Unit 4 Chemistry of Carbon

Organic Chemistry studies the compounds of the element carbon

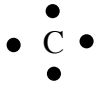
In many of these compounds carbon is found bonded to

Hydrogen, oxygen, nitrogen, phosphorous, sulfur, and halogens

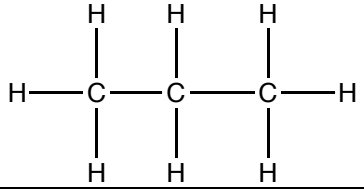
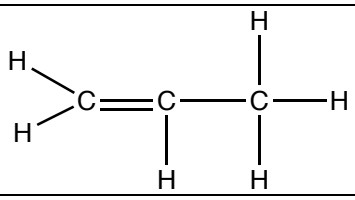
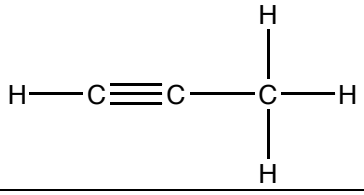
Contrasting organic and inorganic compounds

Type of Compound	**Organic**	**Inorganic**
Type of bonds	Covalent	Ionic
Melting point	Low	High
Boiling point	Low	High
Combustibility	Burns easily	Does not burn easily
Number of molecules	Millions	Thousands
Water solubility	Mostly nonpolar so insoluble	Most are polar or ionic so soluble
Conductivity	Nonelectrolytes	Electrolytes

Elements found in organic compounds

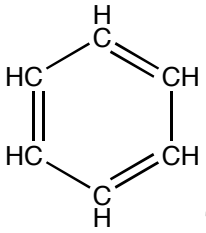
Element	Lewis dot structure	# of bonds	Bond arrangements
Carbon			
Hydrogen			
Oxygen			
Sulfur			
Nitrogen			
Halogens F, Cl, Br, I			

Hydrocarbons: The simplest carbon compounds

	General formula	Example Full Structural formula	Condensed structural formula	Name
Alkanes saturated	CnH2n+2		$CH_3CH_2CH_3$	propane
Alkenes unsaturated	CnH2n		CH_2CHCH_3	propene
Alkynes unsaturated	CnH2n-2		$CHCCH_3$	propyne

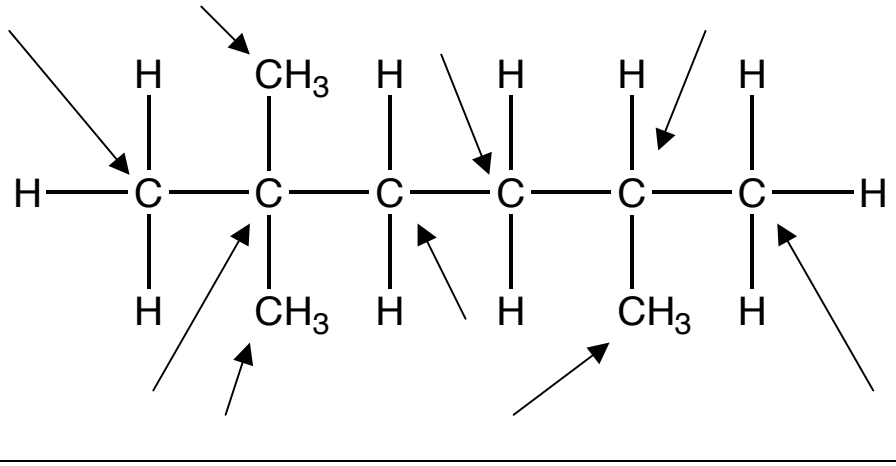
The main source of hydrocarbons is oil.

Hydrocarbons can also have a ring structure:

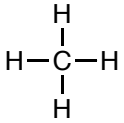
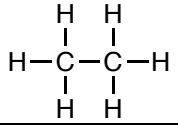
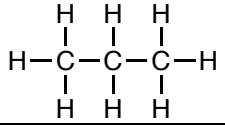
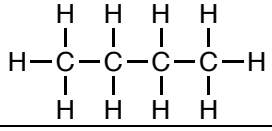
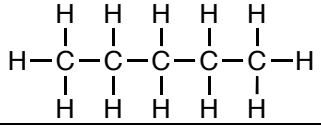
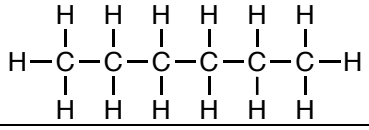
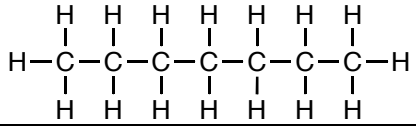
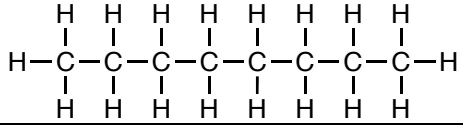
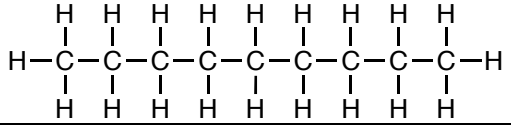
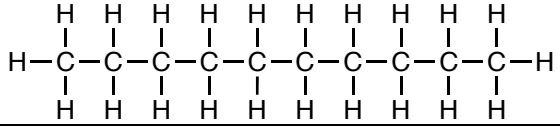


This is benzene. It has what is called an aromatic structure

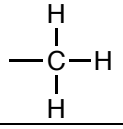
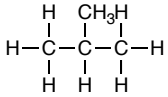
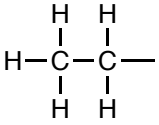
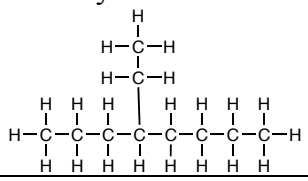
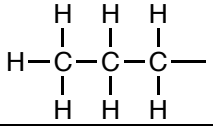
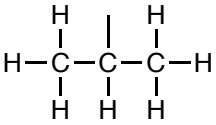
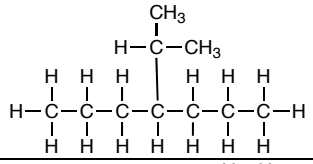
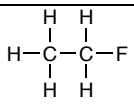
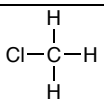
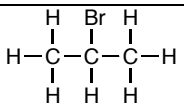
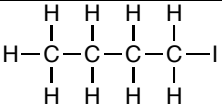
Types of Carbon

