Chapter 22: Hydrocarbon Compounds

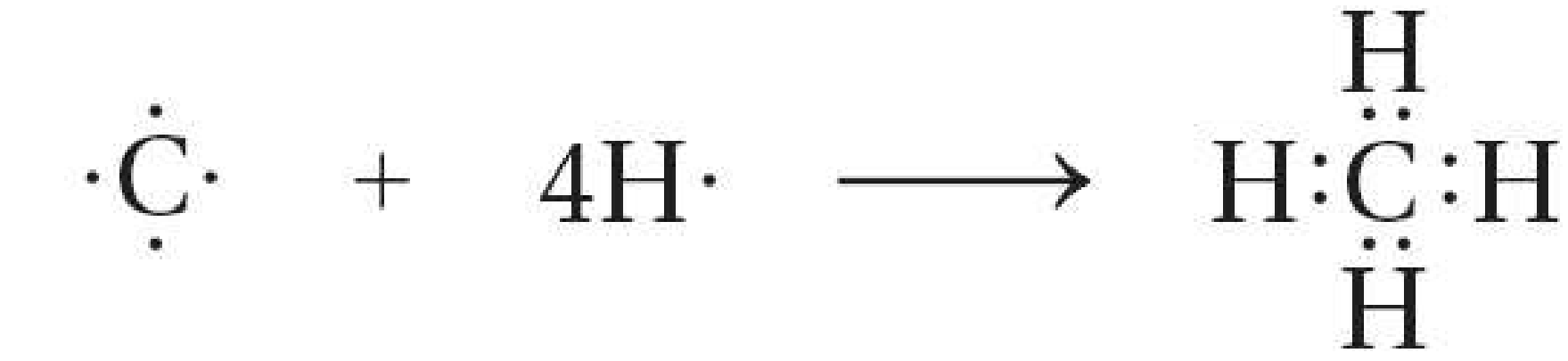
22.1 Hydrocarbons

Organic Chemistry and Hydrocarbons

- Because carbon has _____ valence electrons, a carbon atom always forms _____ covalent bonds.
  - The simplest organic compounds contain only _____ and _____ and are called **hydrocarbons.**

Organic Chemistry and Hydrocarbons

One carbon atom can form a single covalent bond with ____ hydrogen atoms.



Alkanes

- An **alkane** is a hydrocarbon in which there are only _____ covalent bonds.
  - The carbon atoms in an alkane can be arranged in a straight chain or in a chain that has branches.

Alkanes

A group of compounds forms a **homologous series** if there is a constant increment of change in molecular structure from one compound in the series to the next.

Carbon Prefixes

# C	Prefix	# C	Prefix
1	Meth	6	Hex
2	Eth	7	Hept
3	Prop	8	Oct
4	But	9	Non
5	Pent	10	Dec

Alkanes

- In a **condensed structural formula**, some bonds and/or atoms are left out of the structural formula. Although the bonds and atoms do not appear, they are there.

CONCEPTUAL PROBLEM 22.1

Drawing Structural Formulas for Alkanes

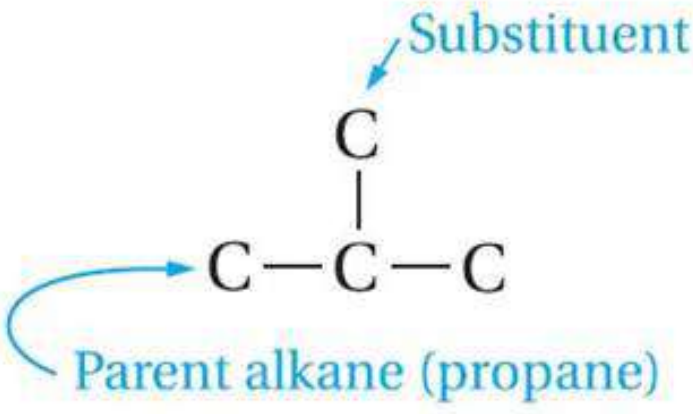
Draw complete structural formulas for the straight-chain alkanes that have three and four carbons.

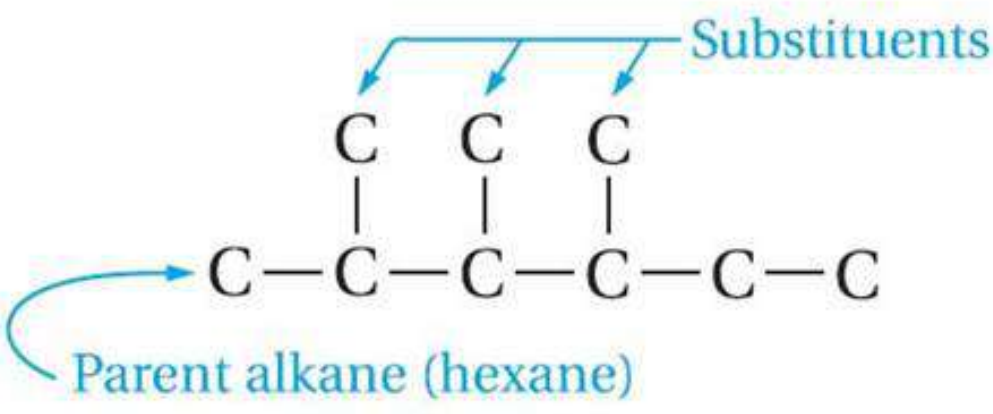
for Conceptual Problem 22.1

1. Draw complete structural formulas for the straight-chain alkanes with five and six carbons.

Alkanes

- Branched-Chain Alkanes
  - An atom or group of atoms that can take the place of a hydrogen atom on a parent hydrocarbon molecule is called a **substituent**.

