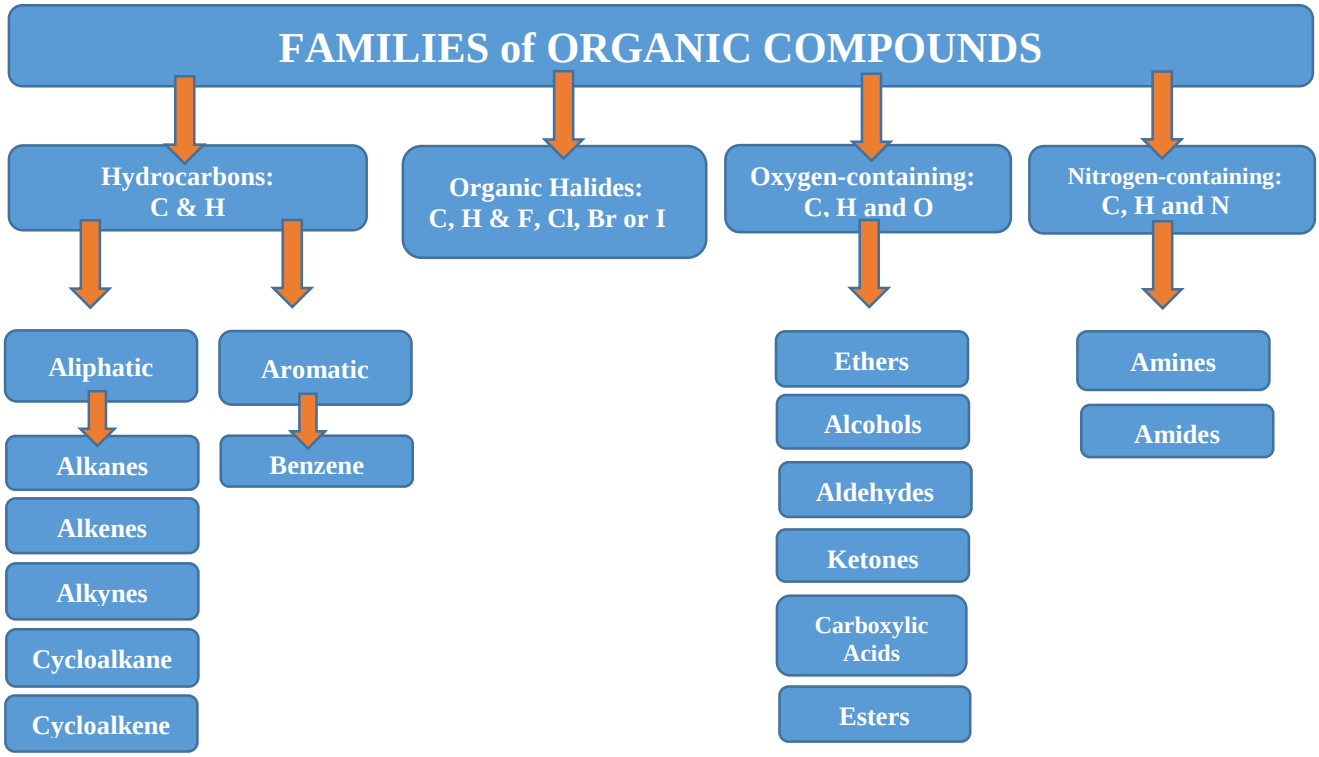
Organic Chemistry

- Is the chemistry of compounds that contain carbon (except: CO, CO_2, HCN, CO_3^{2-})
- Carbon is covalently bonded to another carbon, hydrogen and possibly to oxygen, a halogen or nitrogen
- All carbon atoms have four valence electrons and therefore need to make four bonds to become stable
- Carbon joins other carbons in chains or rings and branches can come off of these chains or rings
- One molecular formula can represent many different compounds (called **structural isomers**)
- Properties of organic compounds are determined by certain groups of atoms within the molecule- called **functional groups**- the part of the molecule where most reactions occur
- Organic compounds are divided into **families** based on the functional groups they contain



- The naming of organic compounds is based on the number of carbons that are in a chain, branch and ring.
- The following prefixes are used to indicate the number of carbons:

#C's	Prefix
1	Meth
2	Eth
3	Prop
4	But
5	Pent
6	Hex
7	Hept
8	Oct
9	Non
10	Dec

Hydrocarbons

Saturated vs unsaturated

When an organic compound contains only single bonds, it is said to be saturated. A saturated hydrocarbon is "saturated" with hydrogen; that is, the maximum number of hydrogens surround the carbon atoms. When double or triple bonds exist in the compound, hydrogen atoms have to be eliminated, hence less than the maximum number of hydrogens are a part of the molecule and they are therefore unsaturated. You will likely be familiar with this terminology with regard to fats: saturated and unsaturated fats. This will all make more sense once we begin to draw some hydrocarbons.