Primary	1^o	Bonded to only 1 other carbon	
Secondary	2^o	Bonded to 2 other carbons	
Tertiary	3^o	Bonded to 3 other carbons	
Quarternary	4^o	Bonded to 4 other carbons	

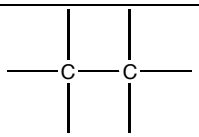
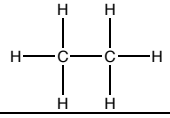
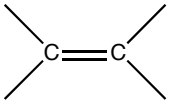
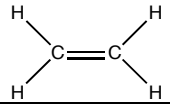
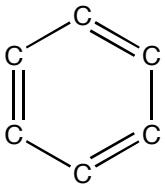
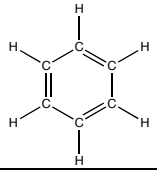
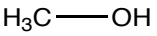
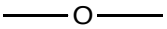
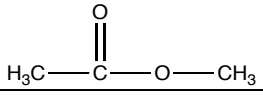
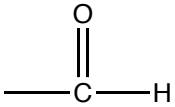
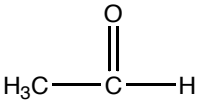
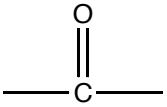
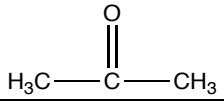
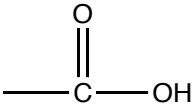
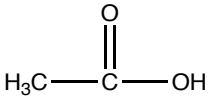
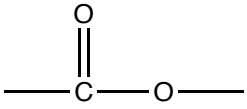
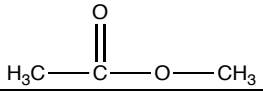
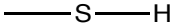
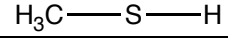
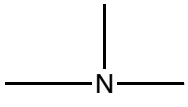
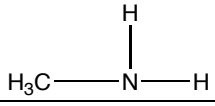
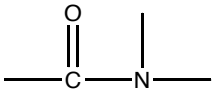
Alkanes

Name	Molecular Formula	Full Structural formula	Uses
Methane	CH_4		
Ethane	C_2H_6		
Propane	C_3H_8		
Butane	C_4H_{10}		
Pentane	C_5H_{12}		
Hexane	C_6H_{14}		
Heptane	C_7H_{16}		
Octane	C_8H_{18}		
Nonane	C_9H_{20}		
Decane	$C_{10}H_{22}$		

Side Chains and side groups

Name	Full Structure	Example
methyl		 2- methylpropane
Ethyl		4-methyloctane 
Propyl		
Isopropyl		4-isopropylheptane 
Fluoro		 Fluoroethane
Chloro		 Chloromethane
Bromo		 2-bromopropane
Iodo		 1-iodobutane

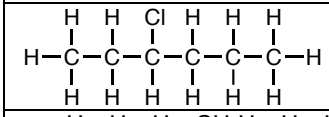
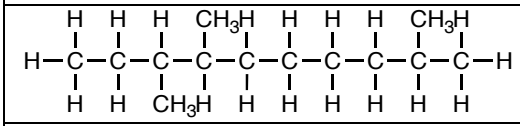
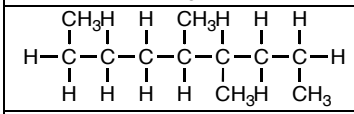
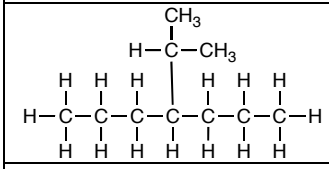
Functional Groups

Class of compound name	Functional group	Functional group name/ description	Example Name
Alkane		Single bonded carbons	Ethane 
Alkene		Double bonded carbons	Ethene 
Alkyne		Triple bonded carbon atoms	Ethyne
Aromatic		Aromatic ring of six carbons	Benzene 
Alcohol		hydroxyl	Methanol 
Ether		Oxygen bonded to 2 carbons	Methoxymethane 
Aldehyde		carbonyl	Methanal 
Ketone		Carbonyl between 2 carbons	2-propanone 
Carboxylic acid		carboxyl	Ethanoic acid 
Ester		Carboxyl group with H replaced by C	Methylmethanoate 
Thiol			Methanethiol 
Amine			Amino methane 
Amide			

Alkanes, Alkenes, and Alkynes

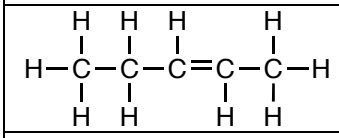
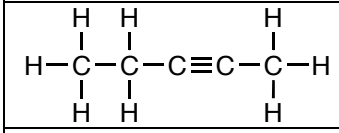
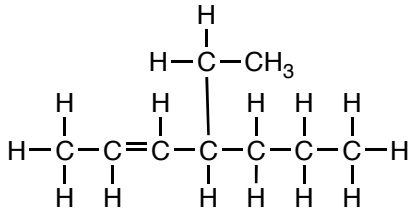
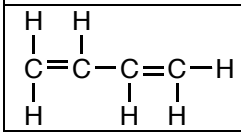
The name is one word. These can get long so the longest words in the English language are the names of huge organic molecules.

1. Find the longest continuous hydrocarbon chain .
2. Number the carbons in this chain from the end that will give the added units the smallest total number
3. Number the added groups with the number of the carbon they are attached to followed by a hyphen and then the name of the added group. (2-methyl or 5-chloro) If there are more than one of the same added group use the numbers separated by commas and then use di, tri, tetra, penta, etc. (2,2,3-trimethyl)
4. If there are more than one kind of added group put them in alphabetical order. (4-ethyl, 3-methyl)

Structure	Name
	
	
	
	
	3-fluoro-2methylhexane
	4-ethyl,3-methylheptane
	2,2,4-trimethyloctane
	Octane
	2,2,4-trimethylpentane Also called isooctane

Octane and 2,2,4-trimethylpentane both have the same formula C_8H_{18}. The difference is that 2,2,4-trimethylpentane is more branched. The branched chained molecules are better for gasoline mixtures. Straight chain molecules ignite too explosively causing "knocking". Branched molecules burn more smoothly. Isooctane has an octane number of 100 because of its anti-knocking properties. Heptane has an octane rating of 0. It has poor anti-knocking quality. A 95 octane rating would be like having 95% isooctane and 5% heptane. For diesel engines, just the opposite is best. Diesel engines work better on less branched molecules. Diesel engines run on cetane or hexadecane, 16-carbon molecules. If you are like my friend and accidentally put diesel in your car designed for gasoline, it won't work. Don't try to drive it. It could damage the engine.

