all end with "e"
3. Triple bonds are drawn linear
4. None have substituents
5. None have stereoisomerism

Section 5.2: Multiple double and/or triple bonds

- For multiple double or triple bonds we use these prefixes with the unsaturation term:
  - di = 2
  - tri = 3
  - tetra = 4
  - penta = 5
  - hexa = 6
  - (would continue with hepta, octa, nona, deca…)

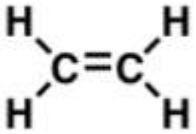
    - EXAMPLES:
      - two double bonds = "-_____-"
      - three double bonds = "-_____-"
      - five triple bonds = "-_____-"

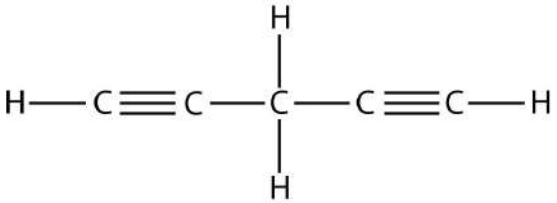


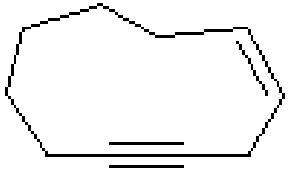
- **NOTE:** _____ **bonds always get listed** _____**!** We must be explicit in addressing how many double and triple bonds are present. ***(everything else is assumed to be single bonds)***

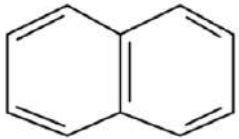
Section 5.2: Practice with Unsaturation

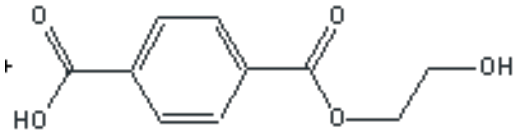
- Write the unsaturation portion of the name!

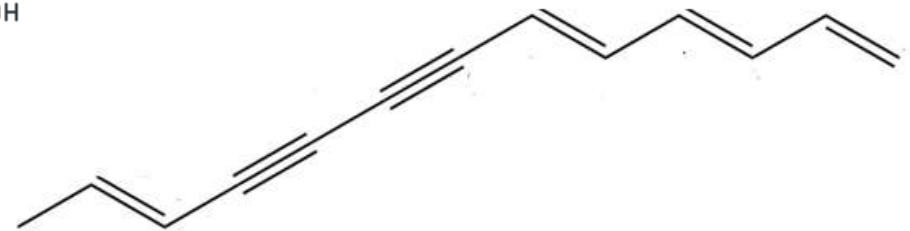








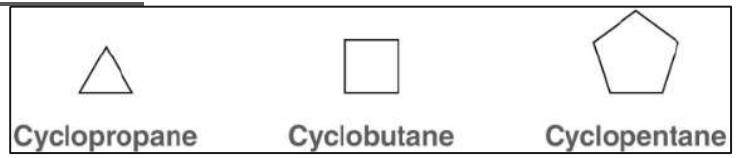




Section 5.3: Parent Chain

- **Parent Chain** - the root of the name that is based off of the longest _____ *chain* of carbons, making sure to **include** the following groups, if present, **in this order**:
    1. _____
    2. _____
    3. _____

Note: *if the carbon atoms are in a ring*, we add the term "_____"
EX: ring of 6 C's = "_____"



Helpful Saying:
"My Evil Puppy Bites People Horribly Hard On Nasty Days!"

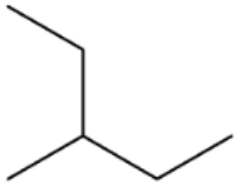
Longest Chain of C's	Parent Chain Name
1	
2	
3	
4	
5	
6	
7	
8	
9	

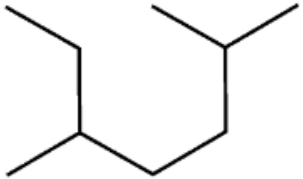
Section 5.3: How to find the Parent Chain (no FG)

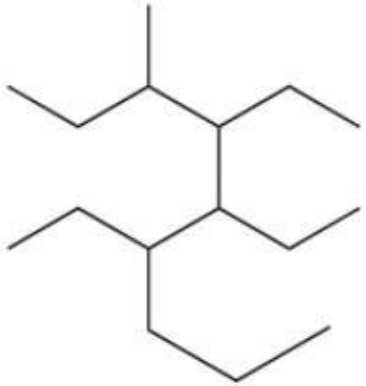
Pick a “starting” point and begin counting as many carbons in a row as you can (it can go L to R, down to up, the direction doesn’t matter!)

