LIFEPAC®

SCIENCE

STUDENT BOOK

11th Grade | Unit 9

Alpha Omega PUBLICATIONS

SCIENCE 1109

CARBON CHEMISTRY: FUNCTIONAL GROUPS

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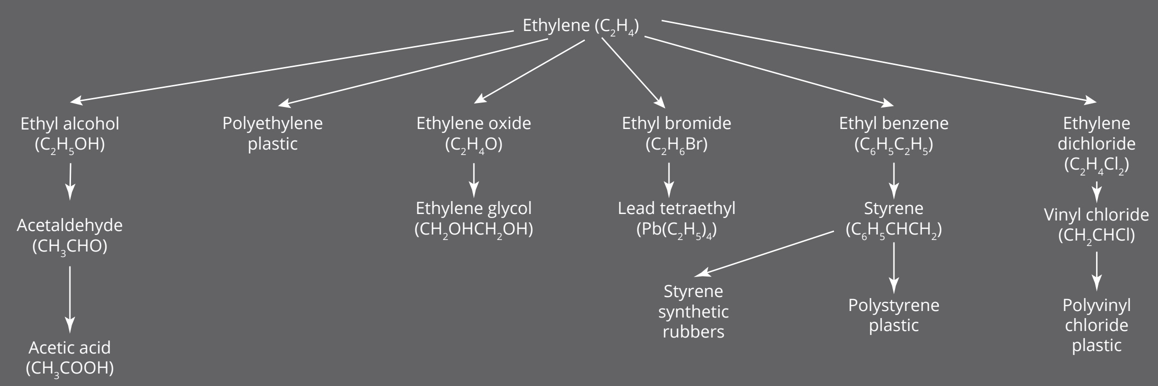
CARBON CHEMISTRY: FUNCTIONAL GROUPS

Introduction

One of the most widely used (12 million tons annually) organic chemicals in industry is ethylene, C_2H_4, which is manufactured from ethane, C_2H_6, obtained from petroleum. Ethylene is formed according to the dehydrogenation reaction given by the equation: $C_2H_6 \longrightarrow C_2H_4 + H_2$.

The variety of substances produced from ethylene are indicated in the following diagram.



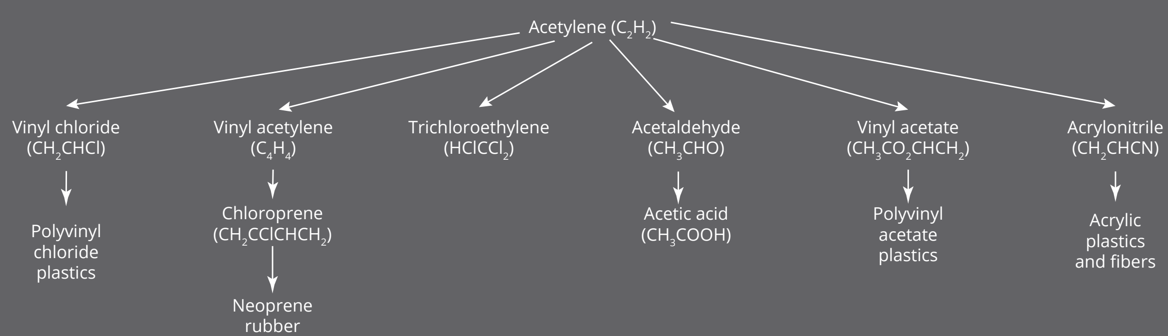
Another useful organic chemical is acetylene, C_2H_2, which is manufactured by heating CaO (lime) and C (coke) in an electric furnace to produce calcium carbide, CaC_2:

$$CaO + 3\,C \longrightarrow CaC_2 + CO$$

Calcium carbide is then combined with water to give acetylene gas:

$$CaC_2 + 2\,H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

The uses of acetylene are summarized in the following diagram.



This LIFEPAC® is designed to help you study some of the chemistry of the functional groups of organic chemistry. You will learn the chemistry of saturated and unsaturated molecules, oxygen derivatives, and nitrogen-containing organic molecules. You will also learn that God's great design of protein molecules leaves no doubt that a Creator made our universe and all life in it. Study the preceding diagrams to see how Science LIFEPAC 1108 fits this LIFEPAC.

Objectives

Read these objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAC®. When you have finished this LIFEPAC, you should be able to:

1. Diagram the reaction between an alkane and a halogen.
2. Describe the reaction between an alkane and a halogen.
3. List some examples of halides of the alkane series.
4. Diagram the reaction between halogens and unsaturated molecules.
5. Describe the reaction between halogens and unsaturated molecules.
6. List some examples of halides of the unsaturated series.
7. Classify and identify oxygen families by functional group.
8. Describe the properties of the different oxyorganic functional groups.
9. Balance reactions involving the oxygen functional groups.
10. List some common examples of each of the oxygen functional groups.
11. Classify and identify amines and amides.
12. Describe the chemical properties of some common nitrogen-containing organic compounds.
13. Describe amino acids and identify the peptide linkage.
14. Describe proteins.
15. Explain how proteins give evidence of God's Creation.

