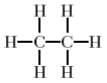
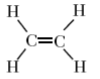
Organic Chemistry Test Review Sheet

Reference Tables: P, Q, and R

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	

Note: n = number of carbon atoms

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	—F (fluoro-) —Cl (chloro-) —Br (bromo-) —I (iodo-)	$R—X$ (X represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	—OH	$R—OH$	$CH_3CH_2CH_2OH$ 1-propanol
ether	—O—	$R—O—R'$	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde			 propanal
ketone			 2-pentanone
organic acid			 propanoic acid
ester			 methyl propanoate
amine			$CH_3CH_2CH_2NH_2$ 1-propanamine
amide			 propanamide

Note: R represents a bonded atom or group of atoms.

Definition of Organic Chemistry: The chemistry of the element carbon.

Carbon has 4 valence electrons that can be involved in covalent bonds with other carbon atoms as well as many other elements. Carbon must have four bonds which can include single, double or triple covalent bonds. **The bonding of carbon allows for long chains, branches and rings to form a variety of structures that determine the properties of organic compounds.**

There are many more organic compounds (compounds containing carbon than other compounds formed by other elements.

Alkanes, Alkenes and Alkynes are Hyrdocarbons

Hyrdrocarbons are organic compounds where there are only carbons atoms combined with hydrogen-You must know the basic properties of hydrocarbons (look at the powerpoint slides)

Saturated hydrocarbons have only single covalent bonds between carbon atoms

Unstaturated hydrocarbons have at least one double or triple covalent bond

See Table Q for the different homologous series and general formulas of hydrocarbons: alkanes, alkenes and alkynes.

Alkanes must have only single covalent bonds between the carbon atoms and are also classified as <u>saturated</u> hydrocarbons.

Alkenes must have at least one double bond in the carbon chain and **alkynes** must have at least one triple bond in the carbon chain. Both alkenes and alkynes are <u>unsaturated</u> hydrocarbons.

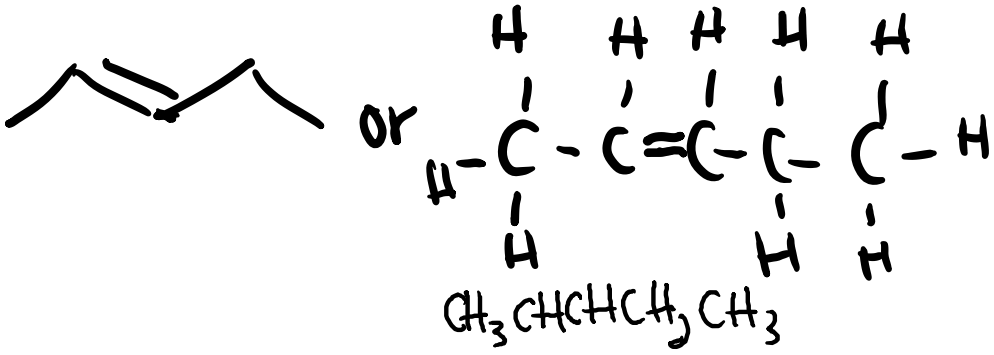
Example: Alkanes have the formula C_nH_{2n+2}. This means that C_8H_{18} is an alkane. Alkenes with one double bond have the formula C_nH_{2n}. This means that C_6H_6 is an alkene. Alkynes with one triple bond have the formula C_nH_{2n-2}. This means C_5H_8 is an alkyne.

Drawing Structural Formulas from Name of Unsaturated Hydrocarbons

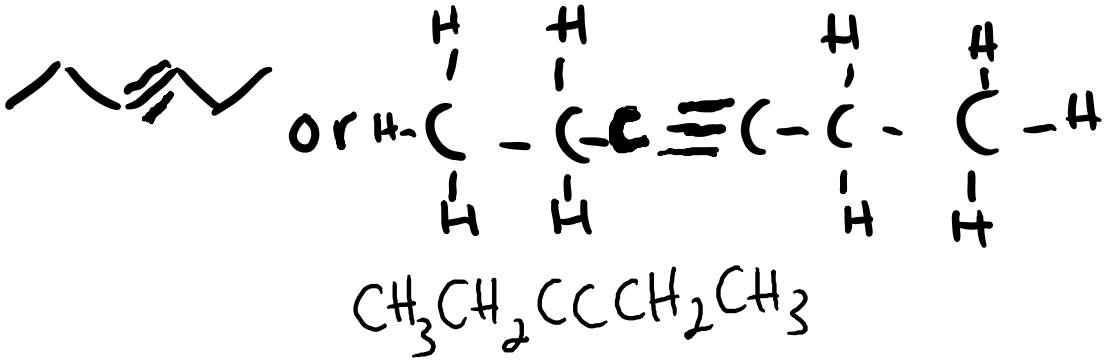
The number in the front of the name indicates the carbon number where the double or triple bond begins. Remember that when naming a structural formula, count the carbon atoms from any direction that gives you the lowest carbon number where either a double bond or triple bond begins.

Ex:

2-pentene



3-hexyne



Naming the Compound from Structural Formula

Use Table P to find the prefix of the name based on the number of carbon atoms: For example if the formula has 5 carbon atoms, use the prefix "pent-" followed by either the ending "-ane", "-ene" or "-yne" if it is an alkane, alkene or alkyne.

Condensed Structural Formulas: For example the condensed structural formula for butane would be shown as $CH_3CH_2CH_2CH_3$

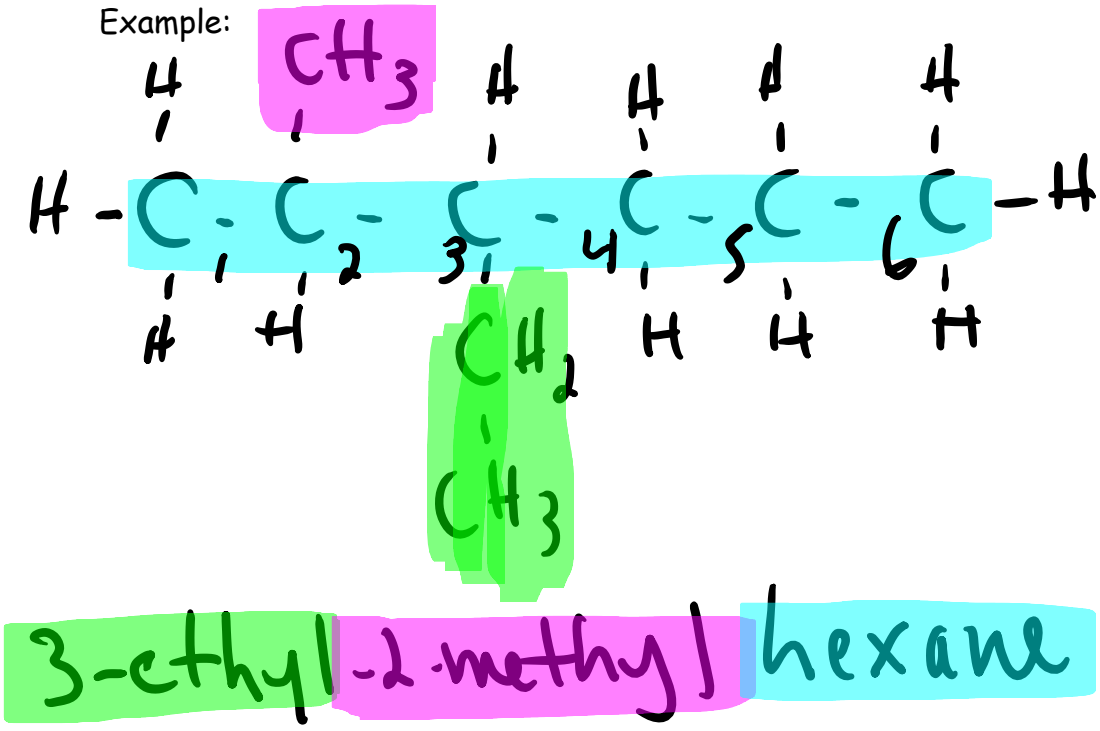
Number the carbon atom where the double or triple bond starts. Count from any direction that results in the lowest carbon number.

Branched Hydrocarbons

Naming Compounds from Branched Structural Formulas/Drawing Branched Structural Formulas from Name of Compound

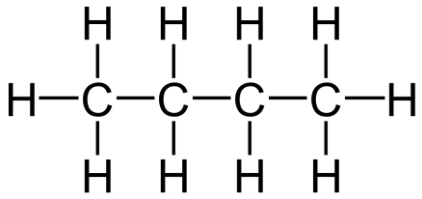
1. Find the longest hydrocarbon chain and name it (This is your parent chain)
2. Number the parent chain. Remember to count from the direction that gives your substituent(s) the lowest carbon number.
3. Substituent hydrocarbon groups are called "alkyl groups" and end in "yl". They are written in alphabetical order (including the number carbon they are attached to) before the name of the parent chain.

Example:

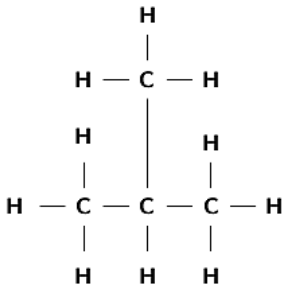


"Isomers" have the **same molecular formula**, but **different structural formula.** Isomers are not the same substance and have **different physical and chemical properties.**

Ex: Draw all isomers containing the molecular formula C_4H_{10}



C_4H_{10}
Butane



C_4H_{10}
2-methylpropane

Functional Groups

MUST BE ABLE TO USE "TABLE R" TO PERFORM THE FOLLOWING SKILLS

1) Identify functional groups given Structural Formula

2) Name basic compounds with functional groups given structural formula

3) Draw structural formula from the name

4) Identify functional groups from condensed structural formulas: For example: $CH_3CH_2CH_2Cl$ (halide or halocarbon); CH_3OH (alcohol); CH_3CONH_2 (amide); CH_3COOH (organic acid);CH_3OCH_3 (ether); CH_3CHO (aldehyde)

5) Some functional groups that are commonly isomers of each other: Alcohols and Ethers, Aldehydes and Ketones, Organic Acids and Esters

Important Organic Reactions

Substitution

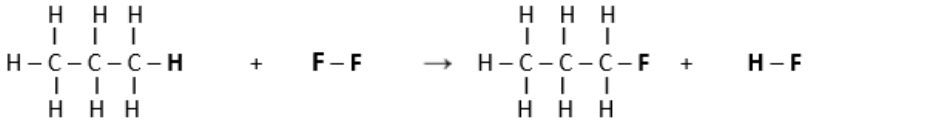
Substitution reactions typically involve the removing of a hydrogen atom from an alkane and replacing it with a halogen. The main organic product in substitution reaction is a halide.

Organic reactant	*Organic product*
Alkane (saturated hydrocarbon)	Halide (with 1 halogen attached)

An example of a substitution reaction is shown below.

Alkane + Halogen → Halide + Acid

C_3H_8 + $\mathbf{F_2}$ → $C_3H_7\mathbf{F}$ + **HF**



Propane + Fluorine → Fluoropropane + Hydrogen fluoride

Addition

Addition reactions usually involve the breaking of a double or triple bond in unsaturated hydrocarbons, and adding hydrogen (or halogen) atoms to the free electrons. The organic reactant in addition reactions is an alkene or alkyne. In addition reactions, one of the multiple bonds of an alkene (or an alkyne) is broken. The two free electrons from the broken bond covalently bonded with hydrogen atoms or halogens atoms.

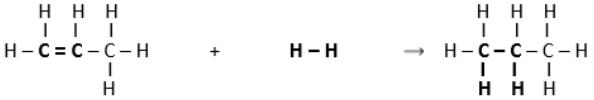
Below are two types of addition reactions.

Hydrogen Addition (Hydrogenation)
In a hydrogenation, hydrogen atoms are added to a double bond of an alkene. In this reaction, an unsaturated hydrocarbon (an alkene) is changed to a saturated hydrocarbon (an alkane).

Organic reactants	*Organic products*
Alkene (unsaturated)	Alkane (saturated)

Alkene + Hydrogen → Alkane

C_3H_6 + H_2 → C_3H_8



Propene + hydrogen → Propane

Halogen Addition (Halogenation)
In halogenation, halogen atoms are added to a double bond of an alkene. In this reaction, unsaturated hydrocarbon, such as an alkene, is changed to a halide compound with two attached halogen atoms.

Organic reactants	*Organic product*
Alkene (unsaturated)	Halide (with 2 halogen atoms attached)

Alkene + Halogen → Halide

C_3H_6 + Br_2 → $C_3H_6Br_2$

Propene + Bromine → 1,2-dibromopropane

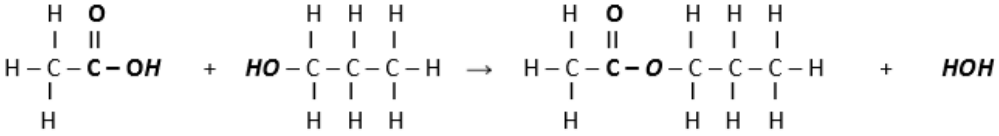
Esterification

Esterification is the process of making an ester by reacting an organic acid with a primary alcohol.
In esterification processes, water is also formed from the H^+ ion of the acid and the -OH (hydroxyl) group of the alcohol.

Example of an ester reaction is shown below. Pay attention to the atoms in the structures to help you see and understand how the products are formed from the reactants.

Organic acid + Alcohol → Ester + Water

$CH_3\mathbf{COO}\boldsymbol{H} + \boldsymbol{HO}CH_2CH_2CH_3 \rightarrow CH_3\mathbf{COO}CH_2CH_2CH_3 + \boldsymbol{H_2O}$



ethanoic acid + propanol → propyl ethanoate + HOH

Note:
The first part of the ester's name (*prop*-) comes from the alcohol (*prop*anol).
The second part of the ester's name (*eth*-) comes from the organic acid (*eth*anoic)

Fermentation

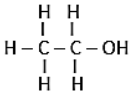
Fermentation is an organic process of making ethanol (an alcohol) from sugar.

- CO_2 (carbon dioxide) and water are also produced
- Enzyme (a catalyst) is required for this process.

Fermentation reaction is shown below:

sugar → ethanol + carbon dioxide

$C_6H_{12}O_6 \xrightarrow{\text{enzyme}} 2C_2H_5OH + 2CO_2$

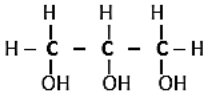


Saponification

Saponification is an organic process of making soap.
Glycerol, a tertiary alcohol, is also produced during a saponification process.

Saponification reaction is shown below:

Fat + Base → Soap + Glycerol (an alcohol)



1,2,3-propanetri*ol* (glycerol)

Combustion

Combustion is the process of burning an organic compound (fuel) in the presence of oxygen.
Carbon dioxide (CO_2) and water (H_2O) are the two main products of combustion reactions.

A combustion reaction is shown below.:

Organic compound + Oxygen → Carbon dioxide + water

$\mathbf{2}C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

Octane (car fuel)

Polymerization

Polymerization is a process of joining small organic molecules together to make a long chain molecule.
Monomers are small unit molecules that are joined together by covalent bonds to form a polymer.

Two types of polymerization reactions are discussed below.

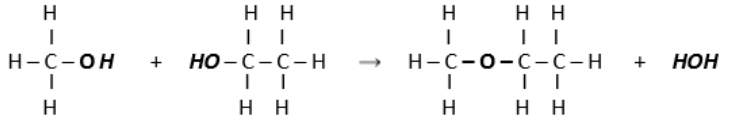
Condensation Polymerization
In condensation polymerization reactions, monomers with -**OH** groups are joined together as water is removed. *Ethers and proteins* are substances commonly produced by condensation polymerization.

Example of a condensation polymerization reaction is given below:

Monomer + Monomer → Polymer + water

(alcohol monomers) *(ether polymer)*

$CH_3\mathbf{OH} + \mathbf{HO}CH_2CH_3 \rightarrow CH_3\mathbf{O}CH_2CH_3 + \mathbf{H_2O}$



Methanol Ethanol Methyl Ethyl ether water

Addition Polymerization
In addition polymerization reactions, several identical small molecules with double bonds are joined together to create a larger polymer.

Example equation showing an addition polymerization process is shown below:

$n(CH_2{=}CH_2) \rightarrow (\text{-}CH_2\text{-}CH_2\text{-})_n$ n represents several repeated units of the monomer.

monomers (several identical small units) Polymer (one long unit)

Substances produced by polymerization reactions.
Common polymers that are produced by natural and synthetic polymerization processes are listed below.

Natural polymers: Protein, starch, and cellulose

Synthetic polymers: Nylon, plastic, polyethylene, and polyvinyl