5. Alkenes and alkynes are named the same way with the longest chain that contains the double bond, change ane to ene, or triple bond, change ane to yne.
6. The double or triple bond gets the lowest possible number.
Remember, each carbon can only have 4 bonds. These are referred to as **unsaturated hydrocarbons.**

Structure	Name
	
	
	
	
	2-butyne
	3-heptene
	

Importance of hydrocarbons
You are currently paying close to 4 bucks a gallon for hydrocarbons! So to say they are important is an understatement. There are 2 major uses of hydrocarbons
1. Energy
Small hydrocarbons (1-4 C's) are gases, medium sized (5-17C's) hydrocarbons are liquids, and big hydrocarbons (over 17 C's) are solids like waxes. They burn well :

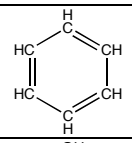
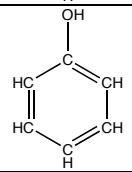
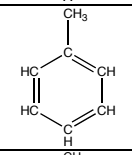
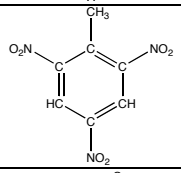
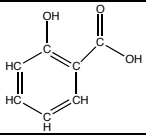
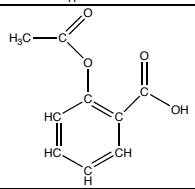
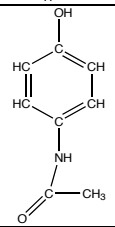
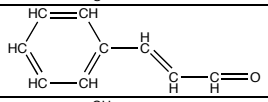
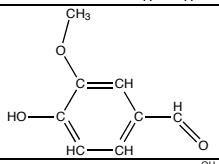
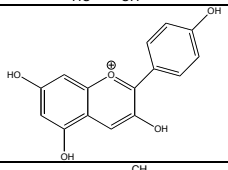
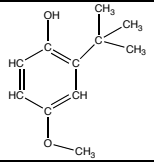
$$C_xH_y + O_2 \rightarrow H_2O + CO_2 + \text{energy (calories)}$$

There is a lot of energy given off when this reaction occurs. Liquid hydrocarbons are excellent fuels for cars and trucks or any other transportation form.

2. Building blocks for every day materials
We have become dependent on plastics or, to use the chemical, term polymers. From car parts to fabrics to packaging, it is hard to find anything that does not contain plastics. Also the building blocks for many pharmaceutical drugs come from hydrocarbons.
So many things we use everyday came from hundreds of feet below the earth in a country on the other side of the planet.
Boiling point increases with an increase in molar mass or increase in the number of carbon atoms.

Number of C atoms	Uses	Boiling point
1-4	Natural gas	< 30
5-12	Gasoline	30-200
12-16	Jet fuel	200-250
15-18	Diesel	250-350
18-25	Motor oil	350-450
>25	Tar, asphalt	Solid, does not boil

Aromatic Hydrocarbons

Structure	Name
	
	
	
	
	Salicylic Acid
	Acetylsalicylic Acid
	N-Acetyl-para-aminophenol (Tylenol)
	Cinnamaldehyde
	Vanillin
	Pelargonidin This molecule is responsible for the red color we see in raspberries and strawberries.
	2-tert-butyl-4-methoxyphenol Also called BHA an antioxidant. Molecules in food cause fat molecules to oxidize or rot or break down into smaller molecules and become rancid. BHA attacks the molecules that oxidize the food before they can attack the food.

Importance of aromatic compounds

Aromatic compounds contain a benzene ring. They are very stable compounds and react in many ways. They are found in fuels, biological molecules, plastics, drugs, explosives, foods, flavors, and dyes just to name a few. They tend to have a characteristic odor or aroma, hence the name aromatic. Benzene, toluene and phenol are starting materials for so many other compounds.

Kekule's dream

How we smell:

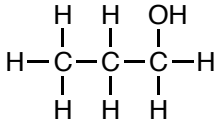
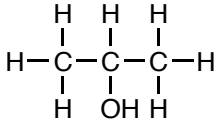
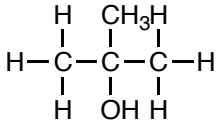
Functional Groups

Groups of atoms or single atoms can be added to hydrocarbon chains that greatly influence the physical and chemical properties of these molecules. Double and triple bonds are functional groups. Also, many functional groups contain oxygen or nitrogen.

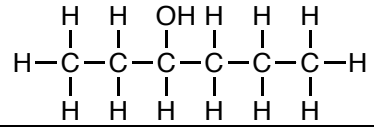
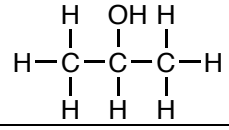
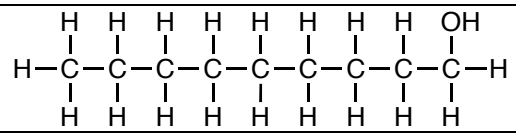
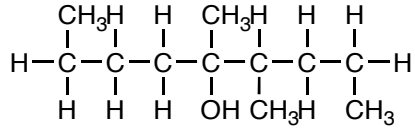
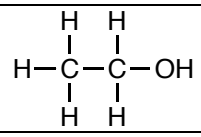
Alcohols

Functional group	-OH	hydroxyl group
General Formula	R-OH	ROH

Three types of alcohols

Primary 1°		The hydroxyl (OH) group is attached to a primary carbon	1-propanol
Secondary 2°		The hydroxyl (OH) group is attached to a secondary carbon	2-porpanol or isopropanol
Tertiary 3°		The hydroxyl (OH) group is attached to a tertiary carbon	2-methyl,1-propanol

1. Change the name of the longest chain that contains the –OH from ane to ol and number the chain giving the OH the lowest number.

