Chemistry Basics

After this module you will be able to...

- Draw organic molecules using skeletal drawings
- Identify basic naming conventions
- Identify simple N, S, and O functional groups
- Describe simple biomolecules

Table of Contents

Lesson 1: Using Skeletal Drawing to Simplify Organic Molecules

Skeletal drawings are used to simplify organic molecules which are mostly composed of carbon and hydrogen atoms. In a skeletal drawing, sometimes called line drawing, a carbon atom is represented by a vertex between two lines and the hydrogen atoms are filled in accordingly so that each carbon atom contains four bonds. Representations of butane, a four carbon molecule, are shown in figure 1.

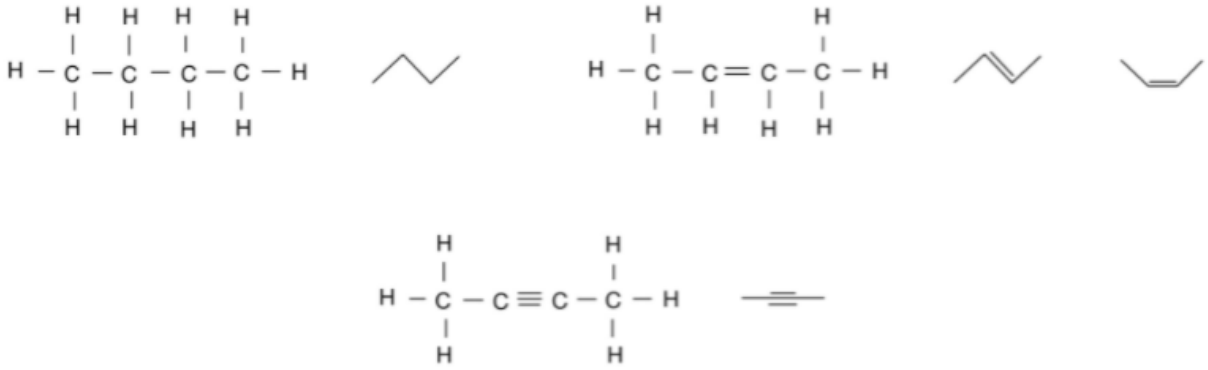


Figure 1. Representations of butane.

Any atoms besides carbon and hydrogen are represented by their chemical symbol. Hydrogen atoms attached to non-carbon atoms are also shown such as on groups like -NH_3 and OH. Examples of these skeletal structures are shown in figure 2.

Figure 2. Representations of non-carbon atoms in skeletal structures.

Using skeletal structures in place of Lewis dot structures creates a simplified image. It makes it easier to see functional groups and picture the three-dimensional structure of the molecule. Both of these could impact the reactivity of the molecule. It also saves organic chemists a whole lot of time!

Lesson 2: Basic Naming Rules

Naming Hydrocarbon Chains

The names of hydrocarbon chains can be broken into three parts: prefix, parent chain, and suffix. The parent chain describes the number of carbons in the longest chain of the molecule. The number of carbon atoms corresponds to the name of the parent chain. These names are shown in Table 1.

Number of Carbons	Name
1	**meth**ane
2	**eth**ane
3	**prop**ane
4	**but**ane
5	**pent**ane
6	**hex**ane
7	**hept**ane
8	**oct**ane
9	**non**ane
10	**dec**ane
11	**undec**ane
12	**dodec**ane

Table 1. Naming the parent chain.

The suffix describes the types of bonds present between the carbon atoms along the main hydrocarbon chain.

- If the hydrocarbon chain is fully saturated with hydrogens (all single bonds), the ending -ane is used.
- If a double bond is present then -ene is used.
- If a triple bond is present then -yne is used.

Examples of different suffixes are shown in figure 3 below. Notice that molecules with two or more double bonds adjust the suffix to -adiene and -atriene accordingly.

Figure 3. Naming unsaturated molecules.

Finally the prefix of a hydrocarbon describes the substituents that branch off from the main chain. There are a number of substituents that are common and display similar chemical properties. These substituents are called functional groups. Examples of a few functional groups are shown in figure 4 below.

