Chapter 20 Organic Chemistry

20.1 Saturated Hydrocarbons

Key Terms

organic chemistry	biomolecule	hydrocarbons
saturated	unsaturated	alkanes
unbranched hydrocarbons (normal or straight chain)	structural isomerism	petroleum
natural gas	combustion reactions	substitution reactions
dehydrogenation reactions		

Summary

The study of carbon-containing compounds and their properties is called *organic chemistry.* A carbon atom can form bonds to a maximum of four other atoms. When carbon has four atoms bound to it, the atoms will always have a tetrahedral arrangement around the carbon atom. When carbon bonds to fewer than four other atoms, they are joined by double or triple bonds.

Hydrocarbons are compounds made up of carbon and hydrogen. Hydrocarbons in which all the carbon–carbon bonds are single and each carbon is bound to the maximum number of atoms (four) are said to be *saturated.* Saturated hydrocarbons are called *alkanes.* Hydrocarbons containing carbon–carbon multiple bonds are *unsaturated* because the carbon atoms can bond to one or more additional atoms.

Structural isomerism occurs when two molecules have the same atoms but different bonds. The molecules have the same formulas, but their atoms are arranged in different structures. All *alkanes* of three or more carbon atoms have this property.

The names of the alkanes beyond the first four (methane, ethane, propane, and butane) are formed by adding the suffix (word ending) *-ane* to the Greek root for the number of carbon atoms.

The basic rules for naming alkanes are as follows:

1. To determine the base alkane name, find the parent chain, which is the longest continuous chain of carbon atoms.
2. Number the carbons in the parent chain, starting at the end closest to any branching.
3. Using the correct name for each alkyl group, use a number to show its position on the parent chain.
4. When a certain type of alkyl group appears more than once, attach the correct prefix, or word beginning (*di-* for two, *tri-* for three, and so on) to the alkyl name.
5. The alkyl groups are listed in alphabetical order, ignoring any prefix.

Petroleum is a thick, dark liquid made up mostly of hydrocarbons that contain from 5 to more than 25 carbon atoms. *Natural gas,* which is usually found in petroleum deposits, is made up mostly of methane. Petroleum and natural gas probably formed from the remains of marine organisms that lived about 500 million years ago. To be used efficiently, crude petroleum is separated into molecules of various sizes, called fractions. Gasoline, kerosene, heating oil, and asphalt are a few examples of petroleum fractions.

Alkanes can be involved in three main types of reactions. These compounds react strongly with oxygen when the temperature becomes high enough. Such *combustion reactions* are what make alkanes useful as fuels. Alkanes can also undergo *substitution reactions.* In such reactions, one or more hydrogen atoms in the alkane are substituted (replaced) by different atoms. In *dehydrogenation reactions,* hydrogen atoms are removed, and an unsaturated hydrocarbon is produced.

20.2 Unsaturated Hydrocarbons

Key Terms

alkenes	alkynes	addition reactions
hydrogenation reactions	halogenation	polymerization
aromatic hydrocarbons	benzene	phenyl group

Summary

Alkenes are hydrocarbons that contain carbon–carbon double bonds. *Alkynes* are hydrocarbons with carbon–carbon triple bonds. Both are unsaturated. The most important reactions that alkenes and alkynes take part in are *addition reactions,* in which new atoms form single bonds to the carbons formerly involved in the double or triple bonds. In *hydrogenation reactions,* a hydrogen atom is added to each carbon atom formerly involved in the double bond. *Halogenation* of unsaturated hydrocarbons involves the addition of halogen atoms. *Polymerization* is a process in which many small molecules are joined to form a large molecule.

Aromatic hydrocarbons are pleasant-smelling compounds that result when mixtures of natural hydrocarbons are separated. All aromatic hydrocarbons include a ring of six carbon atoms with attached hydrogen atoms, called a benzene ring. *Benzene* has the formula C_6H_6 and a planar (flat) structure in which all of the bond angles are 120°.

Like alkanes, aromatic hydrocarbons can undergo substitution reactions. Substituted benzene molecules are formed by replacing one or more of the hydrogen atoms with other atoms or groups of atoms.