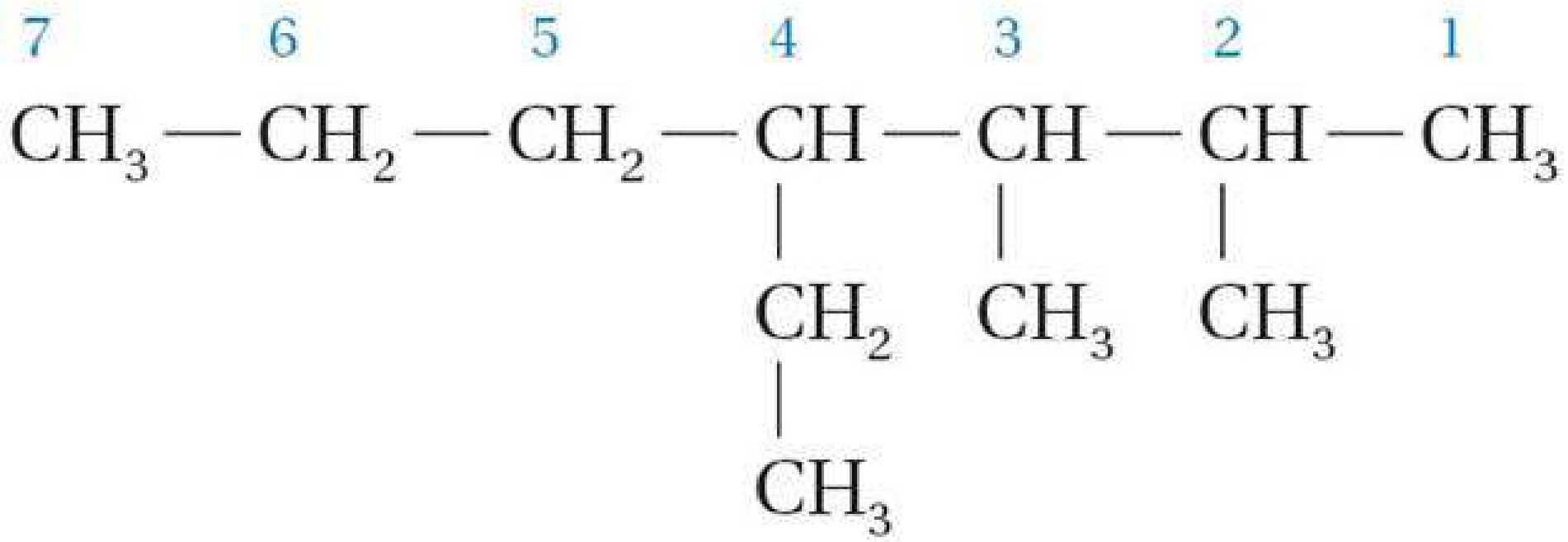




Alkanes

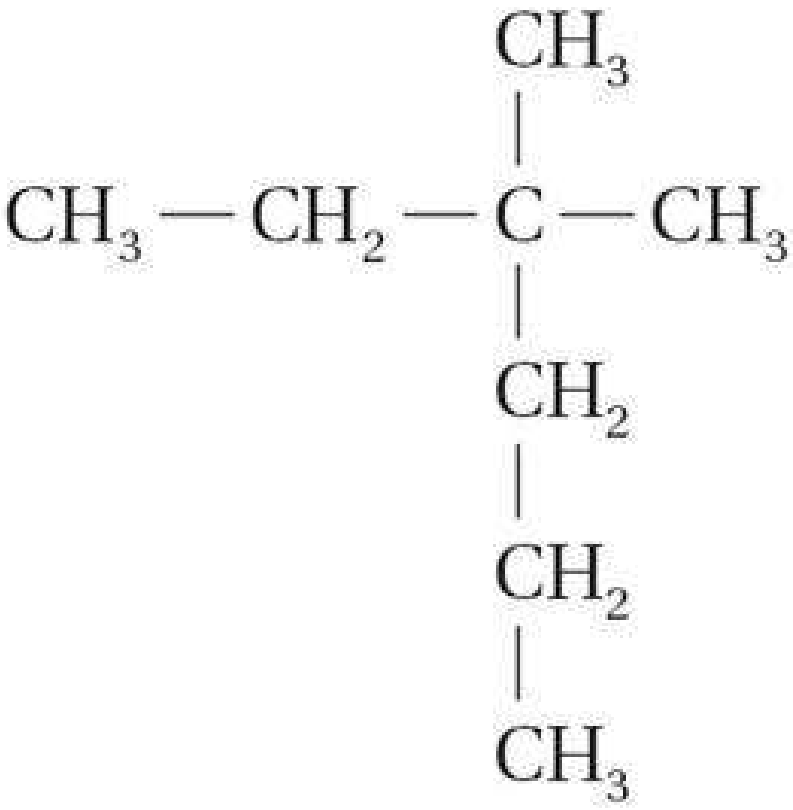
- A _____ substituent is called an **alkyl group**.