1°, 2°, or 3°	Structure	Name
		
		
		
		
		
		Methanol Very poisonous. 50ml is lethal. Small amounts cause blindness.

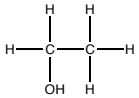
Importance of alcohols:

Fermentation: Yeast ferments sugars found in grains like corn and barley or fruits like grapes and apples to produce ethanol.
Caloric value: Calories/gram

Fat	Alcohol	Carbohydrates	Protein
9	7	4	4

Combustion: In some ways our bodies are like the engines in our cars. Both can combust or burn alcohol to produce carbon dioxide and water and energy. In our bodies the reaction is more complicated but the result is the same

Ethanol + Oxygen → carbon dioxide + water



$+ \quad O_2 \quad \rightarrow \quad CO_2 + H_2O$

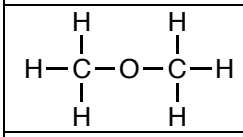
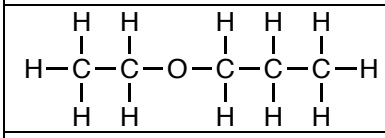
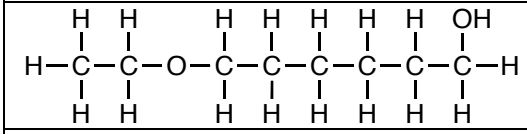
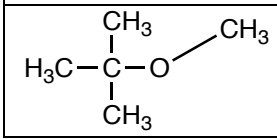
Ethanol, since it can be easily produced from the fermentation of corn, is being considered a good substitute for petroleum or oil based fuels. This could help our country become less dependent on imported oil. Recently, with the increase in demand and price of corn, farmers have been converting from other crops to corn for the purpose of ethanol production. This means that other crops like wheat and other grains are being farmed less. As the population of the world grows and becomes more wealthy, there is an increase in demand for wheat and grains grown by American farmers. Presently there is an increase in cost for those grains. Ethanol from corn, therefore is a two edged sword. It could solve our oil dependency, but it could also cause an increase in the cost of other farm produce we rely on.

Ethers

Ethers are similar to alcohols in that they contain an oxygen with 2 single bonds. They differ in that the oxygen is not bonded to a hydrogen but to 2 carbons.

Functional group	COC	
General Formula	R-O-R'	

1. Name the longest continuous hydrocarbon chain with its normal alkane name.
2. Change the name of the other , shorter hydrocarbon chain, with the oxygen, from its normal alkane name from ane to oxy. It is treated as an added group with a number.

Name	Structure
	
	
	
	MTBE fuel additive used to increase oxygen in the fuel for cleaner burning.

Importance of ethers

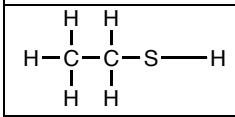
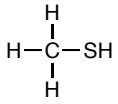
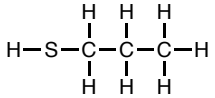
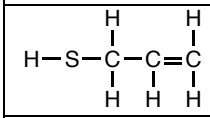
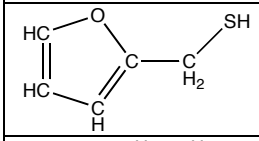
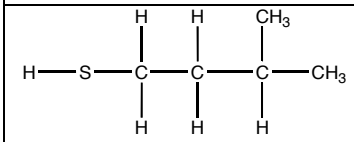
They have been used as anesthetics for many years. They are very volatile and explosive.

Thiols

These molecules are similar to alcohols but the oxygen is replaced by a sulfur with 2 bonds

Functional group	-SH	sulfhydryl
General Formula	R-S-H	

Name the same as alcohols but use the suffix thiol instead of just ol.

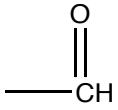
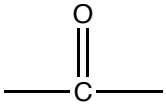
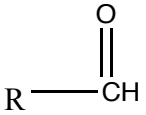
Structure	Name
	Added to natural gas to detect leaks through odor
	Found in oysters and cheese
	Found in onions
	2-propene-1-thiol Found in garlic
	2-furymethanethiol This molecule is responsible for the odor of coffee. This is why you so quickly spend 5 bucks in Starbucks!
	3-methylbutane-1-thiol This is the molecule responsible for the odor of skunk.

Importance of thiols

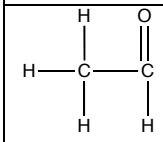
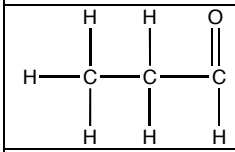
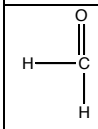
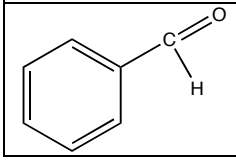
These molecules have a very strong odor and are found in foods, coffee and skunks!

Aldehydes

Aldehydes have a carbon double bonded to an oxygen at the **end** of a hydrocarbon chain

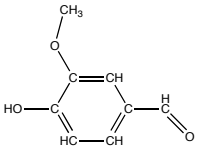
Functional group		 is called the carbonyl group
General Formula		

Change the name of the longest continuous hydrocarbon chain that has the CHO from ane to al. there is no number since the functional group is always on the end or first carbon.

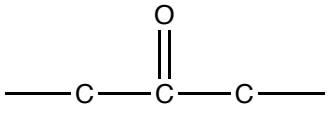
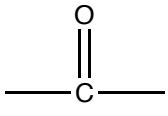
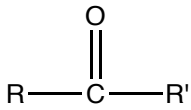
Structure	Name
	Also called acetaldehyde. Ethanol is broken down in the liver into this molecule which is somewhat responsible for the "hangover".
	
	Also called formaldehyde. Very toxic. Used to preserve specimens. Kills bacteria.
	Butanal
	2-methylmutanal
	Benzaldehyde responsible for the flavor of almonds

Importance of aldehydes

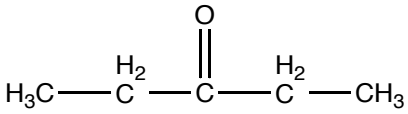
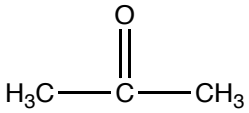
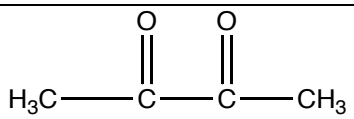
Aldehydes are quite reactive due to the oxygen atom and are used to make many other types of molecules.