- Just don’t “backtrack” over a carbon
- **EX:** choose the parent chain for each

NUMBER OF CARBON ATOMS	PARENT
11	*undec*
12	*dodec*
13	*tridec*
14	*tetradec*



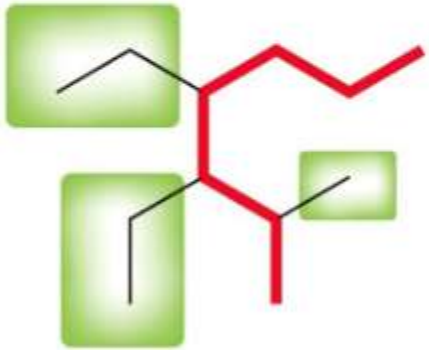




Section 5.3: What about ties?

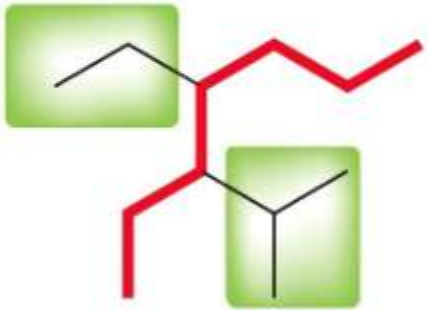
– If there is [ ] possible parent chain, choose the one with the [ ]

Correct
(3 substituents)



Parent has 7 carbon atoms

Incorrect
(2 substituents)

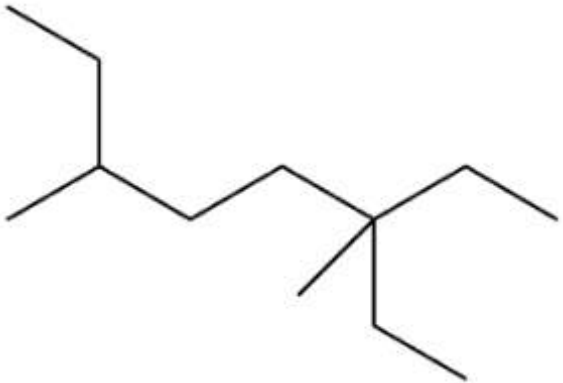


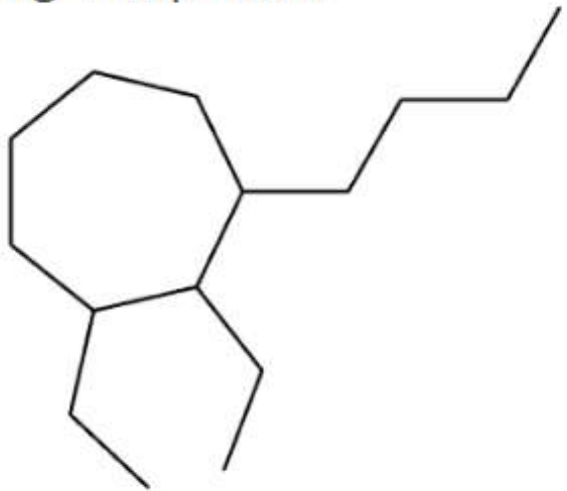
Parent has 7 carbon atoms

What is the parent name for this compound?

Section 5.3: How to find the Parent Chain (no FG)

- Give the parent name for the following compounds

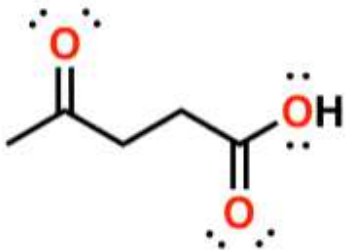


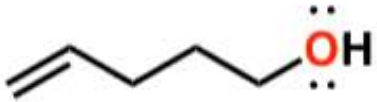


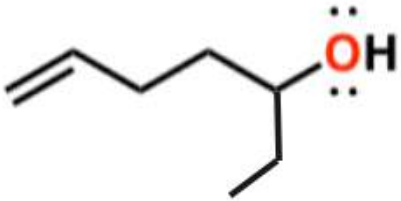
  - The parent name may <u>NOT</u> include carbons that are both in a ring and outside a ring.

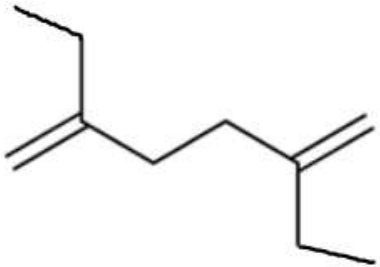
Section 5.3: Practice Finding the Parent Chain

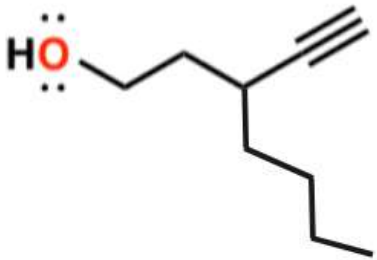
Make sure you parent chain includes **functional groups**, then **multiple bonds**, if present