An alkane with one or more alkyl groups is called a **branched-chain alkane**.



Naming Branched-Chain Alkanes

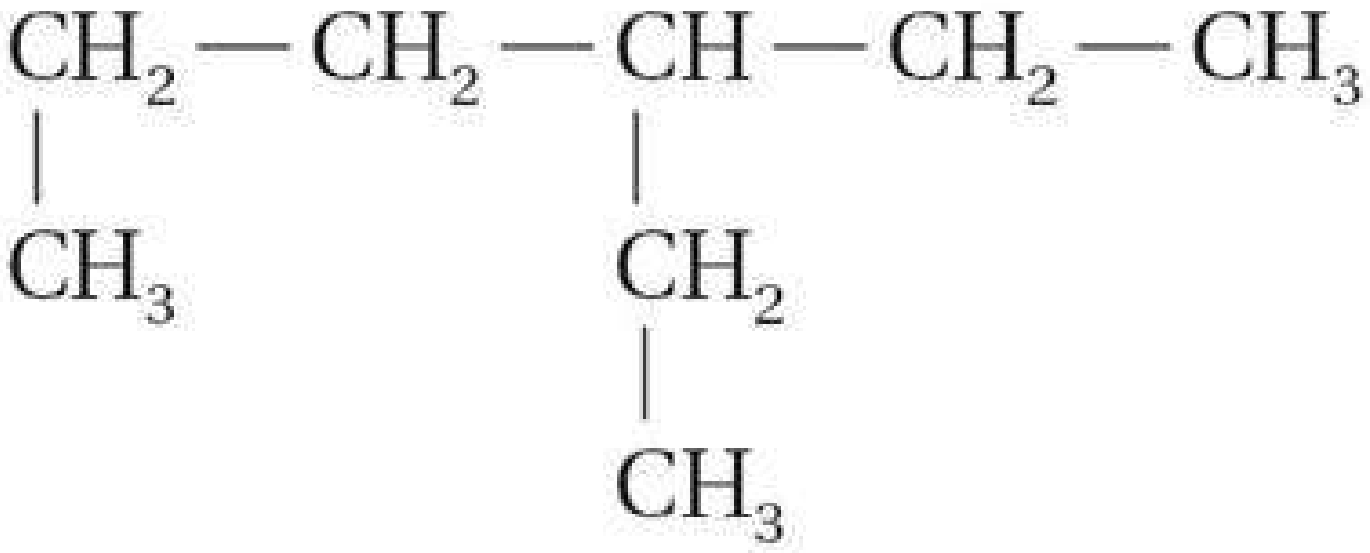
Name this compound using the IUPAC system. Notice that the longest chain is not written in a straight line.



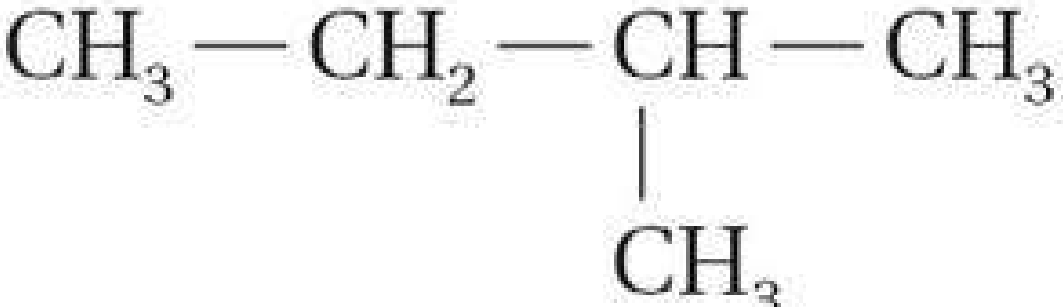
for Conceptual Problem 22.2

3. Name these compounds according to the IUPAC system.

a.



b.



CONCEPTUAL PROBLEM 22.3

Drawing Structural Formulas for Branched-Chain Alkanes

The compound 2,2,4-trimethylpentane (isooctane) is found in gasoline. Draw a complete structural formula for isooctane.

for Conceptual Problem 22.3

5. Draw a structural formula for 2,3-dimethylhexane.

Properties of Alkanes

- Molecules of hydrocarbons, such as alkanes, are _____ molecules.

- **The nonpolar molecules in the oil spill are not attracted to the polar water molecules in the ocean.**

22.1 Section Quiz.

1. Choose the correct words for the spaces. Because carbon has _____ valence electrons, it can form _____ bonds.

- four, four covalent
- four, four ionic
- six, six covalent
- six, four or fewer covalent

22.1 Section Quiz.

2. Alkanes are hydrocarbons that contain only _____ bonds.

- carbon-carbon
- single covalent
- carbon-hydrogen
- ionic

22.1 Section Quiz

3. Choose the correct words for the spaces. Hydrocarbons are highly soluble in _____ solvents because they are _____ molecules.

