FLINN SCIENTIFIC

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Laboratory Report

Part A. Structures of Organic Compounds

Obtain a set of molecular models to answer the questions in Part A.

1. Build models of ethane, C_2H_6, and propane, C_3H_8, and write out their structural formulas.

2. Do the C—C single bonds in ethane and propane rotate freely? Explain.

3. There are two possible structures for butane, C_4H_{10}. Build models of both structures and draw their structural formulas.

4. The two possible structural formulas for butane are called **isomers**. Write a general definition of isomers that describes the relationship between the two structures.

5. Without building models, draw out the possible structural formulas for three isomers of pentane, C_5H_{12}.

6. Alkanes are hydrocarbons—compounds containing only carbon and hydrogen—in which all of the C—C bonds are single bonds. What is the **general formula** for an alkane, where *n* is the number of carbon atoms?

7. **Alkenes** are hydrocarbons that contain at least one C═C double bond in their structure. Build models of ethene (C_2H_4) and propene (C_3H_6) and draw their structural formulas.

8. Describe the molecular geometry around the C═C double bond in an alkene. What is the H—C—H bond angle in ethene?

9. Unlike C—C single bonds, C═C double bonds do not rotate. Draw diagrams showing the overlap of the orbitals responsible for the sigma and pi bonds, respectively, in a C═C double bond. Use the orbital diagram to explain why the C═C double bond does not freely rotate.

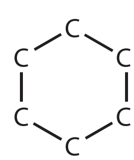
10. Butene (C_4H_8) has one C═C double bond in its structure. Draw structures for three possible **structural isomers** of butene.

11. The structural formula for *2-butene* can be abbreviated CH_3—CH═CH—CH_3. Because of the lack of free rotation about the C═C double bond (see Question 9), there are two possible structures for this compound. Build models and draw structural formulas for two **three-dimensional structures** of 2-butene.

12. The two forms of 2-butene shown in Question 11 are called **geometric isomers**. What is the same and what is different about geometric isomers?

13. What is the general formula of an alkene, where *n* is the number of carbon atoms? Why do you think alkenes are called unsaturated and alkanes are called saturated hydrocarbons?

14. Benzene, C_6H_6, is the parent compound of a class of compounds called aromatic compounds that are very common in nature. The carbon skeleton for benzene is shown below. Add **hydrogen atoms** and **double bonds**, as necessary, to complete the structure of benzene.



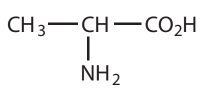
15. Build a model of benzene and describe its molecular geometry (planar, tetrahedral, etc.).

16. The structural formula of benzene in Question 14 shows alternating single (C—C) and double (C═C) bonds. It has been found, however, that all of the carbon-carbon bonds in benzene are identical. This fact may be explained in terms of resonance. Define **resonance** and draw two resonance forms for benzene.

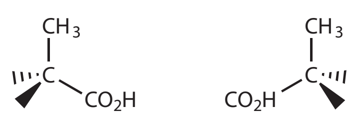
17. Alcohols are organic compounds containing an –OH group attached to a carbon atom. Draw the structural formula of ethanol, C_2H_5OH.

18. Low-molecular weight alcohols such as ethanol are polar compounds and are miscible with water. As the number of carbon atoms in an alcohol increases, the solubility of the alcohol in water decreases. Thus, octanol, $C_8H_{17}OH$, is practically insoluble in water. Explain.

19. Compounds containing at least one carbon atom that is attached to four different groups give rise to a special class of isomers called enantiomers. **Enantiomers** are defined as non-superimposable mirror images of each other. Build models and complete the following diagrams to show the enantiomers of **alanine**, an amino acid.



Alanine



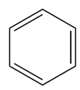
Mirror plane

20. What does it mean to say that the enantiomers shown in Question 19 are **non-superimposable**? Why do you think this property of molecules is sometimes called “handedness?”

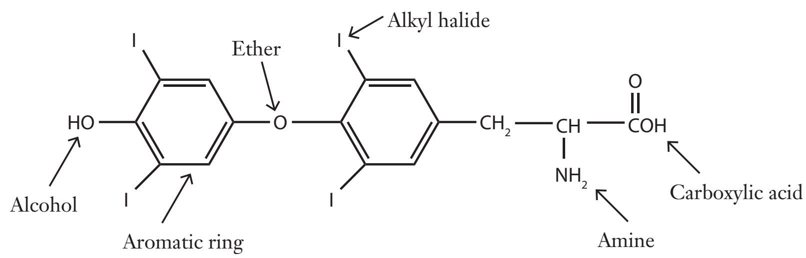
Part B. Functional Groups

Organic compounds are classified into functional group classes based on their structure and properties. A functional group is defined as a specific arrangement of atoms, such as –OH or $-NH_2$, that undergoes characteristic chemical reactions and gives organic compounds similar physical properties. Table 1 shows the structures of common organic functional groups. The symbol R is used to represent rings or chains of carbon and hydrogen atoms.

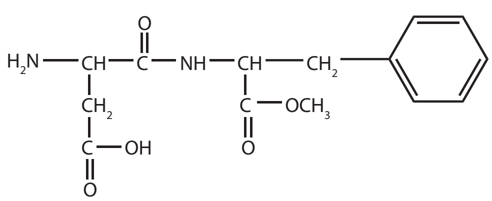
Table 1. Organic Functional Groups

Functional Group	Structure	Functional Group	Structure	Functional Group	Structure
Alkenes	$>C{=}C<$	**Ethers**	R—O—R′	**Aldehydes**	$R-\overset{O}{\overset{\|}{C}}-H$
Alkynes	—C≡C—	**Alkyl Halides**	R—X X = F, Cl, Br or I	**Carboxylic Acids**	$R-\overset{O}{\overset{\|}{C}}-OH$
Aromatic Compounds		**Amines**	$R-NH_2$ (R_2NH and R_3N)	**Esters**	$R-\overset{O}{\overset{\|}{C}}-O-R'$
Alcohols	R—O—H	**Ketones**	$R-\overset{O}{\overset{\|}{C}}-R'$	**Amides**	$R-\overset{O}{\overset{\|}{C}}-NH_2$

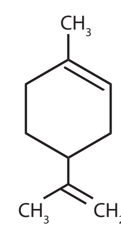
Circle and label the functional groups in the following natural and consumer organic products. The first one has been done for you as an example.



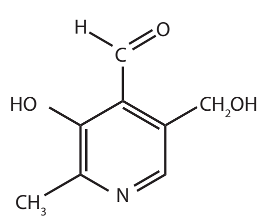
Thyroxine (Thyroid hormone)



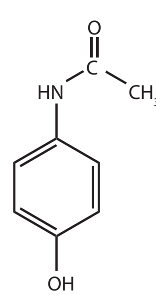
Aspartame (NutraSweet®)



Limonene (Citrus peel oil)



Pyridoxal (Vitamin B6)



Acetaminophen (Tylenol®)