Section 5.4: Naming Substituents

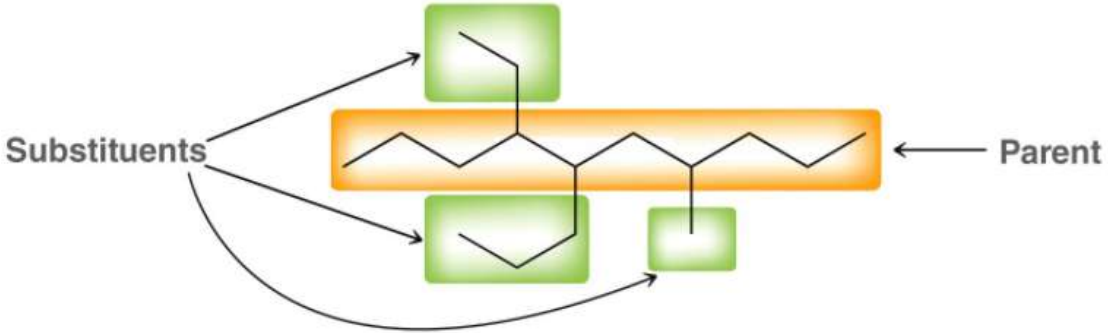
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Substituents: everything that is connected to the parent chain that is NOT covered under the main functional group suffix

_____: these are branches of carbon groups (single bonded)

- **Add "_____"** to the same terminology we would use for the parent chain

EX:

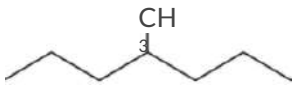


Number of C's in Sub.	Substituent name
1	
2	
3	
4	
5	
6	
7	
8	

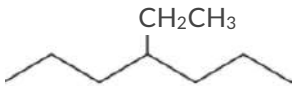
Section 5.4

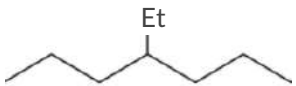
Alternative ways to list/show substituents:

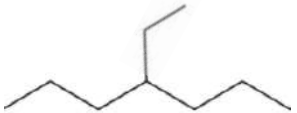
- **Methyl** groups can be shown as:
  - EX:



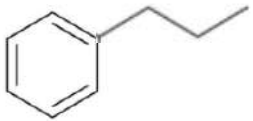
- **Ethyl** groups can be shown as:
  - EX:

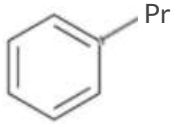






- **Propyl** groups are usually drawn out, but could be written as “-Pr”
  - EX:

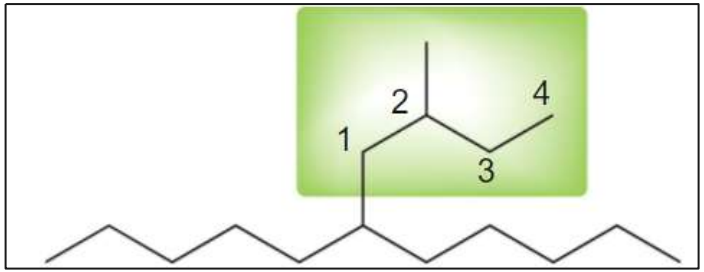




Section 5.4

How to name "Complex Branched" Substituents: *This is a little more than what we will get to in our HS organic course, but is most-definitely on the "college" plate! I just want you to have **seen** this!*

We will only use some of the "common names for branched substituents" from the following slide.

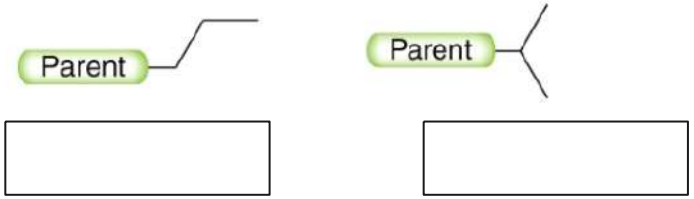


1. Number the longest carbon chain WITHIN the substituent. *Start with the carbon directly attached to the main chain*
2. Name the "parent chain" of the substituent *(in this case butyl)*
3. Name and Number the substituent's side group *(in this case 2-methyl)*
4. The name of the whole substituent is *(2-methylbutyl)*