- nonpolar, nonpolar
- nonpolar, polar
- polar, nonpolar
- polar, polar

22.2 Unsaturated Hydrocarbons

Alkenes

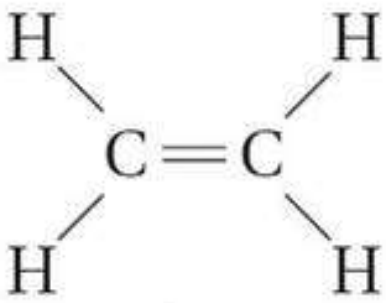
- At least one carbon-carbon bond in an alkene is a _____ covalent bond. Other bonds may be single carbon-carbon bonds and carbon-hydrogen bonds.

Alkenes

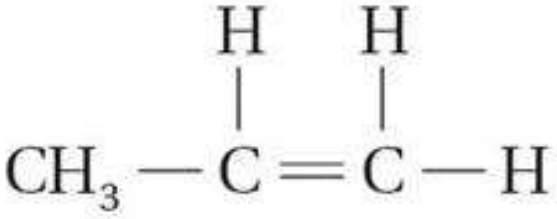
- Organic compounds that contain the _____ number of hydrogen atoms per carbon atom are called **saturated compounds.**
  - Compounds that contain _____ or ____ carbon-carbon bonds are called **unsaturated compounds.**

Alkenes

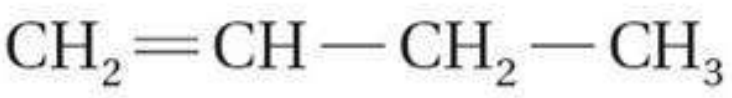
- **Alkenes** are hydrocarbons that contain one or more carbon-carbon double covalent bonds.



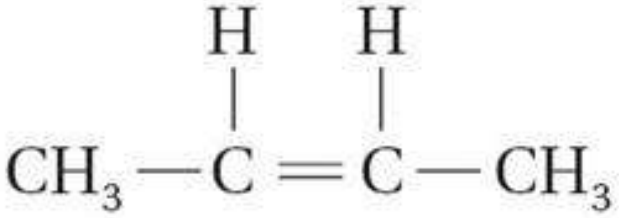
Ethene
(ethylene)



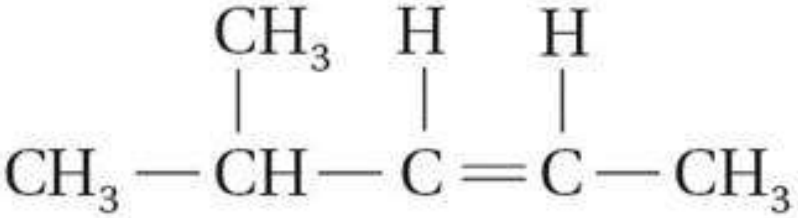
Propene
(propylene)



1-butene



2-butene



4-methyl-2-pentene

22.2 Section Quiz.

1. Alkenes and alkynes are called unsaturated compounds because they contain
   - single bonds only.
   - double or triple bonds.
   - oxygen atoms.
   - hydrogen atoms.

22.2 Section Quiz.

2. What is the correct name for a compound with a C-C-C=C-C carbon skeleton?
   - 3-pentyne
   - 2-pentene
   - 3-pentene
   - 4-pentene

22.2 Section Quiz.

3. Which of the following substances is an alkyne?

- C_6H_{12}
- C_2H_4
- C_2H_2
- C_4H_8

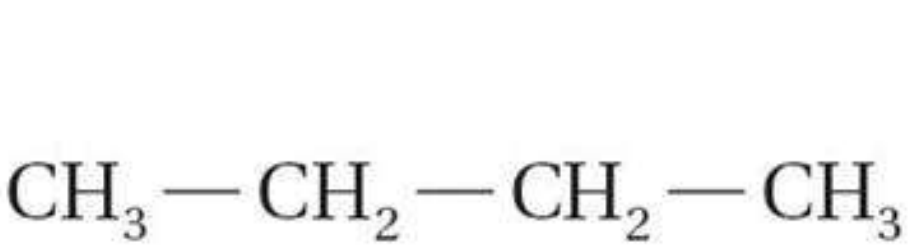
22.3 Isomerism

Structural Isomers

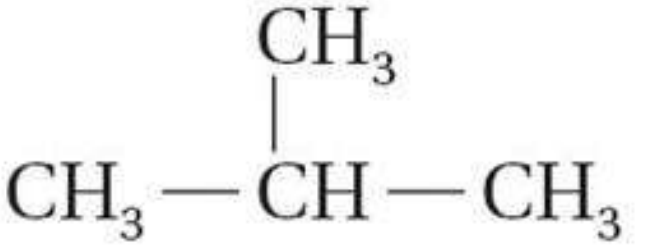
- Compounds that have the same molecular _____ but different molecular _____ are called **isomers.**
  - Structural isomers differ in physical properties such as boiling point and melting point. They also have different chemical reactivities.