Survey the LIFEPAC. Ask yourself some questions about this study and write your questions here.

1. HYDROCARBON CHEMISTRY

The reactions of hydrocarbons are the basis of the chemistry for many other organic compounds. (See the Introduction to this Science LIFEPAC.) In this section you will study the basic reactions of saturated and unsaturated molecules when reacted with halogens, the reaction types of substitution and addition will be reviewed, and examples of organic halides will be listed.

Section Objectives

Review these objectives. When you have completed this section, you should be able to:

1. Diagram the reaction between an alkane and a halogen.
2. Describe the reaction between an alkane and a halogen.
3. List some examples of halides of the alkane series.
4. Diagram the reaction between halogens and unsaturated molecules.
5. Describe the reaction between halogens and unsaturated molecules.
6. List some examples of halides of the unsaturated series.

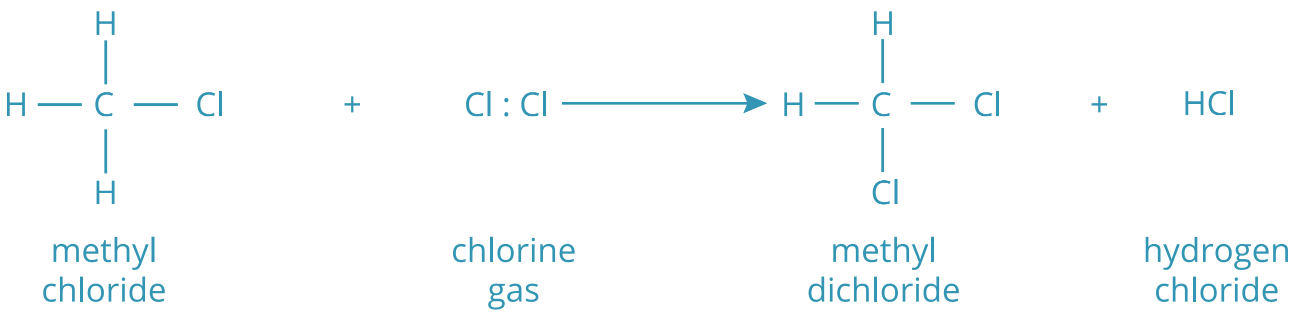
SATURATED

Compounds formed from the reaction of halogens and saturated hydrocarbons are very common. Some compounds in this halide group have been significant in making history. In this section you will study how saturated halides are formed and learn some examples of this family that are important to us today.

Reactions. The formation of saturated halide hydrocarbons is one of replacement (substitution). A typical example is the reaction between chlorine gas (Cl:Cl) and methane. In the presence of ultraviolet light, this reaction occurs at a very rapid rate. The ultraviolet light provides energy of just the right amount to cause the reactants to break apart and react with each other.

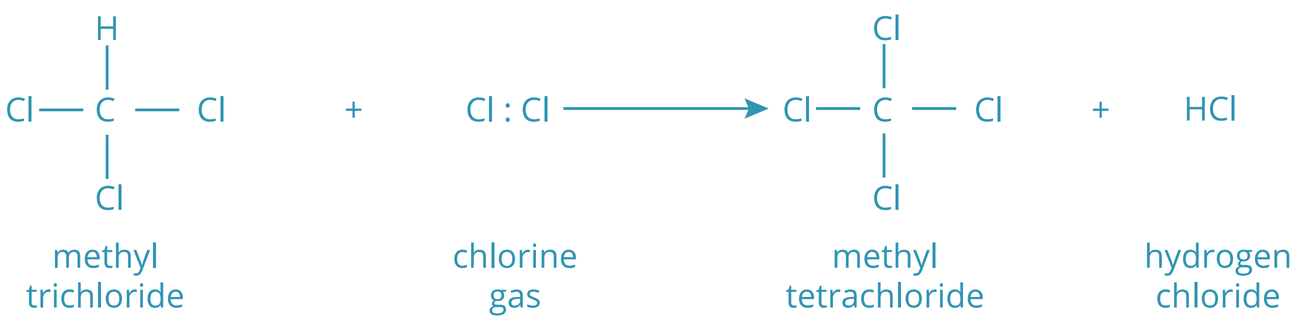
| Reaction 1
(Each — is the same as : in a bond. Each — and each : represents a pair of bonding electrons.)