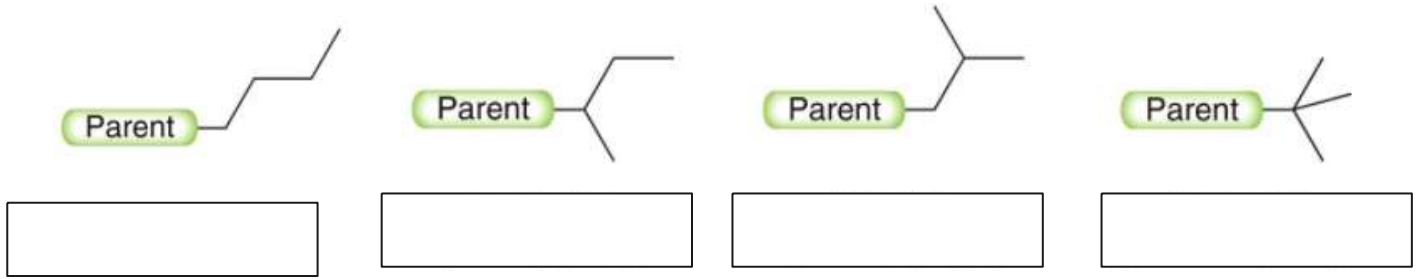
Section 5.4

Common Names for "Branched" Substituents: You WILL need to know these common names!

- 3 Carbon Group Variations
  - EX:



- 4 Carbon Groups Variations
  - EX:



Section 5.4 - How to name functional groups as substituents

**When a molecule has _____ of functional group, the lower-hierarchy functional group will be "picked up" in this portion of the name*

Functional Group Name	How it is Named as a Substituent
aldehyde	-_____-
ketone	-_____-
alcohol	-_____-
amine	-_____-

Section 5.4 - How to name Halogens as substituents

Halogens = group _____ elements

(Basically - add "____" to the end of the halogen's _____ name)

Halogen	How it is Named as a Substituent
F	-_____-
Cl	-_____-
Br	-_____-
I	-_____-

Section 5.4 Final Points

- **For _____ substituents of the same kind we use the same prefixes as we did previously:**

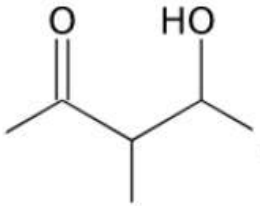
  di, tri, tetra, penta, hexa, hepta, etc...

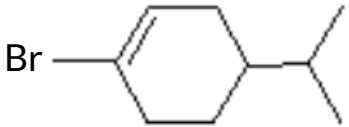
- **Each and _____ substituent needs to be _____ so that we know where it goes on the parent chain** *(more on that once we cover stereoisomerism)*
- **Substituents should be listed in _____ order** *(from the root of their name, more info later)*

Section 5.4 Practice

- **For each molecule, list out all of the info we have learned so far about it**

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups





Section 5.5 Stereoisomerism

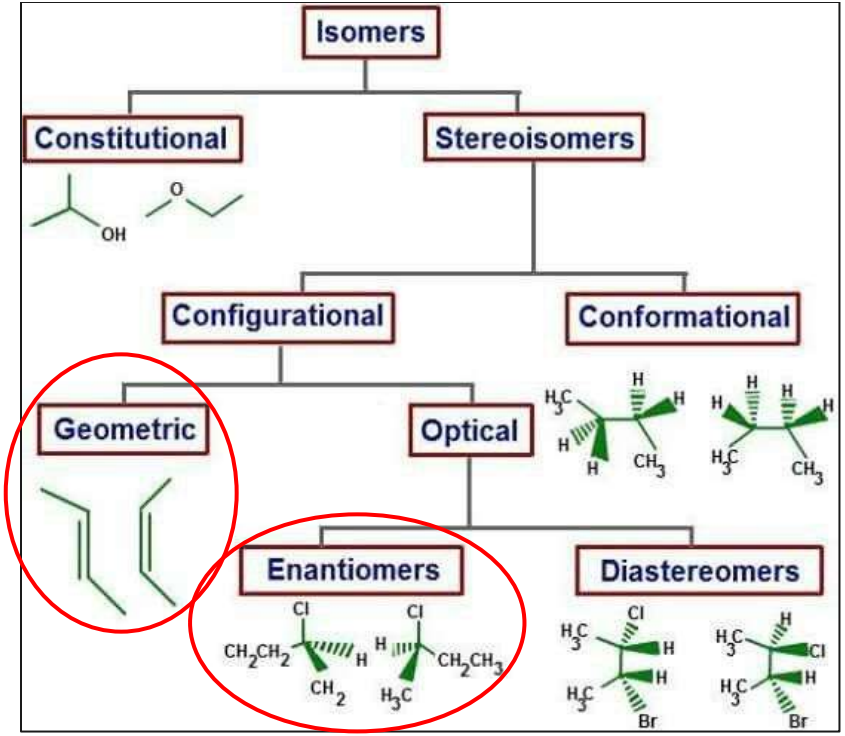
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Stereoisomerism is the first part of many names but may not always be present!