Structural Isomers

- **Structural isomers** are compounds that have the same molecular formula, but the atoms are joined together in a different



Butane (C_4H_{10})
(bp −0.5°C)



2-methylpropane (C_4H_{10})
(bp −10.2°C)

22.3 Section Quiz

1. Structural isomers have different properties because they have
   - a different number of bonds.
   - different types of bonds.
   - different substituents.
   - a different order of atoms.

22.4 Hydrocarbon Rings

Cyclic Hydrocarbons

- In some hydrocarbon compounds, the carbon chain is in the form of a ring.
- Compounds that contain a hydrocarbon ring are called **cyclic hydrocarbons.**

Aromatic Hydrocarbons

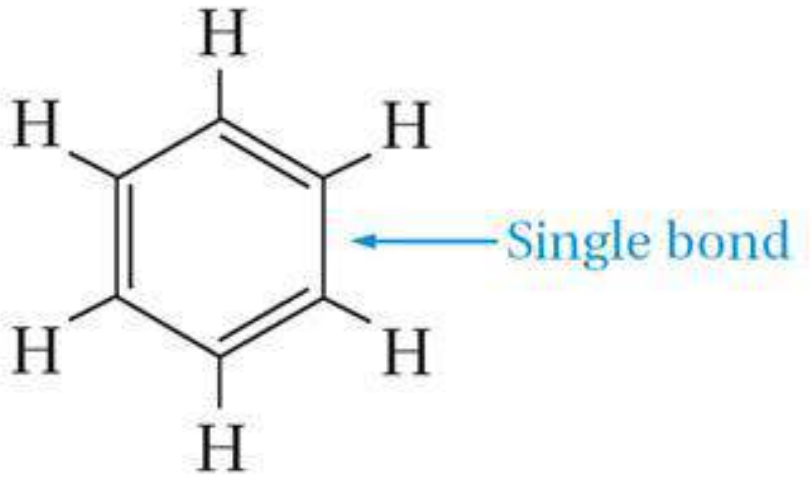
- In a benzene molecule, the bonding electrons between carbon atoms are shared evenly around the ring.

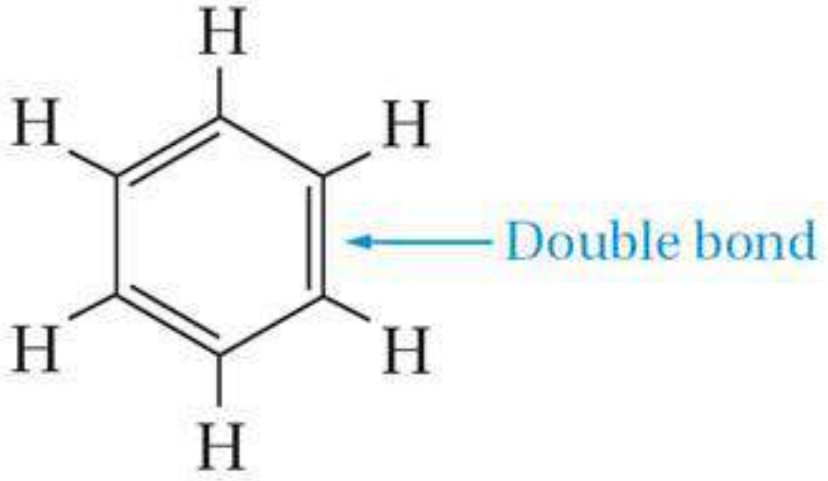
  - An **aromatic compound** is an organic compound that contains a _____ ring or other ring in which the bonding is like that of benzene.

Aromatic Hydrocarbons

The Structure of Benzene

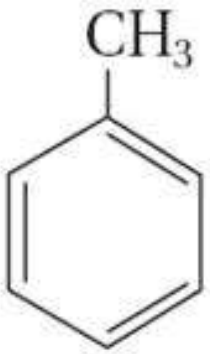
- Benzene can be shown as switching, or resonating, between two arrangements of alternating double and single bonds.



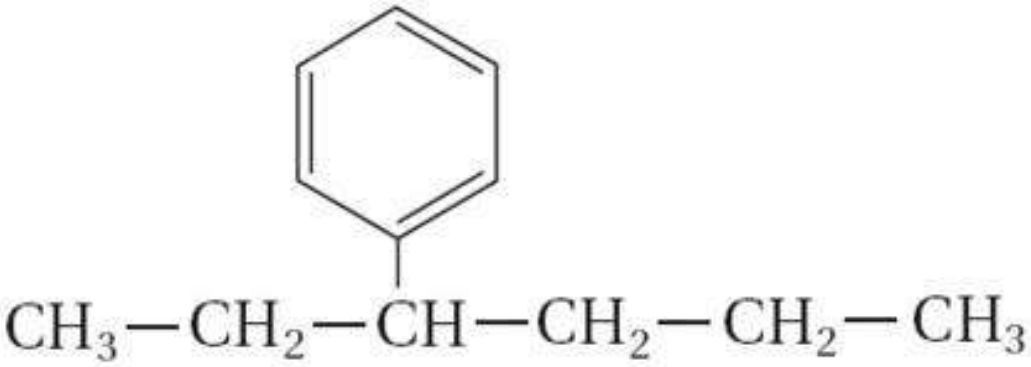


Substituted Aromatic Compounds

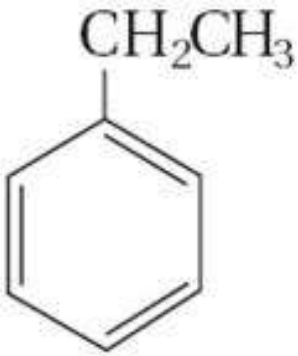
- Compounds with a substituent on a benzene ring are named as a derivative of benzene. When benzene is a substituent, it is called a _____ group.