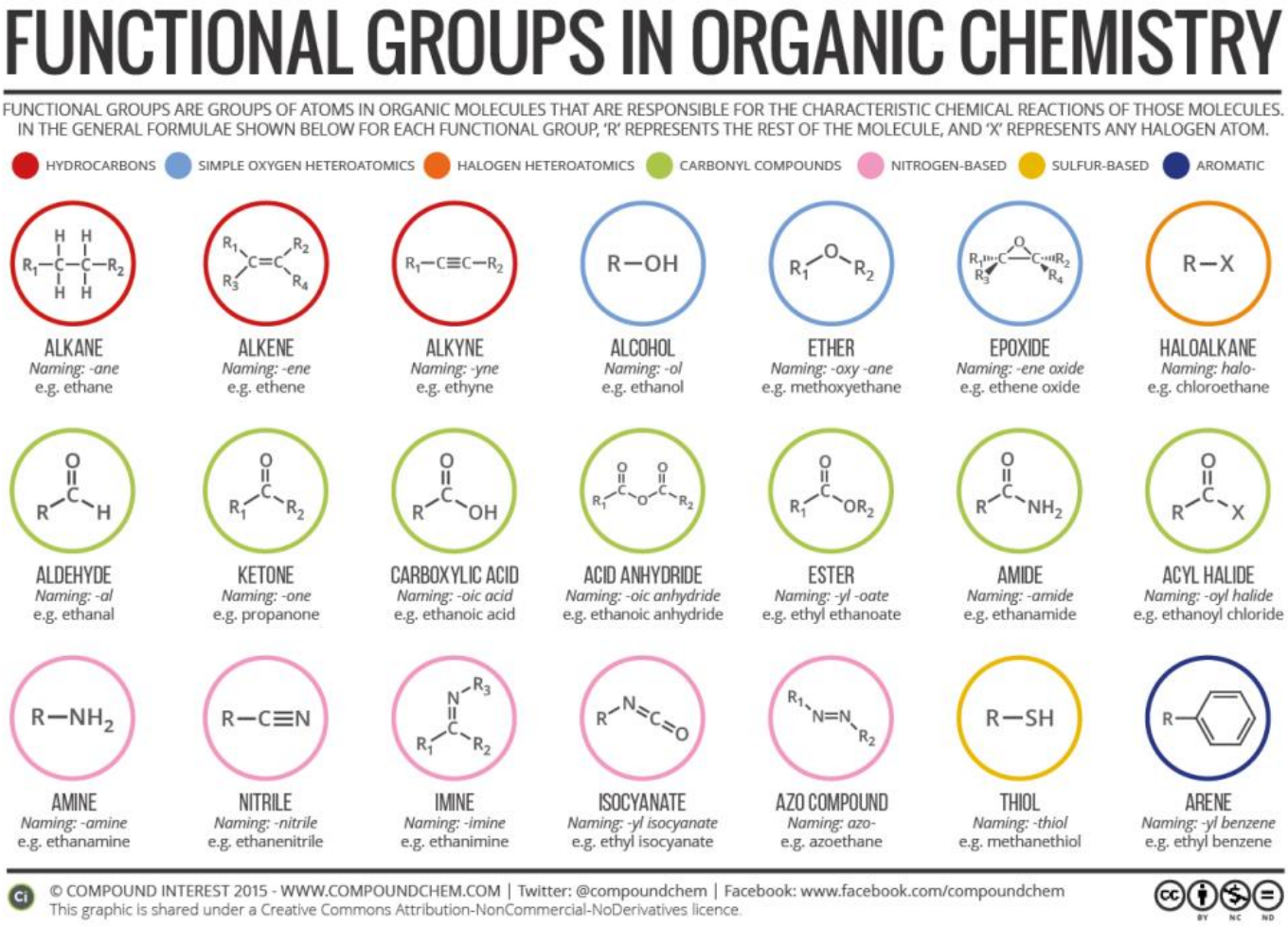


Figure 4. Common functional groups in organic chemistry. (source: compoundchem.com)

Lesson 3: Basic Biomolecules

Biomolecules are molecules created by living organisms. The major biomolecules are proteins, carbohydrates, and lipids. In HTL reactions, biomolecules are typically broken down into their constituent monomers that re-polymerize to form bio-oil. Therefore it is important to understand what monomers make up each type of biomolecule to help better understand and predict reaction products.