It describes the different _____ (3D) arrangements of the atoms in isomers

_____: atoms that have the same chemical formula (numbers & types of atoms) but are _____ differently

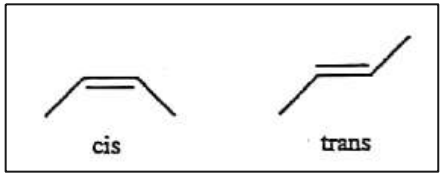
**Many different types, we will be looking at geometric isomers for double bonds and enantiomers*



Section 5.5 Stereoisomerism

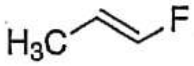
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

1. _____ can have alternate arrangements/configurations
   a. Due to overlapping p-orbitals "lock" the atoms in place *(unlike single bonds which can freely rotate)*
   b. To use _____ or _____, they must have identical groups ***on either side*** of the double bond that can be compared



Examples:

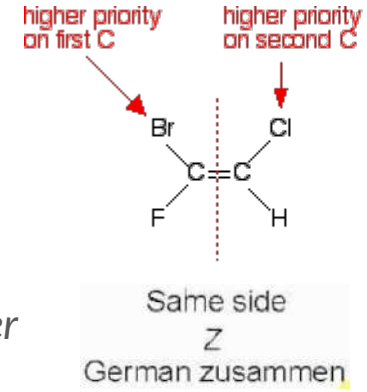
   c. The two groups **can** be hydrogen:

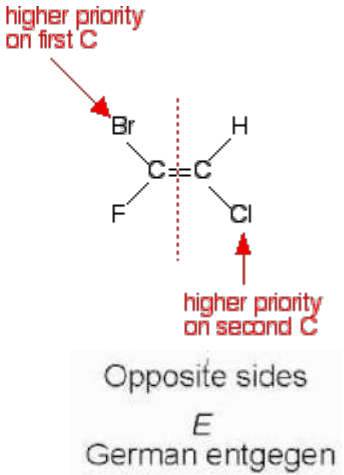


Section 5.5 Stereoisomerism

EXCEPTIONS to the cis/trans terminology:

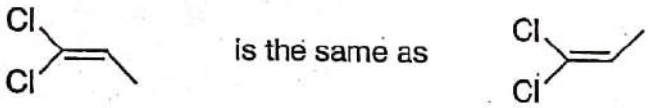
A. Cis/trans has limitations. What if you don't have 2 identical groups opposite of one another?
   - We use E for "_____ side"
   - Or Z for "_____ side" of groups.





   - **This method works for ALL double bonds**
   - **We learn the priorities of these in a later chapter*

A. If there are 2 identical groups attached to the ***same C atom***
   - EX:

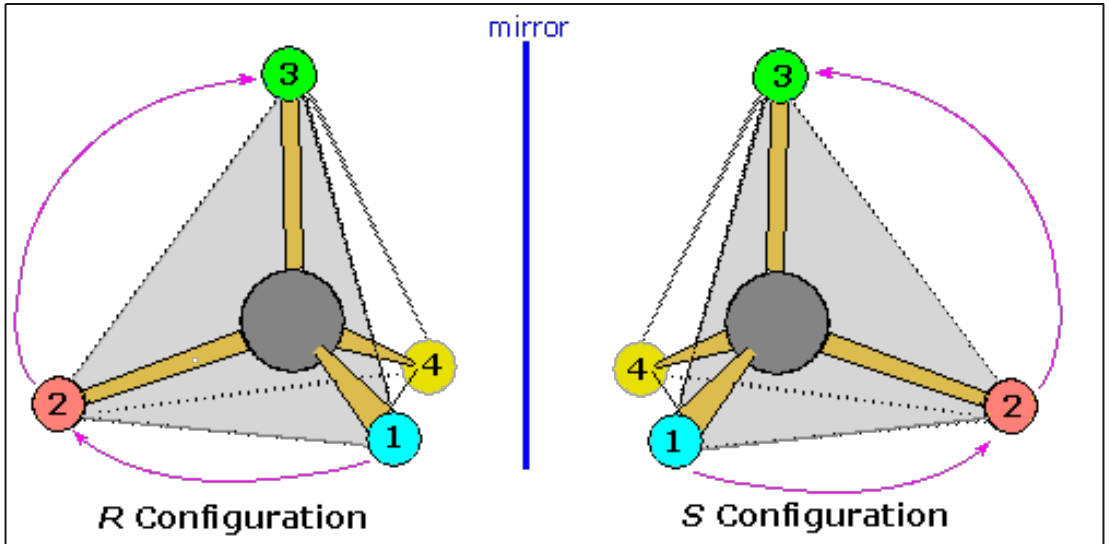


Section 5.5 Stereoisomerism

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

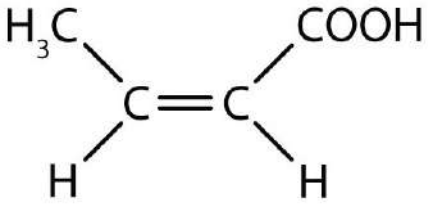
2. Stereocenters *(carbons attached to 4 diff. "things" - we will learn about this later. I'll tell you if it is R or S for now, just get the general idea of it below)*