Saturated Hydrocarbons: Alkanes

- Can exist in two forms: straight chains (although the molecule isn't really straight – it just looks that way when we draw them) and straight chains with branches coming off of the chain.

Example of a straight chain alkane	Example of a branched alkane
1. CH_3- CH_2- CH_2- CH_2- CH_2- CH_3	2. CH_3-CH(-CH_3)-CH_2-CH(CH_2-CH_3)-CH_2-CH_2-CH_3

RULES for NAMING ALKANES

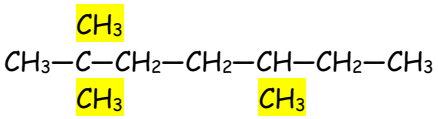
1) Identify longest chain, count the # of carbons & assign the base name (parent name) by finding the appropriate prefix and then add on the suffix "ane". In example 1 above, the chain has 6 carbons therefore it is called **hex**ane. In example 2, the longest chain has 7 carbons, therefore the parent name is **hept**ane. If there is more to be added to a name, as in example 2, the parent name is listed last (kind of like your last name).

Functional Group C-C

2) Name the branches (also called alkyl groups or side groups) by counting the number of carbons in the chain and naming the side chain as you would the parent except you would change the "ane" ending to "**yl**". ie. Methyl, ethyl, propyl
3) Number each C of the parent chain so that any side group is at the lowest C-number possible. This might mean numbering from left to right or right to left
4) Name each side group and where it is located i.e. **2-methyl** if there is a side group attached to the second carbon on the parent chain
5) List the side groups in alphabetical order

So in naming example 2, we identify the two side groups: ethyl and methyl. We start numbering the parent chain going from left to right. The methyl group is found on C#2, therefore it is called **2-methyl**. The ethyl group is found on C#4, therefore it is called **4-ethyl**. (If we had numbered the parent from right to left, we would have named the side groups 6-methyl and 4-ethyl. This would have been incorrect.) Putting this altogether, the name is **4-ethyl-2-methylheptane**. (Note that the side groups were named in alphabetical order.

6) **When a side group occurs more than once, scoop the name of the side groups together For example, if there are 2 methyl side groups, one on carbon #3 and one on carbon #4,rather than naming the methyl groups separately as 3-methyl-4-methyl, you would name it as 3,4-dimethyl**



Try naming the compound above.

Commonly used alkanes:

- natural gas, propane, butane – all found in fossil fuels

Isomers

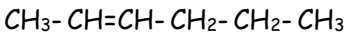
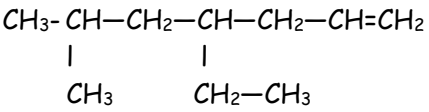
- The tem means "the same"
- An isomer of hexane is an alkane that contains the same number of hydrogens and carbons as hexane but is configured in a different way
- For example, 2-methyl pentane also contains 6 carbons and 14 hydrogens. They both have the molecular formula C_6H_{14} which is why condensed structural formulas are used in organic chemistry as opposed to molecular formulas. Hexane and 2-methyl pentane are not the same compound!

What other alkanes are isomers of hexane?

Complete questions #1-3 from the assignment *Naming Organic Compounds*

Unsaturated Hydrocarbons: Alkenes and Alkynes

Alkenes:

straight chain alkenes	branched alkenes
1. 	2. 

RULES for NAMING ALKENES

You need to follow the same rules we learned for naming alkanes EXCEPT:

- The parent chain must include the double bond (not necessarily the longest chain)
- The parent ending will be "ene"
- If two double bonds occur in the molecule, then "diene" becomes the prefix since there are two "enes", if three double bonds, then "triene"
- You will begin naming the compound by identify the longest chain with double bond (the parent)
- The numbering of the parent chain begins at the end closest to the double-bonded
- The position of the beginning of the double bond will need to be identified

Functional Group C=C

In Example 1, there are 6 carbons in the longest double-bond-containing chain, therefore its name will be hexane. Identifying the position of the beginning of the double bond, the name becomes 2-hexene.

In Example 2, the longest chain containing the double bond has 7 carbons in it therefore the parent is named **1-heptene** (numbering from right to left). Adding in the side groups it becomes **4-ethyl-6-methyl -1-heptene.**

Commonly used alkenes:

Ethene – a gas used to ripen green bananas when they arrive at the grocery store.