If the methane-chlorine mixture is left to continue reacting, successive hydrogens will be replaced and the substitution reaction will continue until all hydrogens have been replaced.



| Reaction 2

| Reaction 3

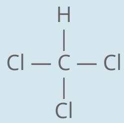
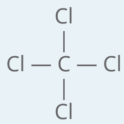
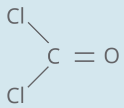
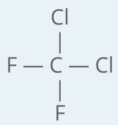
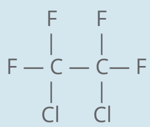


| Reaction 4

This substitution series is an equilibrium series and will finally become a mixture of all four methyl halides. The equilibrium can be shifted to the right in each case by the removal of hydrogen chloride and the use of excess chlorine gas. (If you need a review of equilibriums, review Science LIFEPACs 1106 and 1107.) Since the HCl is an acid and is very soluble in water, the reaction mixture can be pumped through water and the HCl removed. This process leaves the methyl halide to react with chlorine gas until complete substitution has been accomplished. This reaction procedure is common in the production of halides from saturated hydrocarbons.

Examples. Many saturated halide hydrocarbons are common to us in our everyday life. A few examples are listed in Table 1.

Table 1
EXAMPLES OF SATURATED HALIDE HYDROCARBONS

Structure	Formula	Common Name	Uses
	$CHCl_3$	chloroform	anesthetic (dangerous to use)
	CCl_4	carbon tetrachloride	dry cleaning solvent, fire extinguisher (dangerous to use; inhaling vapors causes liver damage)
	$COCl_2$	phosgene	poisonous gas used in warfare, especially World War I
	CCl_2F_2	Freon 12	dispersing gas in aerosols, refrigerant (may cause damage to ozone layer of our atmosphere)
	$C_2Cl_2F_4$	Freon 114	dispersing gas in aerosols, refrigerant (may cause damage to ozone layer of our atmosphere)

Do these activities.

1.1 Assume a single Br replacement in the reaction of methane and Br_2. Use a structural diagram to show the reaction between CH_4 and Br_2.

1.2 What is the reaction type most typical of halides with saturated hydrocarbons?

____

1.3 List three common halide hydrocarbons. a. ____________________ b. ___________________

c. _____________________

1.4 Balance a complete substitution reaction between methane and fluorine gas, F_2.

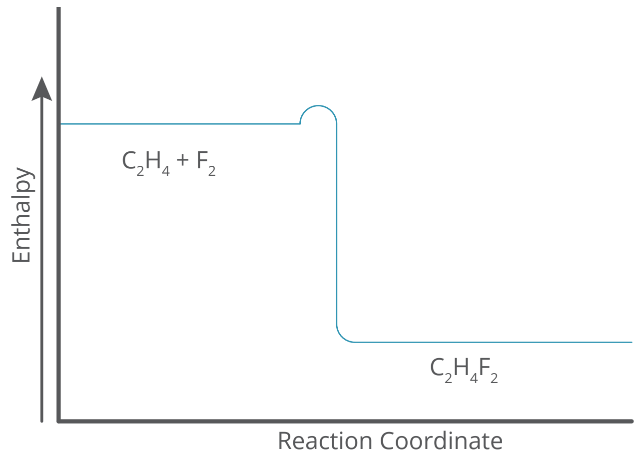
1.5 Balance the following reaction. ______ C_2H_6 + ______ $Cl_2 \rightarrow$ ______ $C_2H_4Cl_2$ + _____ HCl

UNSATURATED

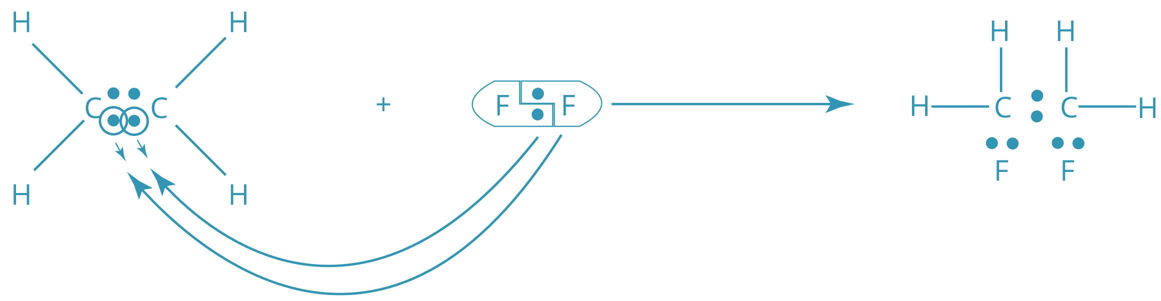
Unsaturated hydrocarbons react very rapidly with halogens. No energy is needed for this reaction as the double or triple bonds are very unstable. In this section, we will study some typical unsaturated hydrocarbon-halogen reactions and list some examples.