Methylbenzene
(toluene)



3-phenylhexane



Ethylbenzene

22.4 Section Quiz.

1. Choose the correct words for the spaces. Alkanes that do not contain a ring structure are _____ hydrocarbons. Alkanes that do contain ring structures are called _____ hydrocarbons.

- aliphatic, aromatic
- aromatic, aliphatic
- aliphatic, cyclic
- aromatic, cyclic

22.4 Section Quiz.

2. The carbon-carbon bonds in a benzene molecule are

- alternating double and single bonds.
- identical hybrid bonds.
- all double bonds.
- all single bonds.

22.4 Section Quiz.

3. When an alkane has a benzene ring as a substituent, the ring is called _____ group.

- a benzene
- a toluene
- a phenyl
- an arene

Chapter 23

- 23.1 Introduction to Functional Groups

Functional Groups

- **Organic compounds can be classified according to their functional groups.**
  - A **functional group** is a _____ arrangement of _____ in an organic compound that is capable of characteristic chemical reactions.

Halogen Substituents

- **A halocarbon is a carbon-containing compound with a _____ substituent.**
- **Halocarbons** are a class of organic compounds containing covalently bonded fluorine, chlorine, bromine, or iodine.

Halogen Substituents

- On the basis of their common names, halocarbons in which a halogen is attached to a carbon of an aliphatic chain are called **alkyl halides.**
- Halocarbons in which a halogen is attached to a carbon of an arene ring are called **aryl halides**.

23.1 Section Quiz.

1. Organic molecules are classified according to their
   - functional groups.
   - longest chain.
   - derivatives.
   - number of rings.

23.1 Section Quiz

- 2. What is the correct IUPAC name for the compound $CH_2BrCH_2CH_2Br$?
  - methylbromoethylbromide
  - dibromopropane
  - 1,3-dibromopropane
  - propyl-1,3-dibromide

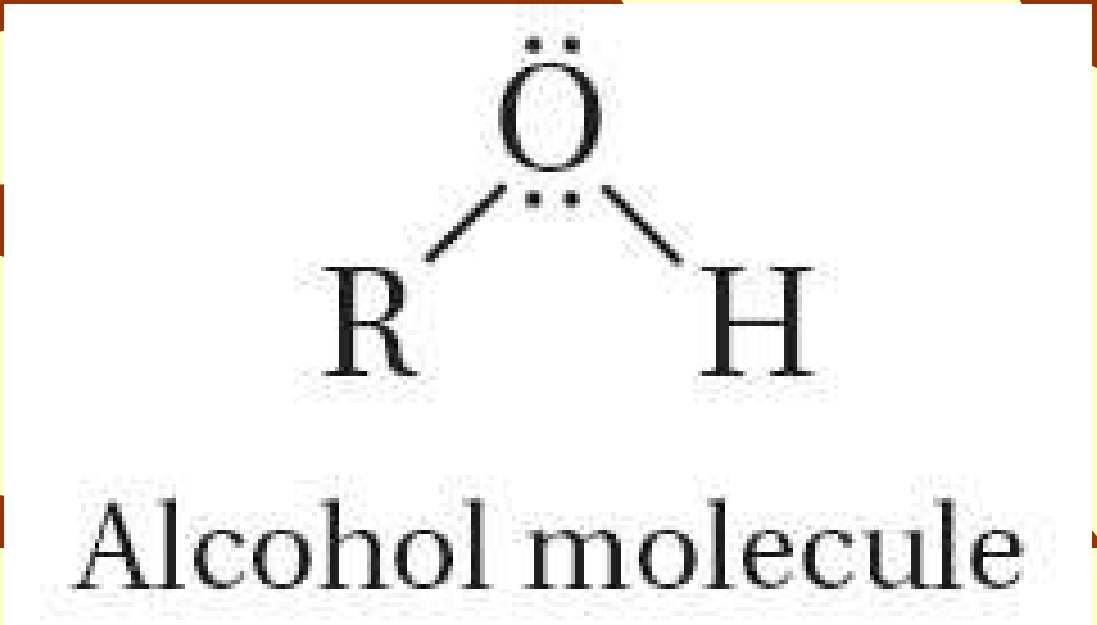
Chapter 23

- 23.2 Alcohols and Ethers

Alcohols

An **alcohol** is an organic compound with an —OH group.

The —OH functional group in alcohols is called a **hydroxyl group** or hydroxy function.



Alcohol molecule

Alcohols

- When using the IUPAC system to name continuous-chain and substituted alcohols, drop the *-e* ending of the parent alkane name and add the ending -___.