Alkynes:

straight chain alkynes	branched alkynes

1.
CH_3- CH_2-C≡C- CH_2- CH_3
 	
Name: 3-hexyne
	2.
	CH_3- CH—CH_2—CH—CH_2—C≡CH
	  | |
	  CH_3 CH_2—CH_3
	
	Name: 4-ethyl-6-methyl -1-heptyne

RULES for NAMING ALKYNES

Follow the same rules as for alkenes
Parent ending: "yne"

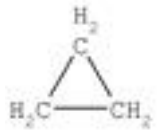
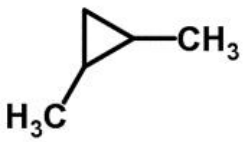
Functional Group C=C

Commonly used alkynes

- **Ethyne – (also known as acetylene) – used as a fuel in welding**

Complete questions #4-5 from the assignment *Naming Organic Compounds.*

Cycloalkanes

No branches		Branched	
			
Name: cyclopropane		Name: methylcyclopropane	Name: 1,2-dimethylcyclopropane

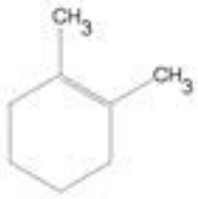
RULES for NAMING CYCLOALKANES

- Identify the ring by counting the number of carbons – this is the parent
  Prefix: cyclo; ending: "ane"
- # the C's in the ring
- name side group & location – if there is only one side group, location is not necessa
- follow rules for alkanes

Functional Group C-C in a ring or loop

Complete questions #6-8 from the assignment *Naming Organic Compounds.*

Cycloalkenes

No branches	Branched	
		
Name: cyclohexene	Name: 1,2-dimethyl-1-cyclohexene	Name: 1,3-cyclohexdiene

RULES for NAMING CYCLOALKENES

- Identify ring by counting the number of carbons – this is the parent
  prefix: cyclo; ending: "ene"
- The numbering of the C's in the ring begins with the double bond
- If there is only one double bond and no side groups, location is not necessary
- name side group & location – if there is only one side group, location IS necessary
- follow rules for alkenes

Functional Group C=C in a ring or loop

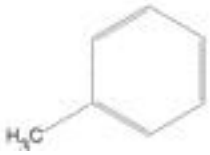
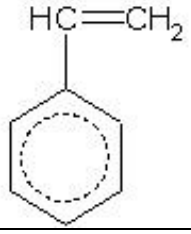
Commonly used cyclic hydrocarbons:

- **biological compounds – cholesterol, testosterone, estrogen**

How many isomers of 1-hexene can you create?

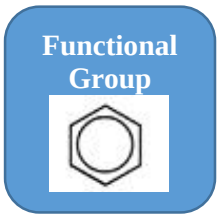
Complete questions #9 from the assignment *Naming Organic Compounds*

Aromatic Hydrocarbons

No branches		Branched	
			
Name: 1,3,5-cyclohextriene Or benzene		Name: methylbenzene	Name: phenylethene

RULES for NAMING AROMATIC HYDROCARBONS

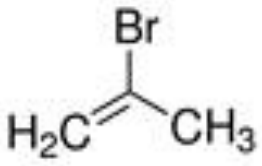
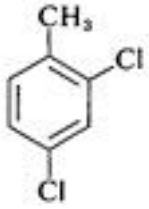
- Benzene is the parent
- name side group & location – if there is only one side group, location is not necessary
- name side groups in alphabetical order
- if the side group also has a functional group it is often easier to name it as the parent and benzene as the side group. In this case benzene is called phenyl.



Commonly used aromatic hydrocarbons:
Vanilla flavouring, aspirin (ASA), naphthalene (found in mothballs)

Complete #10 from the assignment *Naming Organic Compounds*.

Organic Halides

	
Name: 2-bromo-1-propene	Name: 1,3-dichloro-4-methylbenzene

RULES for NAMING ORGANIC HALIDES

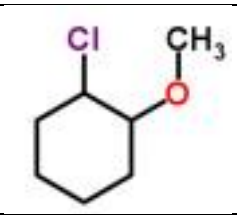
- halogens can be side groups of any of the families
- prefixes: F: fluoro; Cl: chloro; Br: bromo; I: iodo
- be sure that they are put into alphabetical order with other side groups

Commonly used organic halides:
Freon (used in refrigerators and air conditioners), Teflon, and the now banned PCBs (polychlorinated biphenyls)

Complete #11 from the assignment *Naming Organic Compounds.*

Hydrocarbon Derivatives: Oxygen-containing Compounds

Ethers

$CH_3-CH_2-CH_2-O-CH_3$	
Name: 1-methoxypropane	Name: 1-chloro-2-methoxycyclohexane

RULES for NAMING ETHERS

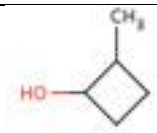
- O and the shortest carbon chain that it is attached to is considered a side group
- Put the side group in alphabetical order with other side groups
- Ending of the side group changes from "yl" to "oxy"

Functional Group C-O-C

Commonly used ethers:
The anesthetic ethoxyethane – more commonly called just ether – no longer used

