Elementary Organic Chemistry Review
Handout 1.1
Introduction to Organic Chemistry, Part 1

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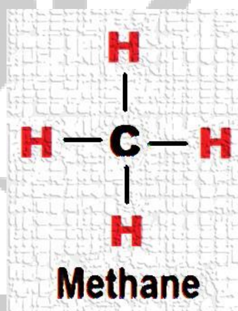
Organic chemistry is the study of carbon compounds.

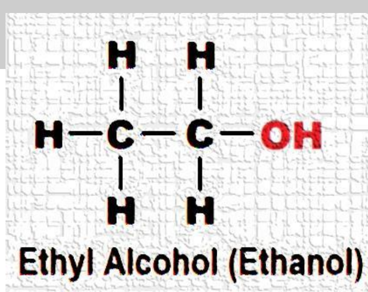
<u>Important properties of organic compounds</u>:

1. Carbon always forms four bonds (tetravalence).
Example: Methane, CH_4



Methane

2. Organic molecules form covalent bonds (bonds that share electrons between atoms)
Example: Ethyl alcohol (Ethanol), CH_3CH_2OH



Ethyl Alcohol (Ethanol)

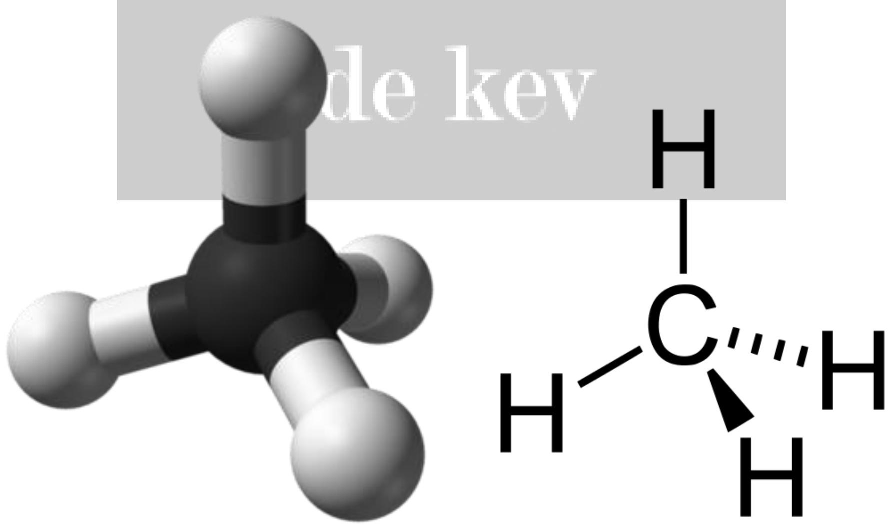
If you remember from general chemistry, the number of covalent bonds that an atom can form is based on the number of additional valence electrons it requires to reach noble-gas configuration (octet rule). Carbon is in Group 4A (14 in the IUPAC system) and has four valence electrons so it can form four bonds (since it needs four more to reach the noble-gas configuration; in this case, it will be for neon's configuration--its nearest noble gas).

Let's take a look at other common elements which you will frequently encounter in organic chemistry:

	Group Number	Valence Electrons	Number of bonds it can form
Hydrogen	1A (1)	1	1
Nitrogen	5A (15)	5	3
Oxygen	6A (16)	6	2
Fluorine, Chlorine, Bromine, Iodine	7A (17)	7	1

3. Carbon forms multiple covalent bonds by sharing more than two electrons with a neighboring atom.
We will see this when we cover alkenes (hydrocarbons with double bonds formed between two carbons) and alkynes (hydrocarbons with triple bonds formed between two carbons). Hydrocarbons are organic compounds composed of only carbon and hydrogen.

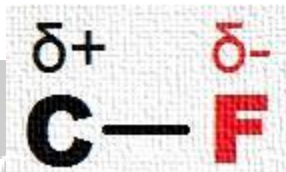
4. Organic molecules have specific 3D shapes.
From our example above, methane has tetrahedral molecular geometry. The bond angles are approximately 109.5°. We won't go into too much complex detail with how the line-bond structure is drawn in this section of the survey of organic chemistry. In the more in depth section that I have for organic chemistry, we will see that wedges represent the hydrogen popping out of the page while dashed lines represent the bond retracting to the back.



5. When carbon bonds to an electronegative element on the right side of the periodic table, the organic molecule contains polar covalent bonds.

If you remember from general chemistry, polar covalent bonds are bonds in which electrons are more strongly attracted by one atom than by the other.