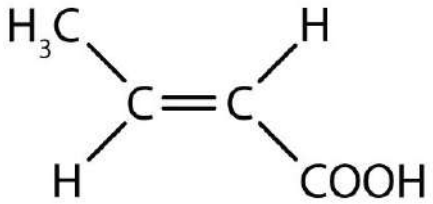
- Uses **R** for "_____ handed" rotation (_____)
- Uses **S** for "_____ handed" rotation (_____)

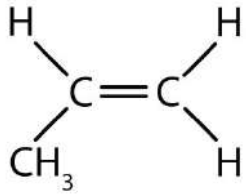


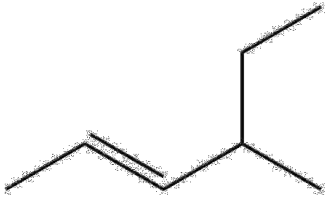
Section 5.5 Practice

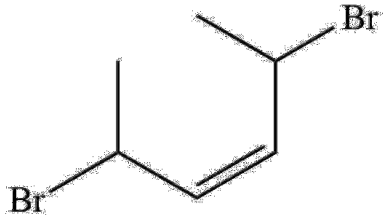
Determine if the double bonds are cis, trans, or neither







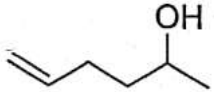


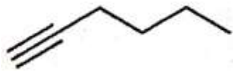


Section 5.6 Numbering

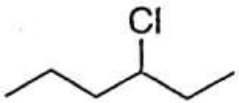
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

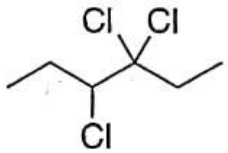
- **Numbering applies to ALL parts of the name!**
- When numbering the parent chain, we use the _____ hierarchy as we did to pick it:
  - Functional group
  - Double bond
  - Triple bond
- Make sure the "_____" option give priority in the order above

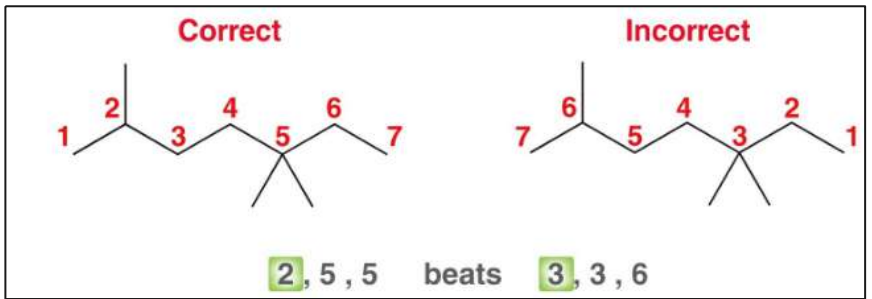




- **If NONE of them are present, simply number so that the total of the substituents has the _____value*

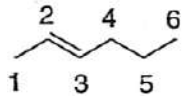






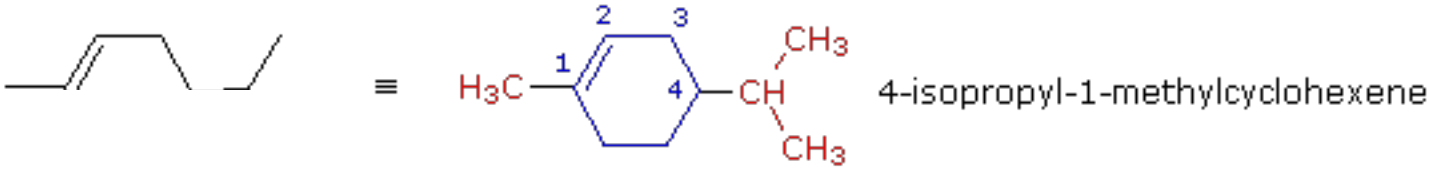
Section 5.6 How to place numbers in names

- **General Number "Rules"**
  - **Everything needs numbered!**
    - *Except a functional group or double bond if it is on the **first carbon only***
    - If you have multiples of a part of the name, then EACH needs numbered
      - EX: "-2,4,6-trimethyl"
  - **Use - (hyphen)between #'s and letters**
  - **Use , (comma) between multiple numbers**