Complete #12 from the assignment *Naming Organic Compounds.*

Alcohols

$CH_3-CH_2-CH_2-OH$		$HO-CH_2-CH_2-CH_2-OH$
Name: 1-propanol	Name: 2-methyl-1-cyclobutanol	Name: 1,3-propandiol

RULES for NAMING ALCOHOLS

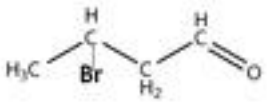
- the longest chain containing the OH group is considered the parent
- The "e" from the parent ending of the alkane, alkene, alkyne, or cyclocompound is dropped and changed to "ol"
- The numbering of the parent starts at the end that is closest to the OH group
- If more than one OH group is present, the ending becomes "diol" or "triol" for example – this resembles the numbering of the double bonds in alkenes

Functional Group C-OH (hydroxy)

Commonly used alcohols:
Ethanol (used in alcoholic beverages and fuel), ethylene glycol (in antifreeze),

Complete #13 from the assignment *Naming Organic Compounds*.

Aldehydes

$CH_3-CH_2-CH=O$	
Name: propanal	Name: 3-bromobutanal

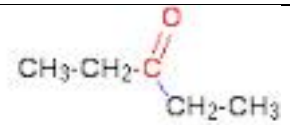
RULES for NAMING ALDEHYDES

- Aldehydes are identified by having an O double-bonded to the first carbon of the chain – this is C #1
- Parent ending: "al"
- There is no need to identify the carbon that has the O attached to it – the ending implies that it is carbon #1

Functional Group C=O (on 1st C) (carbonyl group)

Commonly used aldehydes:
Formaldehyde (methanol) used as a biological preservative,

Ketones

$CH_3-CH_2-\underset{\underset{O}{\|}}{C}-\underset{\underset{F}{\|}}{CH}-CH_2-CH_3$	
Name: 4-fluoro-3-hexanone	Name: 3-pentanone

RULES for NAMING KETONES

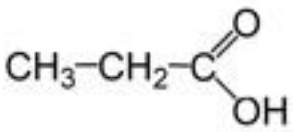
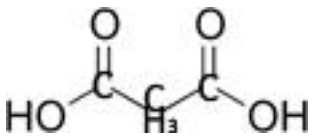
- Ketones are identified by having an O double-bonded to the carbon that is NOT the first carbon of the chain
- Parent ending: "one"
- Numbering of the parent begins at the end that is closest to the C=O

Functional Group C=O (not on 1st C) (carbonyl group)

Commonly used ketones:
Propanone (commonly called acetone) – used to remove nail polish;
Cortisone – an anti-inflammatory

Complete #14 from the assignment *Naming Organic Compounds.*

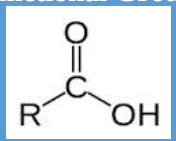
Carboxylic Acids

	
Name: propanoic acid	Name: propandioic acid

RULES for NAMING CARBOXYLIC ACIDS

- carboxyl group is found on the first carbon (and possibly the last carbon as well)
- Parent ending: "oic acid"
- Numbering of the parent begins at the carboxyl group
- If there are 2 carboxyl groups, the ending is "dioic acid"
- All other rules apply

Functional Group

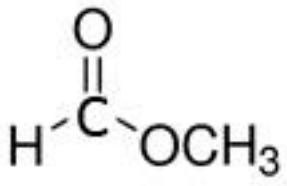
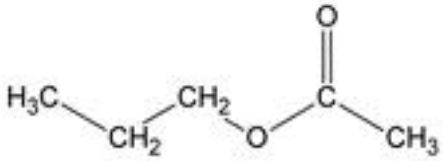


(on 1st C) (Carboxyl group)

Commonly used carboxylic acids:
Ethanoic acid (acetic acid) – found in vinegar; butanoic acid – found in butter; lactic acid; citric acid

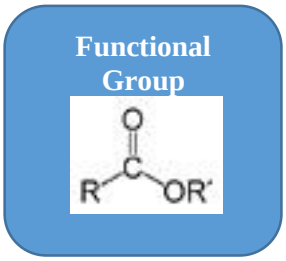
Complete #15 from the assignment *Naming Organic Compounds*.

Esters

	
Name: methyl methanoate	Name: propyl ethanoate

RULES for NAMING ESTERS

- An ester is formed by the reaction of a carboxylic acid with an alcohol
- The part of the ester that comes from the carboxylic acid is considered to be the parent and its ending changes from "oic acid" to "**oate**"
- The part that comes from the alcohol is written prior to the parent and the ending changes from "ol" to "**yl**"
- Any side groups attached to the parent are written first as usual



Commonly used esters:
Many esters have a fruit-like odour and are used in artificial flavourings and fragrances

Complete #16 from the assignment *Naming Organic Compounds*