Vanillin  contains 3 functional groups and is responsible for the flavor of vanilla. Thomas Jefferson introduced this flavor to the United States.

Ketones

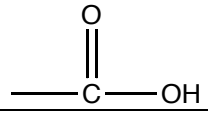
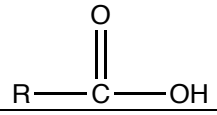
Functional group		 is called the carbonyl group
General Formula		

1. Change the ending of the name the longest hydrocarbon chain that contains the carbonyl from ane to one.
2. Number the carbon with the carbonyl so that it has the lowest number.

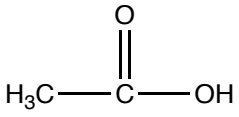
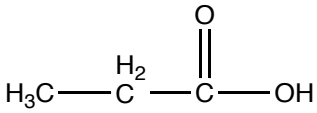
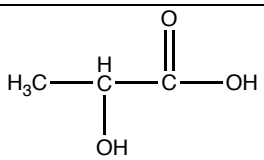
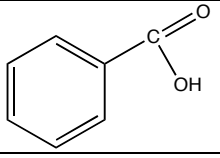
Structure	Name
	
	2-butanone
	Also known as acetone found in nail polish remover. Very flammable.
	3-hexanone
	Butanedione is the flavor of butter and margarine. Produced by bacteria. Found in the smell of armpits and unwashed feet. Ewe!

Carboxylic acids

The functional group is a combination of a carbonyl and a hydroxyl or a carboxyl.

Functional group		Carboxyl group
General Formula		

1. Change the ending of the name of the longest chain that contains the carboxyl group from ane to oic acid. There is no number since the carboxyl group is always on the end.

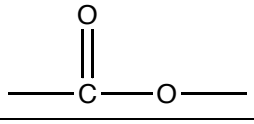
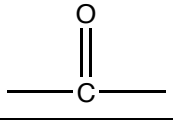
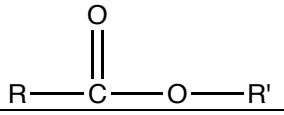
Structure	Name
	Also known as acetic acid, found in vinegar. Alcohol is broken down to this and that is why cheap wines taste like vinegar. Certain bacteria break down the sugar maltose in dough into acetic acid. This produces the sour in sour dough bread.
	Methanoic acid Also called formic acid. Injected by stining ants
	
	Pentanoic acid
	2-methylhexanoic acid
	Lactic Acid Found in milk, yogurt, and pickles. Formed from the breakdown of sugars. Responsible for sore muscles from heavy activity or heavy drinking.
	Benzoic Acid Kills bacteria and is used as a preservative in foods, cosmetics and toothpaste.

Importance of Carboxylic acids

These are weak acids. The hydrogen in the carboxyl group can ionize a little bit in aqueous solution.

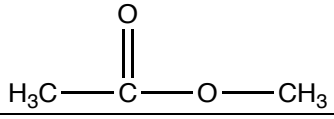
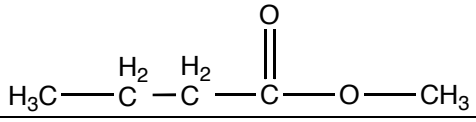
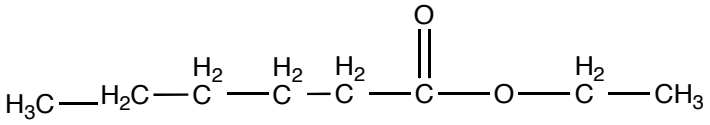
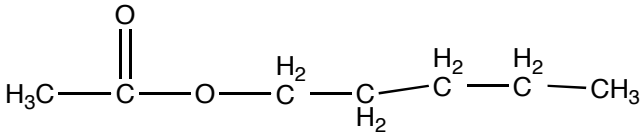
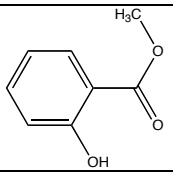
Esters

Esters are similar to carboxylic acids in that they contain 2 oxygens one with a single bond and one with a double bond. They differ in that the functional group is not on the end of the molecule.

Functional group		 is called the carbonyl group
General Formula		

Esters are named with 2 words

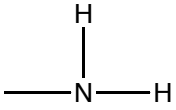
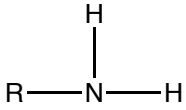
1. The 2nd word is made by changing the name of the carboxylic acid chain from oic acid to oate.
2. The 1st word is the alkyl group that is attached to the single bonded oxygen.

Structure	Name
	
	
	Ethyl ethanoate
	
	Propyl ethanoate
	Also called amyl acetate. This is responsible for the flavor of banans.
	Methyl salycylate This molecule is responsible for the flavor of wintergreen.

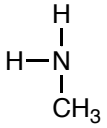
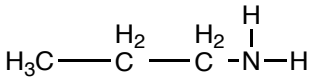
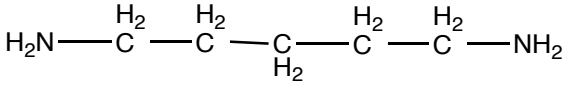
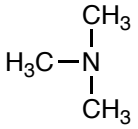
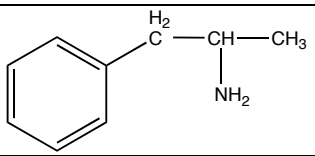
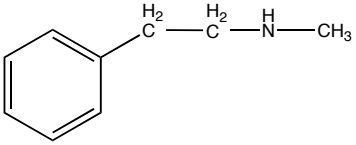
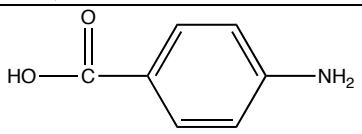
Importance of esters

The food industry relies heavily on esters for the flavoring of food. Many natural flavors are due to ester molecules.

Amines

Functional group		Amino group
General Formula		

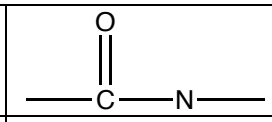
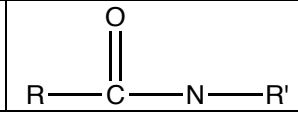
1. Add amino to the name of the longest hydrocarbon chain with the amino group and indicate its position with the smallest possible number.