Reactions. Two types of reactions will be studied. Unsaturated chain hydrocarbons will undergo addition while benzene ring compounds will undergo substitution. For example, ethene reacts with fluorine to produce difluoroethane.

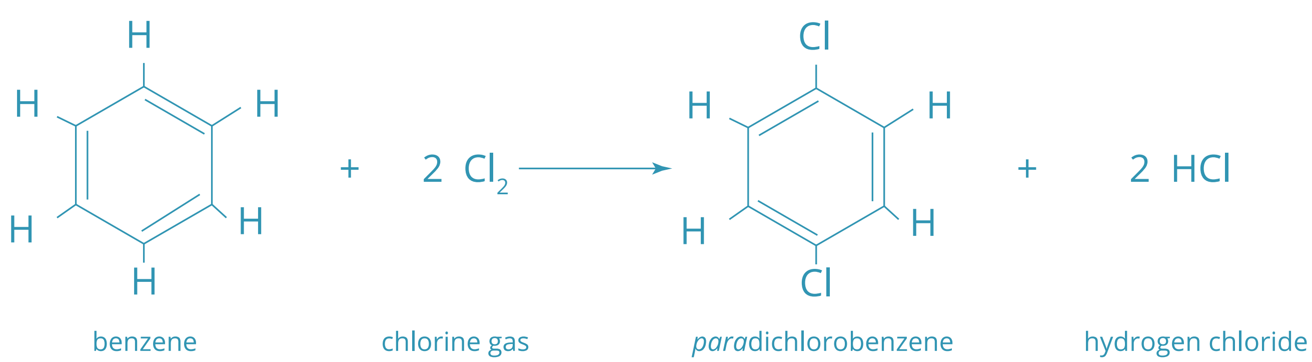
This reaction is by simple addition. The double bond is broken and fluorine is added. An electron dot diagram may help you to see the electron rearrangement that takes place.



The energy necessary to break the double bond is very small and therefore the addition reaction is very rapid. The enthalpy diagram shows a very low activation energy.

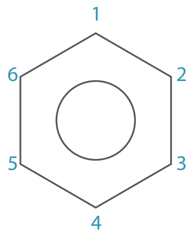


The halogenation of the benzene ring occurs through substitution. A typical reaction is between chlorine and benzene.

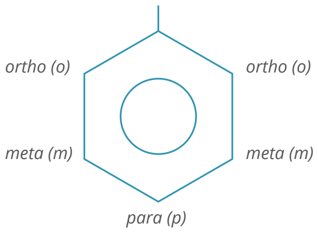


The common name for paradichlorobenzene is moth balls. You used moth balls in Science LIFEPAC 1102.

When more than one substituted group appears on the ring, the positions on the ring are distinguished by numbering the carbons

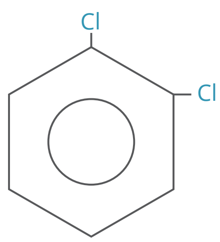


or by the following notation:

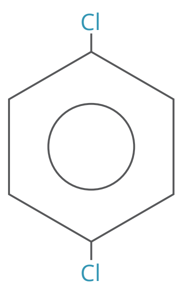


To illustrate, consider the following compounds:

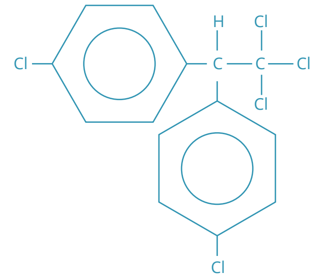
*ortho*dichorobenzene
o-dichlorobenzene
1,2-dichlorobenzene



*para*dichlorobenzene
p-dichlorobenzene
1,4-dichlorobenzene



Examples. The use of polychlorinated (many chlorines) hydrocarbons as insecticides grew very rapidly after World War II. Many of these insecticides were produced from the chlorination of unsaturated hydrocarbons. One example is DDT. This polychlorinated hydrocarbon was used extensively as a delouser among World War II troops and as a killer of typhus-bearing lice and malaria-bearing mosquitoes. Although once thought to be an ideal insecticide, DDT is now known to be a major pollutant in the food chain of wild birds. Scientists have found that DDT concentrates in the food chain of such wild birds as ducks, eagles, and robins. When this concentration occurs, the wild bird eats high doses of DDT. These high doses interfere with the calcium formation in the egg shells of the affected species and cause softshelled eggs to be laid. These soft shells break easily and are easy prey for other animals. DDT is now banned and endangered species have recovered. This problem is a good example of man's interference in God's perfect balance. The chemical name for DDT is dichlorodiphenyltrichloroethane.



| DDT

A second example has already been discussed, para-dichlorobenzene. When the paracompound is produced, some of each of the other two compounds, meta- and ortho-, are produced.

Do these activities.

1.6 Draw an enthalpy diagram of the chlorination of ethene.

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