Carbohydrates

Carbohydrates are biomolecules consisting of carbon, hydrogen, and oxygen. The empirical formula for carbohydrates is generally $(CH_2O)_n$. Simple carbohydrates are called monosaccharides and are composed of a single sugar molecule. Examples of monosaccharides include ribose, deoxyribose, glucose, and fructose. Two monosaccharides can combine to form disaccharides. For example, sucrose (table sugar) is formed when a molecule of glucose combines with a molecule of fructose. Carbohydrates can continue to combine to form polysaccharides. Cellulose, the main component of plant cell walls, is a type of polysaccharide. Under HTL conditions, carbohydrates will undergo hydrolysis to form its constituent sugars.

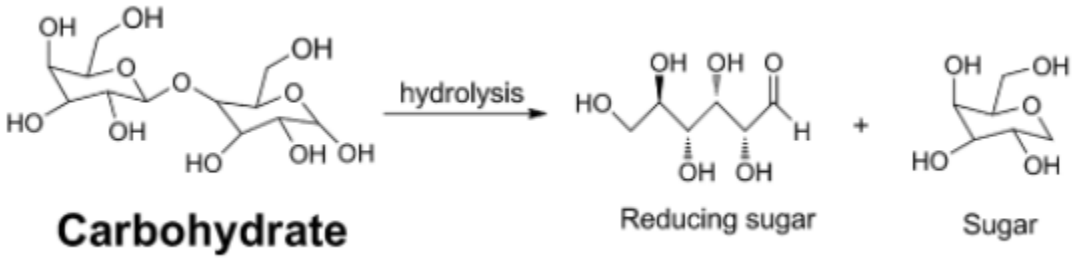


Figure 6. The hydrolysis of carbohydrates, adapted from [1].

Lipids

Lipids are a large and diverse group of biomolecules that are defined by their solubility in water. Lipids are molecules that are insoluble in water but soluble in organic solvents such as acetone or dichloromethane. Lipids include molecules such as fats, steroids, and fatty acids. In organisms, lipids create the cell membrane that has a hydrophobic center and a hydrophilic outer layer. Under HTL conditions, lipids will undergo hydrolysis to form glycerol and fatty acids.

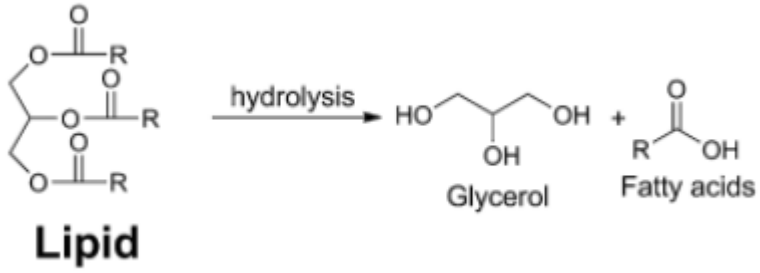


Figure 6. The hydrolysis of lipids, adapted from [1].

Proteins

Proteins are a diverse group of macromolecules that play essential roles in organisms. Proteins help store and transport oxygen in the human body, they act as enzymes to catalyze almost all biological reactions, provide immune support, and generate usable energy for the organism, among many other roles. There are twenty amino acids that combine to form all of the proteins. Under HTL conditions, protein will undergo hydrolysis to produce glycerol and fatty acids.

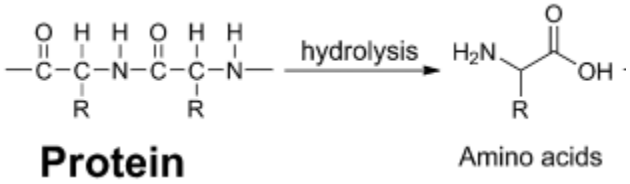
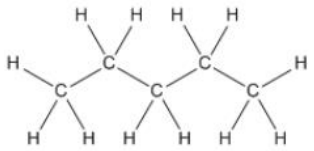


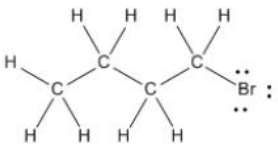
Figure 7. The hydrolysis of proteins, adapted from [1].