Structure	Name
	
	
	2-aminopentane
	Putrescine The horrible odor from rotting flesh
	Trimethylamine Responsible for the odor of rotting fish. When lemon is squeezed onto cooked fish the citric acid in the lemon neutralizes the amine (organic base) and forms a salt getting rid of the fishy taste.
	Amphetamine
	Methamphetamine Also called “speed”.
	para-aminobenzoic acid Also called PABA for short. This molecule absorbs UV light from the sun and is found in sun block preventing UV light from reaching our skin. It is both an amine and a carboxylic acid.

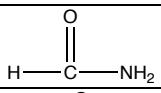
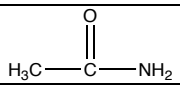
Importance of amines

Amines can accept a hydrogen which makes them weak organic bases. They are an important part of amino acids.

Amides

Functional group		Amide linkage
General Formula		

Examples

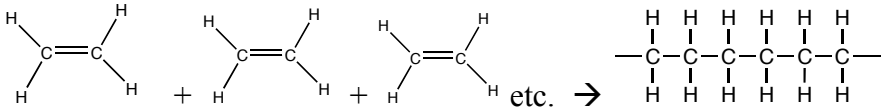
Structure	Name
	Methanamide
	Ethanamide

Polymers

Polymers are enormous molecules made up of repeating units called monomers. "Mer" simply means unit. Just like a train is a long chain of repeating similar train cars hooked together, a polymer is a long chain of similar molecules chemically hooked together. You wear polymers, you drive with polymers, you work with polymers, you chew polymers. They are everywhere. The properties of polymers depends on the individual repeating units and how they are hooked together. Polymers can be "man made" but are also found in nature. Protein is a polymer.

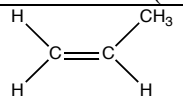
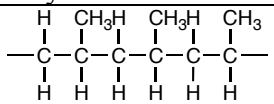
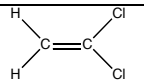
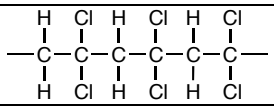
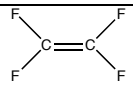
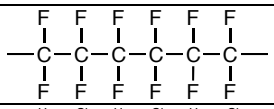
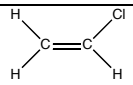
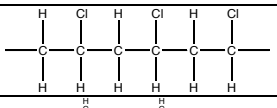
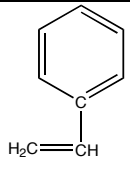
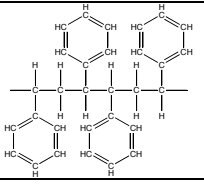
Polyethylene is a very common plastic. It is found in bags, plastic wrap and milk bottles. If you have seen the triangle symbol with HDPE, you are using polyethylene.

Here is how it is made: Ethene or ethylene is hooked together:



This chain can be hundreds or thousands of ethylene units. The chains can be long and straight like spaghetti or the chains can be "cross linked". This means that the chains hook up with other chains from the side forming a web-like structure.

Common Polymers

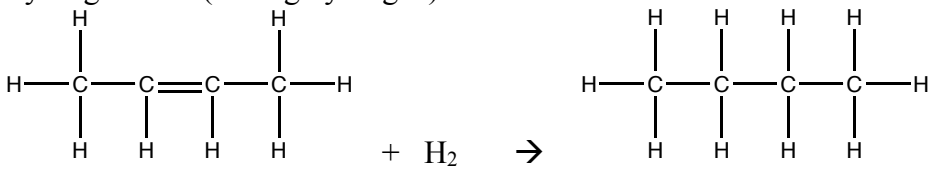
Name	Basic Unit (monomer)	Polymer	Use
Polypropylene			Clothing, carpets
Polydichloroethylene (Saran)			Sandwich wrap
Polytetrafluoroethylene (Teflon)			Non-stick coatings
Polyvinyl chloride PVC			Hoses, pipes, garbage bags
Polystyrene			Coffee cups, insulation, Styrofoam

Other polymers include polyester, rubber, chewing gum, nylon. We consume tremendous amounts of "disposable" polymers. We just throw them away. How long can we continue to do this?

Reactions

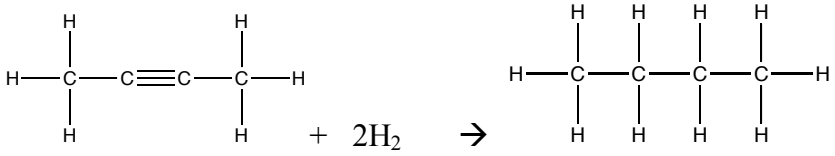
Addition to alkenes and alkynes (unsaturated hydrocarbons)

Hydrogenation (adding hydrogen)

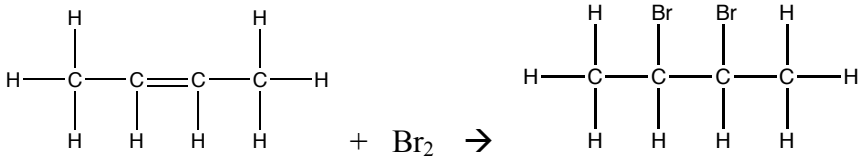


this is how unsaturated fats are saturated into shortenings.

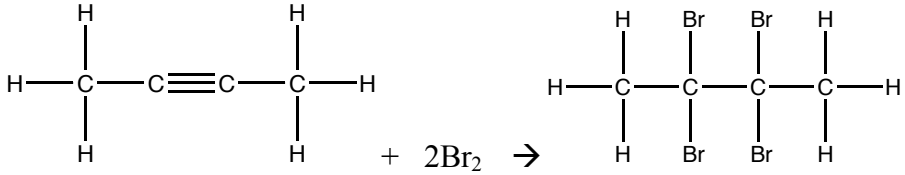
or



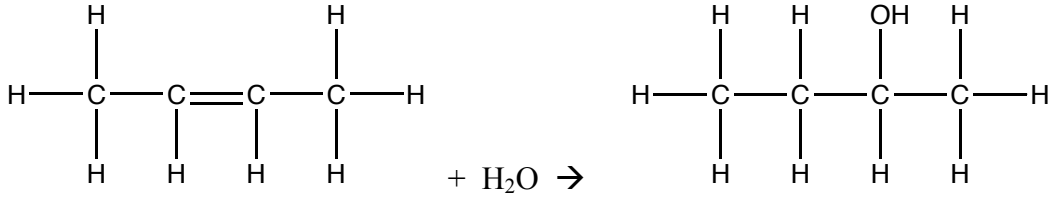
Halogenation (adding a halogen)



or



Hydration (adding a water)



Oxidation

Combustion

Most organic compounds are combustible.