Example: carbon-fluorine bond



This is basically stating that the electronegative atom attracts electrons more strongly than the carbon atom. In the example above, fluorine is more electronegative than carbon, attracting the electrons more strongly. The polarization of this bond gives carbon a partial positive charge and fluorine a partial negative charge.

The partial positive charge is represented by δ+ (delta positive) for the electron-poor atom and the partial negative charge is represented by δ- (delta negative) for the electron-rich atom.

In electrostatic potential maps, the electron-poor δ+ atom is blue and the electron-rich δ- atom is red. In our example, carbon would be blue and fluorine would be red.

<u>Functional groups</u>

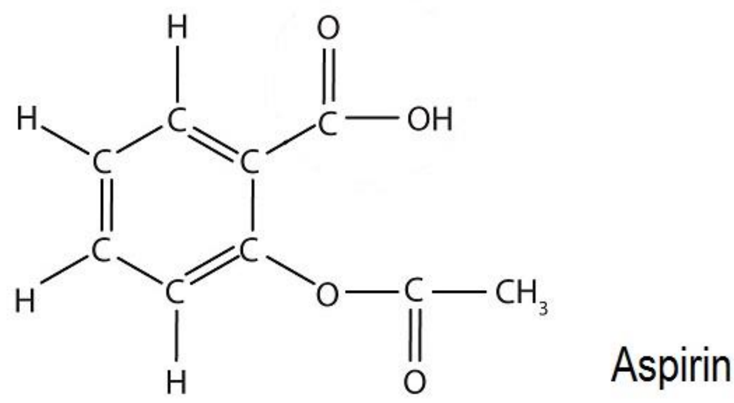
To see structures of common functional groups, please refer to the functional groups handout and refer to it when reading the following information.

Functional groups are atoms or groups of atoms within a larger molecule that have characteristic structures and chemical behaviors. As noted, they allow us to classify compounds through their structural features and predict their chemical behavior. The functional group will behave similarly and undergo the same reactions in every molecule it is a part of.

The functional groups of a molecule determine the molecule's chemistry, not its size or how complex it is. For example, when we cover alcohols, we will see that the secondary alcohols are converted to ketones when an oxidizing agent is used.

Whether it's something simple like cyclohexanol converting to cyclohexanone or the biological process of lactic acid oxidizing to pyruvic acid, they will undergo similar chemical reactions. (both with secondary alcohols)

Let's take a look at a molecule that we are very familiar with (for students studying and people working long hours!) and identify the functional groups.



When you start your journey in organic chemistry, this will look intimidating! However, once we break it down, it becomes less overwhelming. Glance at the functional groups worksheet that I provided.

Now let's break it down and examine the different functional groups.

1. From the left, we can see the hydrocarbon with alternating single and double bonds formed into a ring. We can identify the group as an aromatic (arene). (Pssh…first one's always easy, right?)

2. Next, let's look at the top right. We see a carbon-oxygen double bond (carbonyl group) attached to a carbon and an -OH group. We can identify it as a carboxylic acid. (Now the fun's getting started)

3. Finally, we look at the lower right. This one might make you pause a bit, but let's look at it step by step. We see the carbonyl group (carbon-oxygen double bond) so we can narrow it down to aldehyde, ketone, carboxylic acid, anhydride, ester, and amide.

There's no nitrogen so it can't be an amide. There's no -OH so it can't be carboxylic acid. We see that the carbon is also attached to another oxygen through a single bond so it can't be aldehyde or ketone.

This leaves anhydride and ester. The anhydride functional group has two carbonyl groups with an oxygen between. That's not here.

That leaves us with ester!

The functional groups in aspirin are aromatic (arene), carboxylic acid, and ester. It might seem like a process in the beginning, but once you get exposed to more complex compounds, it will become second nature to you. Believe me, when I was an undergrad student, I had a hard time naming alkanes in the beginning. And alkanes are considered cheesecake compared to the future functional groups!

Families

1. Alkanes, alkenes, alkynes, and aromatic compounds are hydrocarbons, containing only carbon and hydrogen. Alkanes have single bonds. Alkenes have double bonds. Alkynes have triple bonds. Aromatic compounds have a ring of six carbons with alternating single and double bonds.

2. Alkyl halides, alcohols, ethers, and amines are functional groups with single bonds in which carbon is bonded to an electronegative atom. In alkyl halides, carbon is bonded with a halogen. In alcohols, carbon is bonded with oxygen. Ethers have two carbons bonded to the same oxygen. In amines, carbon is bonded with nitrogen.

3. Aldehydes, ketones, carboxylic acids, anhydrides, esters, and amides have a carbon-oxygen double bond (carbonyl group).

Now that we have a foundation in the basic principles of organic chemistry, we can begin examining these functional groups in depth.