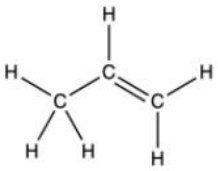
[1] Gai, C., Zhang, Y., Chen, W-T., Zhang, P., and Dong, Y. (2015) An investigation of reaction pathways of hydrothermal liquefaction using Chlorella pyrenoidosa and Spirulina platensis. *En. Con. Man.* **96**: 330-339.

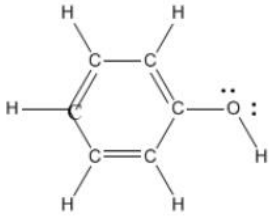
Check Quiz

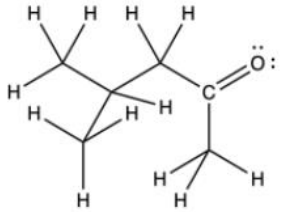
1. Draw the following organic molecules using skeleton drawing.

a.) 

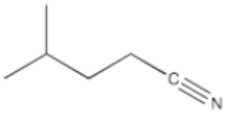
b.) 

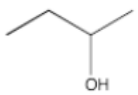
c.) 

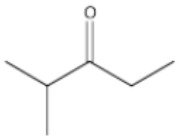
d.) 

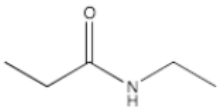
e.) 

2. Identify the functional groups in the following molecules.

a.) 

b.) 

c.) 

d.) 

3. Which biomolecule is composed of amino acids?
    a. Carbohydrates
    b. Lipids
    c. Proteins

4. Which biomolecule has the empirical formula $(CH_2O)_n$?
    a. Carbohydrates
    b. Lipids
    c. Proteins

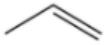
5. Which biomolecule creates cell membranes?
    a. Carbohydrates
    b. Lipids
    c. Proteins

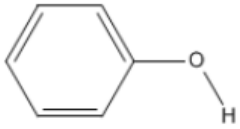
KEY

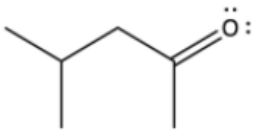
1. Skeletal drawings:

a.) 

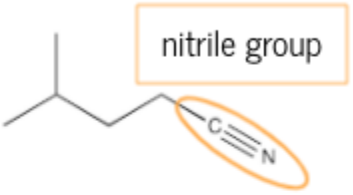
b.) 

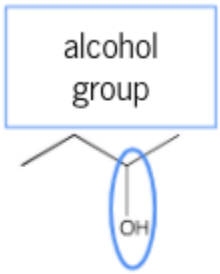
c.) 

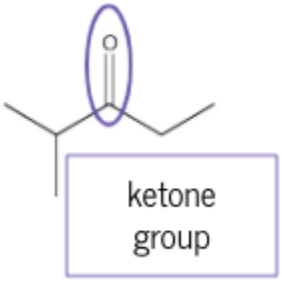
d.) 

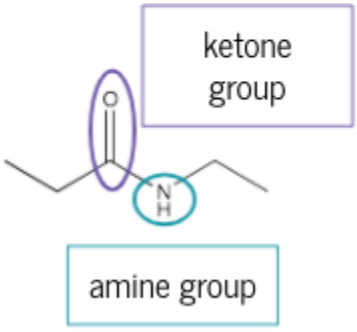
e.) 

2. Identify the functional groups:

a.) 

b.) 

c.) 

d.) 

3. **Answer C**; Proteins are composed of twenty amino acids.

4. **Answer A**; Carbohydrates are hydrated hydrocarbon chains. The ratio of water molecules to carbon will be about 1:1 with some exceptions.

5. **Answer B**; Lipids that create cell membranes have a hydrophobic tail and a hydrophilic head. These combine to form cell membranes that are hydrophobic on the inside and hydrophilic on the outside.