20.3 Introduction to Functional Groups and Alcohols

Key Terms

functional groups alcohols

Summary

Hydrocarbon derivatives are molecules that are considered to be hydrocarbons but have added atoms or groups of atoms called *functional groups.*

Alcohols are compounds that contain the –OH group. To name an alcohol, we replace the final *-e* of the parent hydrocarbon name with *-ol* and then use a number, if necessary, to show the position of the –OH group.

Methanol and ethanol are the simplest alcohols and have the most practical uses. Methanol is made by the hydrogenation of carbon monoxide. It is used in the manufacture of acetic acid, adhesives, fibers, and plastics. Ethanol is the alcohol in alcoholic beverages and is an alternative fuel for automobiles. It is made by fermenting the glucose (a type of sugar) in grains and fruits.

Ethylene glycol is one of a group of alcohols that have more than one –OH group. It is an ingredient in antifreeze. Phenol is a type of aromatic alcohol. It is used in the manufacture of adhesives and plastics.

20.4 Additional Organic Compounds

Key Terms

carbonyl group	ketones	aldehydes
carboxylic acids	ester	polymers
addition polymerization	condensation polymerization	copolymer
homopolymer	dimer	polyester

Summary

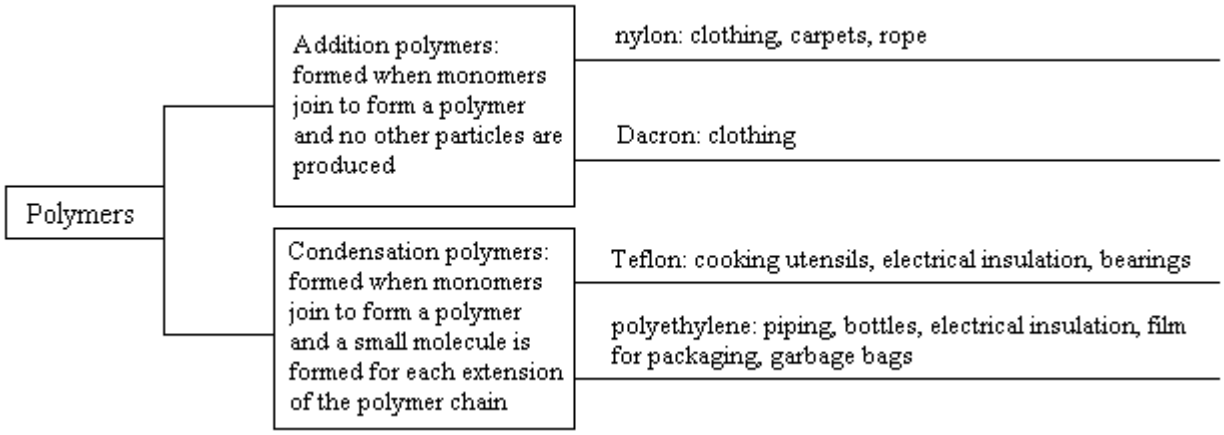
Aldehydes and ketones contain a carbon–oxygen group called the *carbonyl group.* In *ketones,* this group is bonded to two carbon atoms. In *aldehydes,* the carbonyl group always appears at the end of the hydrocarbon chain. This means at least one hydrogen is always bonded to the carbon atom in the carbonyl group.

To name an aldehyde, we remove the final *-e* from the parent alkane and add *-al.* For ketones, the final *-e* is replaced by *-one* and, if necessary, a number that tells the position of the carbonyl group.

Carboxylic acids are compounds that include the carboxyl group, which is –COOH. Carboxylic acids are usually weak acids in aqueous solution. We name carboxylic acids by

dropping the final *-e* from the parent alkane (the longest chain containing the –COOH group) and adding *-oic*. A carboxylic acid reacts with an alcohol to form an *ester*.

Polymers are large molecules that are usually formed from chains of small molecules called monomers. Many fibers and plastics are made of polymers.



Additional Active Reading Questions

1. What is the study of carbon-containing compounds and their properties?

2. Compare saturated hydrocarbons to unsaturated hydrocarbons.

3. Which property occurs when two molecules have the same formulas but atoms that are arranged in different branched structures?

4. From what materials do scientists believe petroleum and natural gas probably formed?

5. What types of reactions make alkanes useful as fuels?

6. Write the formula for benzene and describe the structure of the molecule.

7. What type of alcohol is made by fermenting the glucose in grains and fruits?

8. Name the carbon–oxygen group that characterizes aldehydes and ketones.

9. Which two compounds react to form esters?