Complete combustion:

Organic compound + O_2 → CO_2 + H_2O + energy

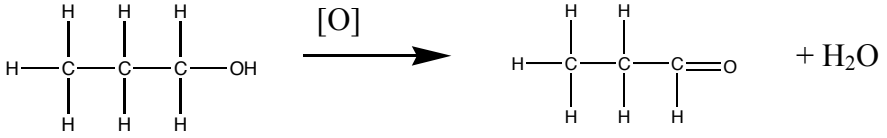
incomplete combustion:

Organic compound + O_2 → CO + less CO_2 + H_2O + energy

Oxidation of alcohols

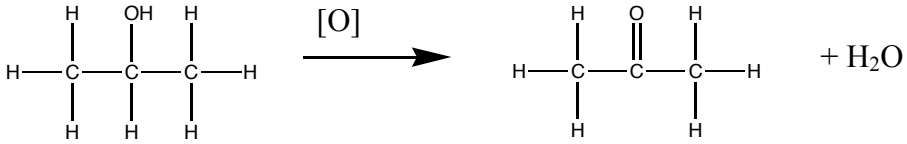
Primary alcohol

Primary alcohols are oxidized to form an aldehyde and water



Secondary alcohol

Secondary alcohols are oxidized to form a ketone and water

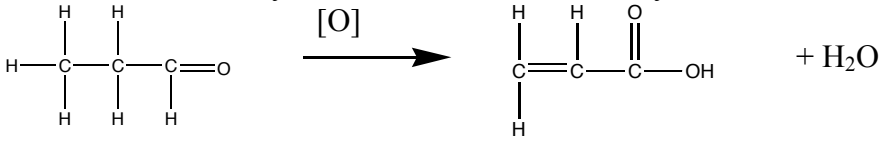


Tertiary alcohol

These alcohols do not readily oxidize

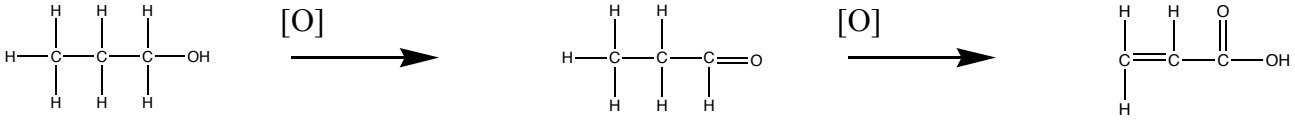
Oxidation of aldehydes

Aldehydes oxidize to form a carboxylic acid and water



Summary of oxidation reactions

Alcohol [O] → Aldehyde [O] → Carboxylic Acid

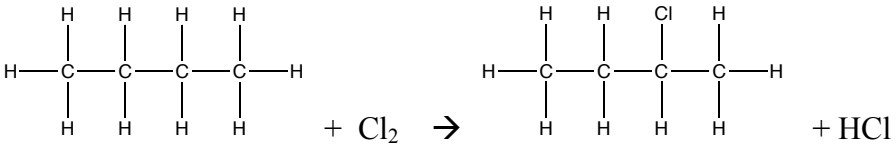


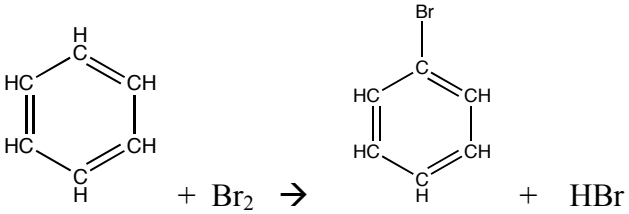
Oxidation causes an increase in carbon-oxygen bonds. Oxygen is added and hydrogen is removed.

When one drinks ethanol it is oxidized to ethanal to ethanoic acid to carbon dioxide and water by enzymes in the liver. The acid and aldehyde can damage liver cells. Some alcoholics are given the drug Antabuse which prevents the aldehyde from being converted to the carboxylic acid. This increases the hangover affect and discourages the use of alcohol.

Substitution

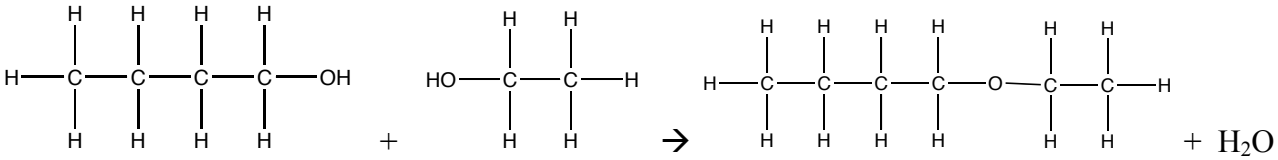
Dehydrohalogenation



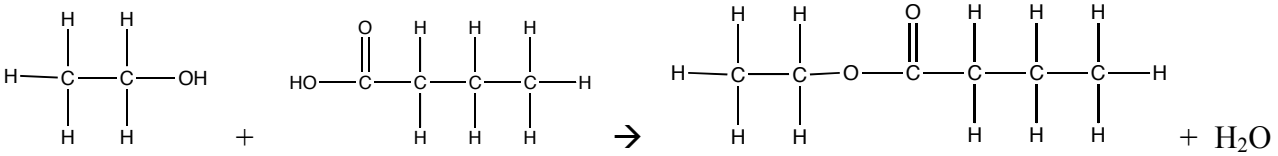


Condensation

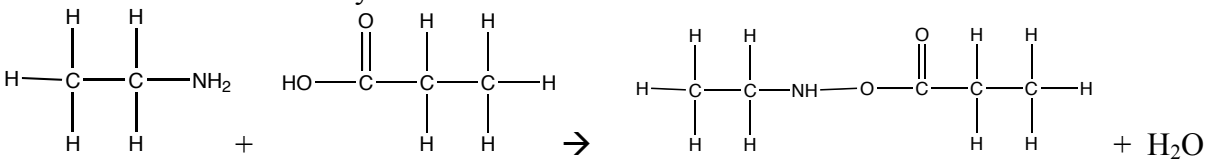
2 alcohols react to make ether and water