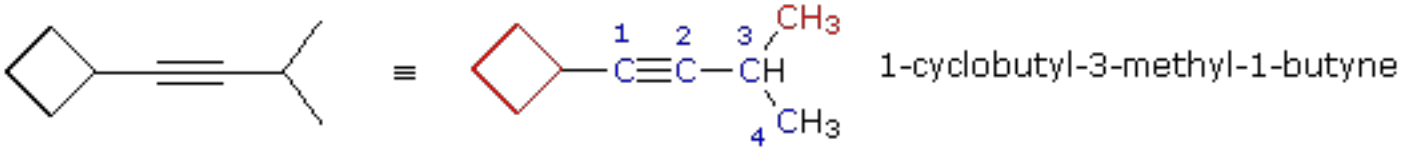
- ***Functional Group*** - place the number in front of the suffix
- ***Unsaturation*** - use only the lower of the carbon's number on the parent chain
  - EX: 

- ***Substituents*** - place directly in front of each substituent
- ***Stereoisomerism*** - if more than one double bond we have to indicate each with a number. If there is only one double bond we can just put *cis* or *trans* / E or Z out front. Stereocenters, (R or S) are placed in parentheses.

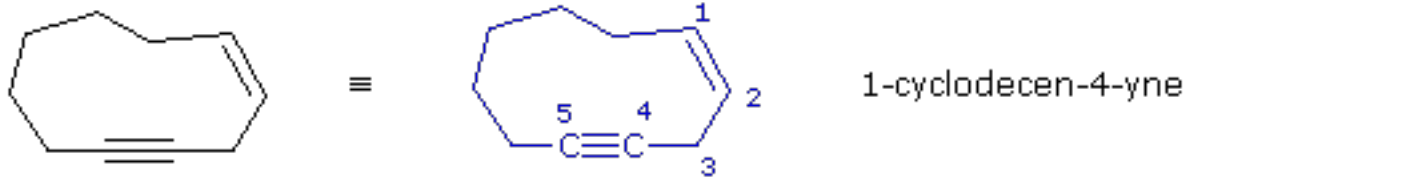
Worked-out Examples to reference



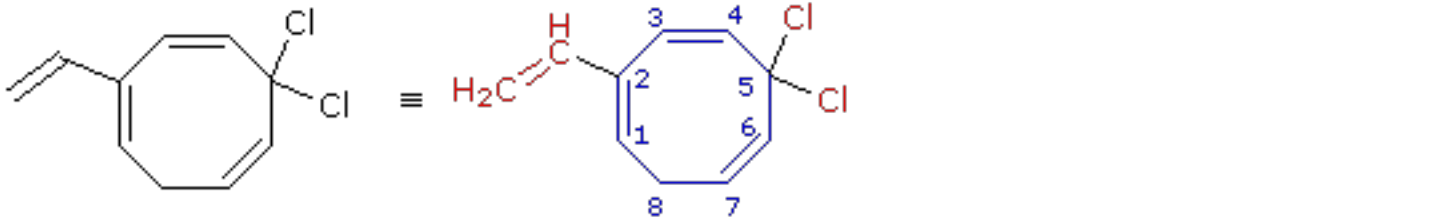
4-isopropyl-1-methylcyclohexene



1-cyclobutyl-3-methyl-1-butyne



1-cyclodecen-4-yne

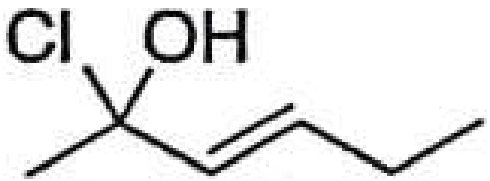


5,5-dichloro-2-vinyl-1,3,6-cyclooctatriene

Section 5.6 Practice - Putting it all together

1. **Name the molecule!**

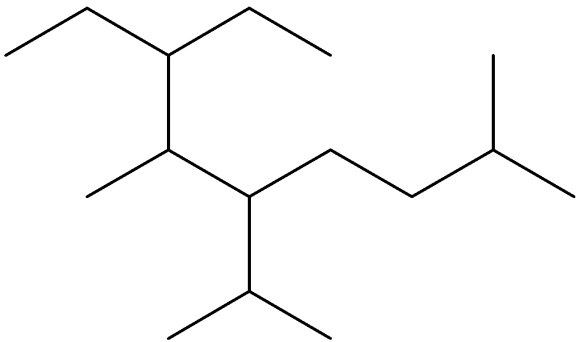
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

2. Name the molecule!

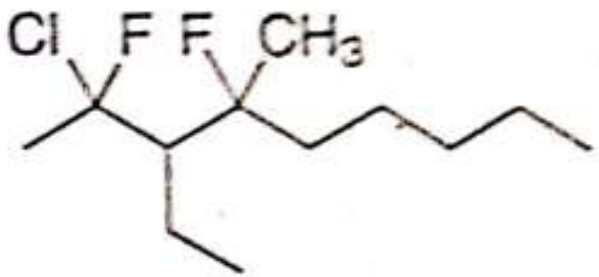
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