Properties of Alcohols

Fermentation is the production of _____ from _____ by the action of _____ or bacteria. A second reaction product, carbon dioxide, causes bread to rise.

$$C_6H_{12}O_6(aq) \longrightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$$

Glucose — Ethanol — Carbon dioxide

Properties of Alcohols

Ethanol is the intoxicating substance in alcoholic beverages. It is a depressant that can be fatal if taken in large doses at once.

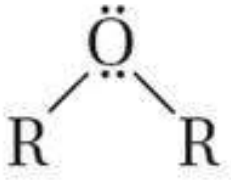
- **Denatured alcohol** is _____ with an added substance to make it _____ (poisonous).
- Denatured alcohol is used as a reactant or as a solvent in industrial processes.

Ethers

- The general structure of an ether is R—O—R. The alkyl groups attached to the ether linkage are named in alphabetical order and are followed by the word _____.

Ethers

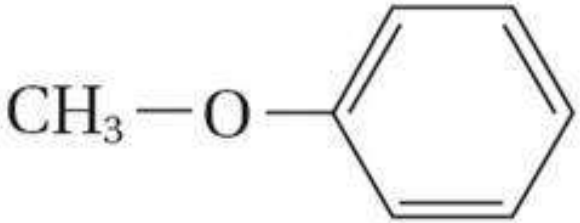
An **ether** is a compound in which _____ is bonded to _____ carbon groups.



Ether molecule

$CH_3CH_2-O-CH_3$

Ethylmethyl ether



Methylphenyl ether
(anisole)

23.2 Section Quiz.

4. Which structure is ethylmethyl ether?

- $CH_3—CH_2—OH—CH_2$
- $CH_3—CH_2—CHO$
- $CH_3CH_2—O—\ CH_3$
- $CH_2CH—CH_3—OH$

Chapter 23

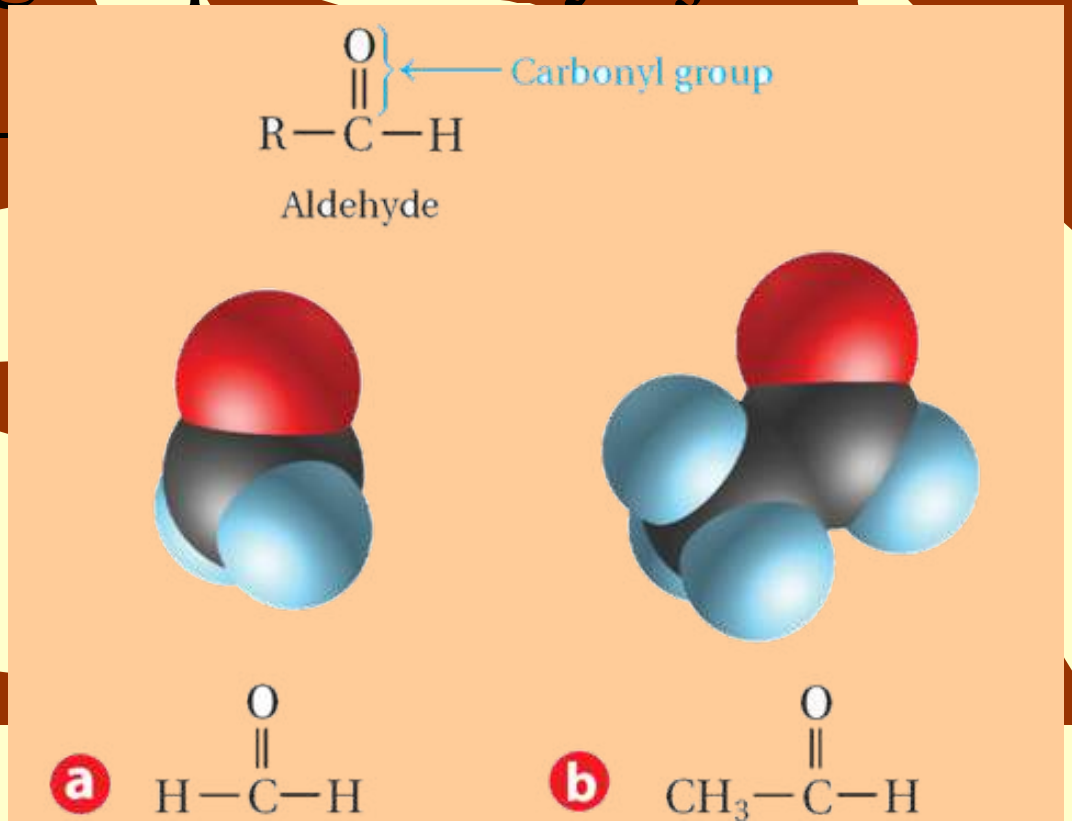
- 23.3 Carbonyl Compounds

Aldehydes and Ketones

- A **carbonyl group** is a functional group with the general structure C═O.
  - The C═O functional group is present in aldehydes and ketones.