Alcohol and a carboxylic acid



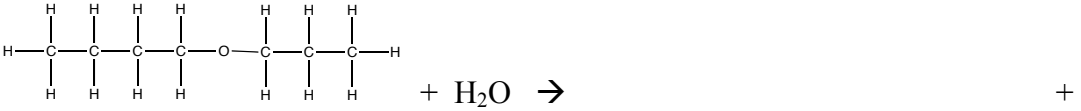
Amine and a carboxylic acid



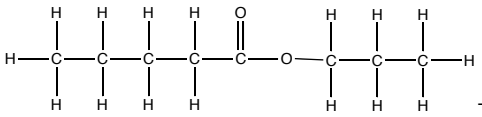
Hydrolysis

This is the opposite of condensation.

Hydrolysis of an ether to produce _____+_____

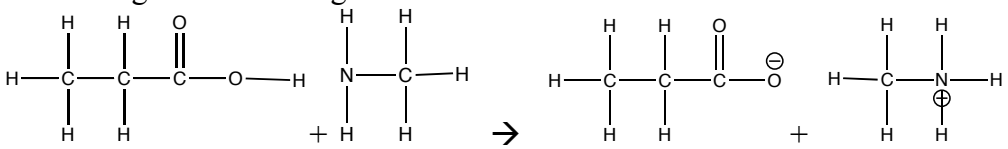


Hydrolysis of an ester to produce _____+_____

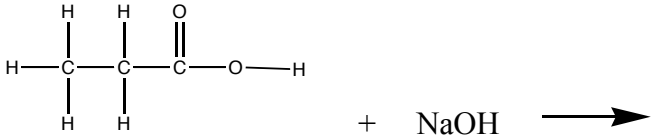


Neutralization

Organic acid + Organic base



Organic acid + inorganic base



Organic base + inorganic acid

Overview of organic reactions:

Addition

Alkene + hydrogen → alkane

Alkene + halogen → haloalkane

Alkene + water → alcohol

Alkyne + hydrogen → alkane

Alkyne + halogen → haloalkane

Oxidation

Primary alcohol $\xrightarrow{[O]}$ aldehyde + water

Secondary alcohol $\xrightarrow{[O]}$ ketone + water

Aldehyde $\xrightarrow{[O]}$ carboxylic acid

Organic compound + oxygen → carbon dioxide + water

Substitution

Alkane + halogen → haloalkane + HX	X = Cl, Br, or I
Benzene + halogen → halobenzene + HX	

Condensation

Alcohol + alcohol → ether + water
Carboxylic acid + alcohol → ester + water
Carboxylic acid + amine → amide+ water

Hydrolysis

ether + water → Alcohol + alcohol
ester + water → Carboxylic acid + alcohol
amide+ water → Carboxylic acid + amine

Neutralization

Acid + Base

Isomers

It is possible for two different molecules to have the same molecular formula. These are called isomers. There are several types of isomers.

Structural Isomers

Skeletal isomers

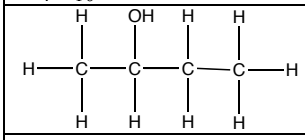
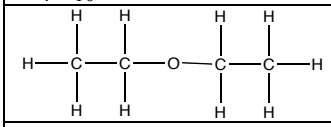
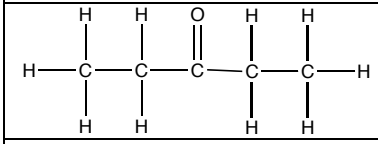
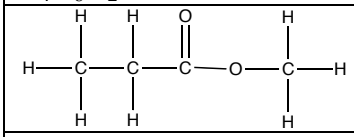
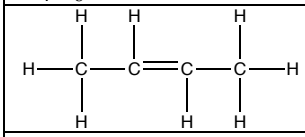
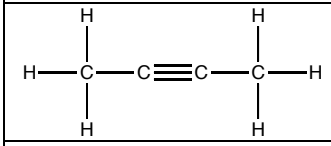
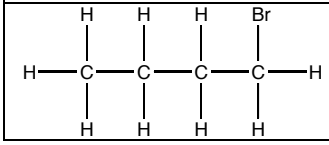
C_4H_{10}

C_5H_{12}

C_6H_{14}

Positional Isomers

Some isomers differ in the position of a functional group like a double bond, triple bond hydroxyl etc.

$C_4H_{10}O$	
	
$C_4H_{10}O$	
	
$C_5H_{10}O$	
	
$C_4H_8O_2$	
	
C_4H_8	
	
C_4H_6	
	
C_5H_9Br	
	

Functional Isomers

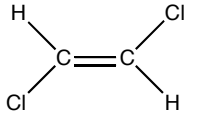
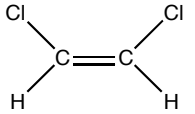
Some isomers have the same molecular formula but different functional group

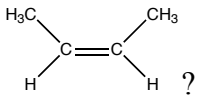
$C_4H_8O_2$	
Carboxylic acid	Ester
C_4H_6	
Alkene	Diene
$C_4H_{10}O$	
Alcohol	Ether
C_4H_8O	
Aldehyde	Ketone

Stereoisomers

Geometrical isomers

These molecules have a double bond. Because the bond cannot rotate two types of isomers can form, Cis and Trans.

Trans		Cis	
	The Cl's are across the double bond		The Cl's are on the same side of the double bond

Which isomer is this  ? Draw the other one:

Optical isomers

Some isomers differ in the same way as your left and right hand. These isomers are mirror images of each other. In order for this to occur a carbon atom must have 4 different groups attached to it. This makes the carbon asymmetric or "chiral".

Here are two optical isomers. They are non-superimposable mirror images.

Here are some more examples: