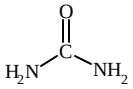
23 • Organic Chemistry
Historical Ideas
(1 of 16)

Chemicals from living things were thought to contain a "**vital force**" that could not be duplicated in the lab. This changed with **Friedrich Wöhler** who mixed cyanic acid (HCNO) with ammonium hydroxide making ammonium cyanate (NH_4CNO).



urea

He usually allowed the salt solution to evaporate overnight, but tried heating it to hurry the process. The result was a crystal that he recognized as **urea** (H_2NCONH_2).

The modern view of organic chemistry is the chemistry of carbon compounds. **C** is the key element. It can form **four** bonds and that are **very strong bonds** due to its **small size**.

23 • Organic Chemistry
Alkane Series -- Saturated Hydrocarbons
(2 of 16)

The **alkanes** (**paraffins**) follow the formula: $\mathbf{C_nH_{2n+2}}$:
These molecules contain ONLY **single** bonds. They are said to be "**saturated**" with hydrogens.

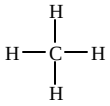
Memorize these prefixes also used with alkenes & alkynes.

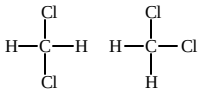
CH_4	**meth**ane	C_6H_{14}	**hex**ane
C_2H_6	**eth**ane	C_7H_{16}	**hept**ane
C_3H_8	**prop**ane	C_8H_{18}	**oct**ane
C_4H_{10}	**but**ane	C_9H_{20}	**non**ane
C_5H_{12}	**pent**ane	$C_{10}H_{22}$	**dec**ane

Given a formula, you can tell that it contains only single bonds because it fits the alkane formula.

23 • Organic Chemistry
Structural Formulas Can Be Misleading
(3 of 16)

CH_4, can be drawn using a **structural formula**. This can be misleading. The molecule is *not* flat with bond angles of 90°. You must be aware of the **3-D structure** and the **109.5°** bond angles.



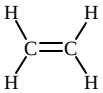


For example, there is only **one** isomer of dichloromethane, but you can draw it at least two ways.

Building models of the molecules is an important part of strengthening this skill.

23 • Organic Chemistry
Alkenes and cis- /trans- Isomerism
(4 of 16)

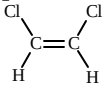
Alk<u>ene</u>s contain 1 double bond. The formula is $\mathbf{C_nH_{2n}}$. They are said to be "**unsaturated**" (like unsaturated fats). The double bond can be broken and more hydrogens added.



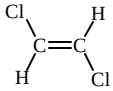
eth**ene**

Since double bonds cannot easily **rotate** (due to the pi bonding) **cis**- and **trans**- **isomers** can be formed.

Example: 1,2-dichloroethene can be built two ways.



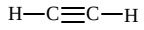
cis-1,2-dichloroethene
(a polar molecule)



trans-1,2-dichloroethene
(a nonpolar molecule)

23 • Organic Chemistry
Alkynes, Alkadienes, and Cyclic Hydrocarbons
(5 of 16)

Alk**yne**s contain 1 triple bond (unsaturated). Formula: $\mathbf{C_nH_{2n-2}}$.

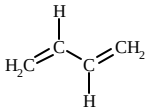


eth**yne** (acetylene)

The triple bond is linear, so no cis/trans isomerism occurs.

Alkadienes are molecules with **two** double bonds. They have the **same formula** as the alkynes, $\mathbf{C_nH_{2n-2}}$.

Example: C_4H_6 is named 1,3-butadiene because the double bonds start on carbons #1 and #3.



Cyclic compounds contain **rings** having the **same formula** as the alkenes, C_nH_{2n}.
Example: **cyclo**propane, C_3H_6.

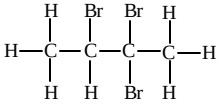
23 • Organic Chemistry
Naming Organic Compounds
(Organic Nomenclature Using IUPAC Rules)
(6 of 16)

The basic idea is to name the molecule after the **longest** continuous chain of **carbon** atoms. **Side groups** are listed with #'s to indicate the C atom to which they are attached.

Side Groups: -Cl chloro -Br bromo -I iodo
$-CH_3$ methyl $-C_2H_5$ ethyl $-C_3H_7$ propyl, etc.

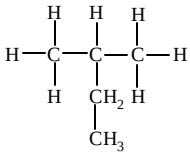
di- = 2 groups **tri-** = 3 groups **tetra-** = 4 groups

2,2,3-tribromobutane *(not 2,3,3-)*
Note that we # the carbons from whichever end results in the smallest numbers.

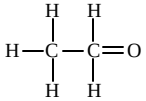


23 • Organic Chemistry
Common Errors in Drawing/Naming Structures
1-methyl*something* & 2-ethyl*something*
(7 of 16)

While drawing the isomers of pentane, C_5H_{12}, students draw this structure, naming it **2-ethyl<u>propane</u>**. (a chain of 3 C's with an ethyl group) The longest chain is **four** C's, and *should* be named **2-methyl<u>butane</u>**.



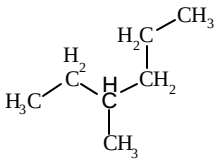
A similar error is to draw and name "**1-methyl**something".



5 bonds to C

Two more tips… **double check** that each C has **four** and **only four** bonds. Also, remember that N and O atoms have **lone pairs** of e^-'s although they are seldom drawn. (Impt. for steric #!)

23 • Organic Chemistry
Optical Isomers
Chiral Compounds
(8 of 16)



3-methylhexane

Some molecules have the ability to **rotate polarized light**.

These molecules can be **recognized** by a C atom (the **chiral** carbon) bonded to **four different groups**.

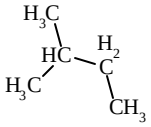
This carbon is bonded to H, methyl, ethyl, & propyl groups.

You can build two versions of this molecule that are "**nonsuperimposable mirror images** of each other." One will rotate light **clockwise**, one **counterclockwise**.

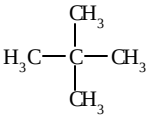
In biology, these are called dextro- and levo- (D and L) forms.

23 • Organic Chemistry
Common Names You Should Know About
(9 of 16)

ethene is also called **ethylene**
propene is also called **propylene**

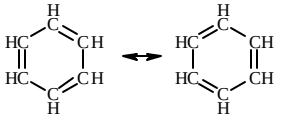


2-methylbutane is also called **<u>iso</u>pentane**. "**Iso-**" means the **same**… the same two methyl groups come branch from C #2. 2-methylpentane is isohexane, etc.



2,2-dimethylpropane is called **<u>neo</u>pentane**. These common names show up occasionally in names… such as in isopropyl alcohol.

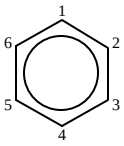
23 • Organic Chemistry
Aromatic Compounds
Benzene and its Derivatives
(10 of 16)



two resonance structures

Benzene, C_6H_6, is unique. It can be drawn as shown, but the actual structure involves a circular **pi** bond (sp^2 orbitals & delocalized e^-'s).

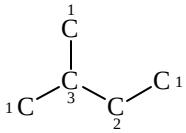
Benzene is also shown with a **circle** as the pi bond.



The carbon #'s can be used for substituted benzene. Example: **dichlorobenzene**
1,2- is known as the **ortho-** position
1,3- is known as the **meta-** position
1,4- is known as the **para-** position
Paradichlorobenzene: the main ingredient in some moth balls.

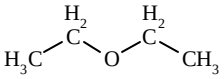
23 • Organic Chemistry
Functional Groups I
Alcohols and Ethers
(11 of 16)

Alcohols General formula: **R-O-H** [R ≈ Rest of molecule]

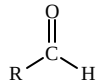


C atoms are classified as **primary** (1), **secondary** (2), or **tertiary** (3) by the number of C atoms it is bonded to. A **primary alcohol** has the -OH group bonded to a primary carbon, etc.
This is not a base because the -OH is covalent, not ionic.
Naming: group + "alcohol" (e.g. ethyl alcohol or ethanol)

Ethers General formula: **R-O-R'** [R' <u>can</u> = R, but not H]
Naming: two groups + "ether"
diethyl ether was the 1st effective surgical and dental anesthetic.

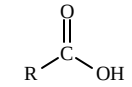
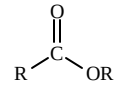


23 • Organic Chemistry
Functional Groups II
Aldehydes and Ketones
(12 of 16)

	Aldehydes	**Ketones**
General formula:		
Naming:	names end in "al" or "aldehyde" methanaldehyde (formaldehyde)	names end in "one" propanone (acetone)

Aldehydes and ketones both have a **C=O** group (**carbonyl group**). **Aldehydes** have it on an **end** carbon. **Ketones** have it on a **middle** carbon. **Reactions**: **Primary** alcohols can be oxidized into **aldehydes**. **Secondary** alcohols into **ketones**.

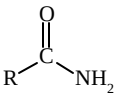
23 • Organic Chemistry
Functional Groups III
Carboxylic Acids and Esters
(13 of 16)

	Carboxylic Acids	**Esters**
General formula:		
Naming:	names end - "oic acid" ethanoic acid (acetic acid)	names end - "ate" ethyl acetate (acetic acid + ethyl alcohol)

Reactions: **Acids** can be made by **oxidizing aldehydes**. **Esters** are formed ("**esterification**") from a **carboxylic acid** & an **alcohol**. Water is removed (a "**condensation**" reaction).

Esters often have pleasant, agreeable odors (e.g. banana.)

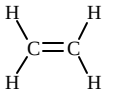
23 • Organic Chemistry
Functional Groups IV
Amines & Amides
(14 of 16)

	Amines	**Amides**
General formula:		
Naming:	names contain "amino" or end in "amine" aminomethane (methylamine)	names end in "amide" acetamide

The N may have 1 or 2 or all 3 H atoms replaced with groups. The **lone pair** on the N atom makes these molecules **basic**. Your body **needs** certain amines "vital amines" ≈ "**vitamins**."

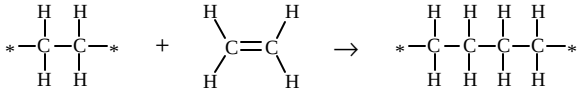
23 • Organic Chemistry
Polymers I
Monomers & Addition Polymerization
(15 of 16)

Monomer = **one** part **Polymer** = **many** parts



"ethylene"

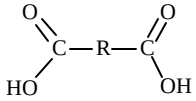
One kind of polymer is made up of monomers that contain a double bond. The double bond can break and we can ADD to it… "Addition polymerization."



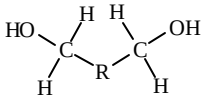
Different monomers form different polymers. This polymer would be called **polyethylene**. Replace on H on the monomer with Cl and you can make **polyvinyl chloride**, "**PVC**."

23 • Organic Chemistry
Polymers II
Copolymers & Condensation Polymerization
(16 of 16)

Another polymerization involves **condensation** reactions.



a di-acid



a di-alcohol (a glycol)

Esters form from an **acid** and an **alcohol**. Using a **di-acid** and a **di-alcohol**, you can make a continuous chain by removing **water** molecules. The resulting polymer is called a **polyester**.

Soda bottles are made from a polyester, **p**oly**e**thylene **t**erephthalate **e**ster (**PETE**).

Nylon (a **polyamide**) can be made from a di-amine & a di-acid.