3. Name the molecule!

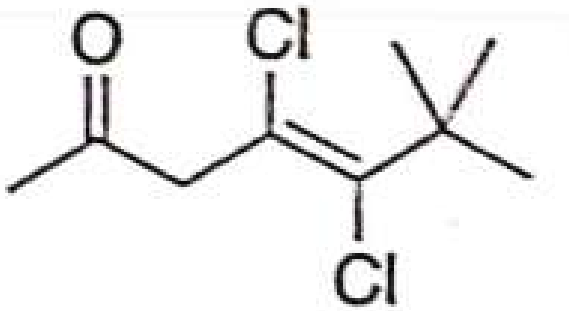
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

4. Name the molecule!

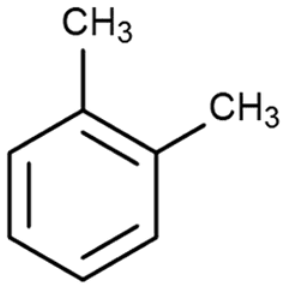
Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups



Section 5.6 Practice - Putting it all together

5. Name the molecule!

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

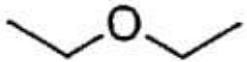


Practice with “rings” of carbons!

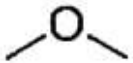
Section 5.7 Common Names

- Most of these names are so common, you may never hear anyone use their IUPAC name! It is important to familiarize yourself with them.

- **SPECIAL NOTE ON ETHERS**:
  - The common way to name ethers is to place the group on "either" side of the O is named as a substituent before the term "ether"

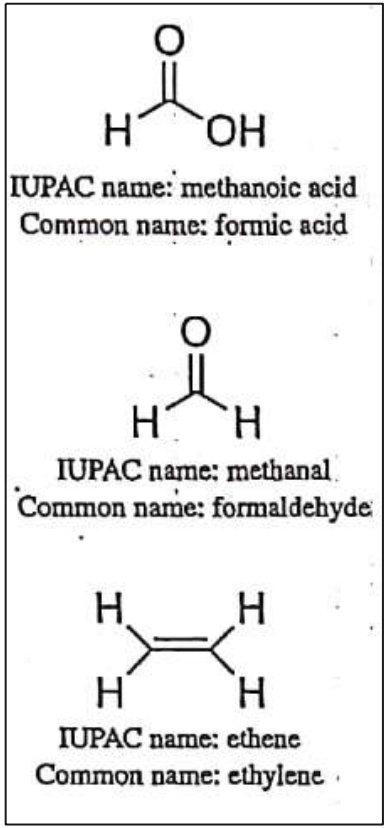


Diethyl ether
(also just ethyl ether)



Dimethyl ether

  - The IUPAC method would be to treat the O like a C and use the term -oxa. So diethyl ether would be 3-oxapentane *(but no one calls it that!)*

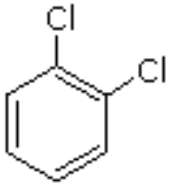


5.7 Common names of “di-substituted” Rings!

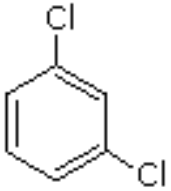
Sometimes Rings use some special terminology. *You are not required to know this for HS O-Chem, but you will for college!*

You may see this on Nomenclature WS #5

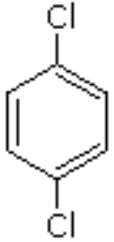
Conjugated double bond cyclohexanes are also called ***benzene*** *rings*



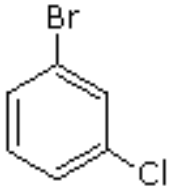
1,2-dichlorobenzene
ortho-dichlorobenzene
o-dichlorobenzene



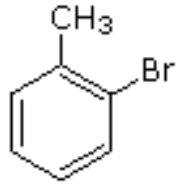
1,3-dichlorobenzene
meta-dichlorobenzene
m-dichlorobenzene



1,4-dichlorobenzene
para-dichlorobenzene
p-dichlorobenzene



1-bromo-3-chlorobenzene
meta-chlorobromobenzene
m-chlorobromobenzene



2-bromotoluene
ortho-bromotoluene
o-bromotoluene

Section 5.8 Going from a Name to a Structure

Draw out the molecule! (MUCH EASIER!)

1. 2,4-dimethylcyclopent-1-ene **Note you could also see:* 2,4-dimethylcyclopentene

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

Section 5.8 Going from a Name to a Structure

Draw out the molecule! (MUCH EASIER!)

2. *trans*- 6-hydroxy-3,4-dimethyloct-3-enal

Stereoisomerism	Substituents	Parent Chain	Unsaturation	Functional Groups

CONGRATULATIONS! YOU HAVE REACHED THE END OF CHAPTER 5!!!!!

Professor Dave Explain has MANY videos on his playlist for various parts of organic nomenclature.