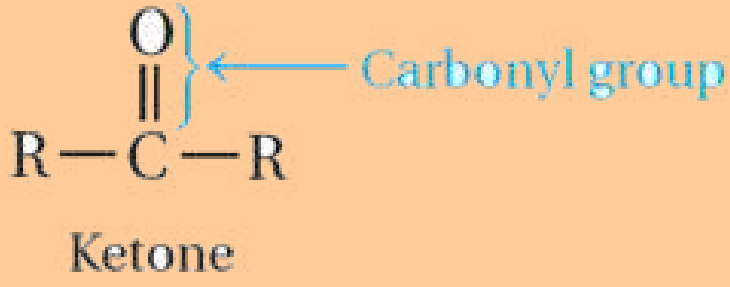
Aldehydes and Ketones

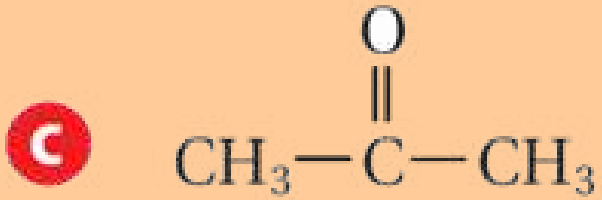
An **aldehyde** is an organic compound in which the carbon of the carbonyl group is always joined to at least one _



Aldehydes and Ketones

A **ketone** is an organic compound in which the carbon of the carbonyl group is joined to two other _____.

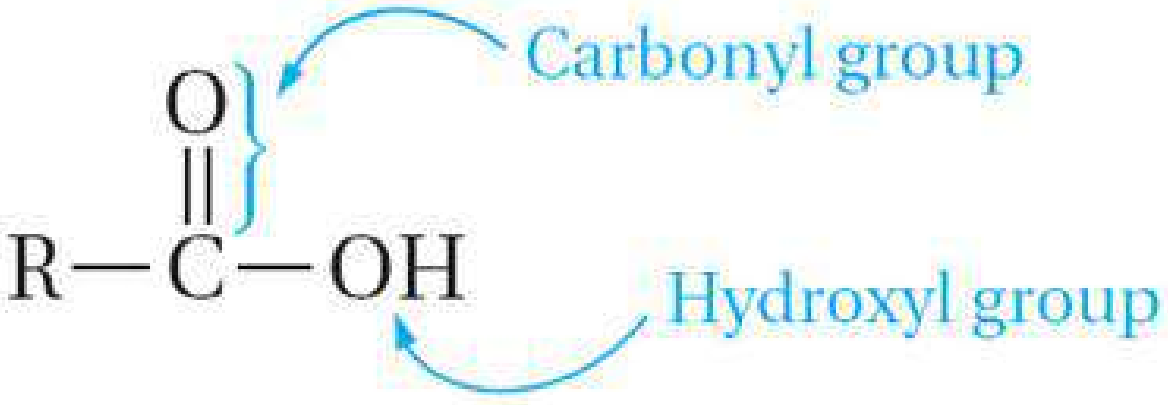




Carboxylic Acids

A **carboxyl group** consists of a carbonyl group attached to a hydroxyl group.

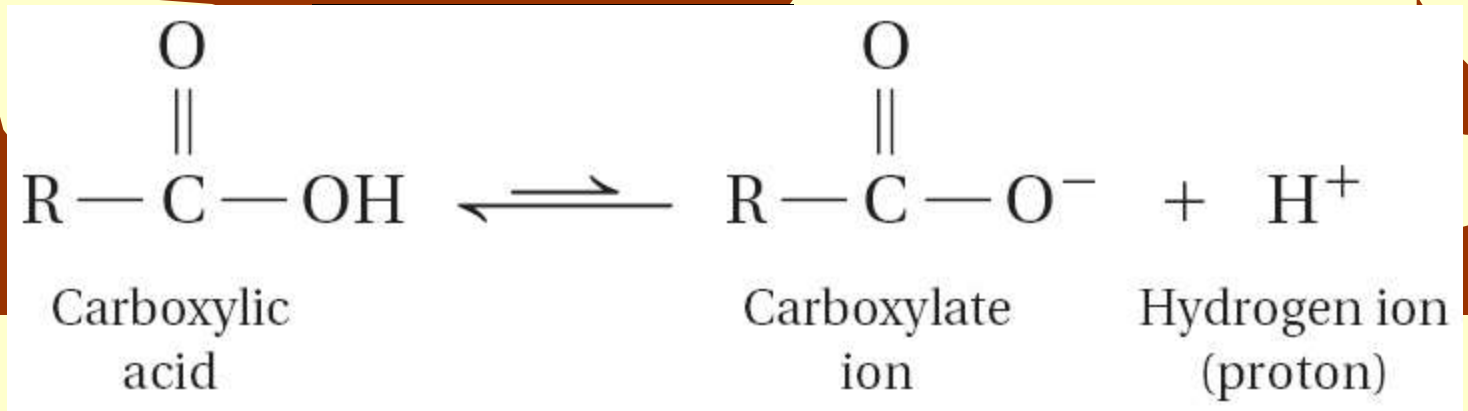
A **carboxylic acid** is a compound with a carboxyl group.



Carboxyl group
(also written —CO_2H or —COOH)

Carboxylic Acids

- **The general formula for a carboxylic acid is RCOOH.**
  - Carboxylic acids are _____ because they ionize slightly in solution to give a carboxylate ion and a _____ ion.



Carboxylic Acids

Many continuous-chain carboxylic acids were first isolated from ____ and are called **fatty acids.**

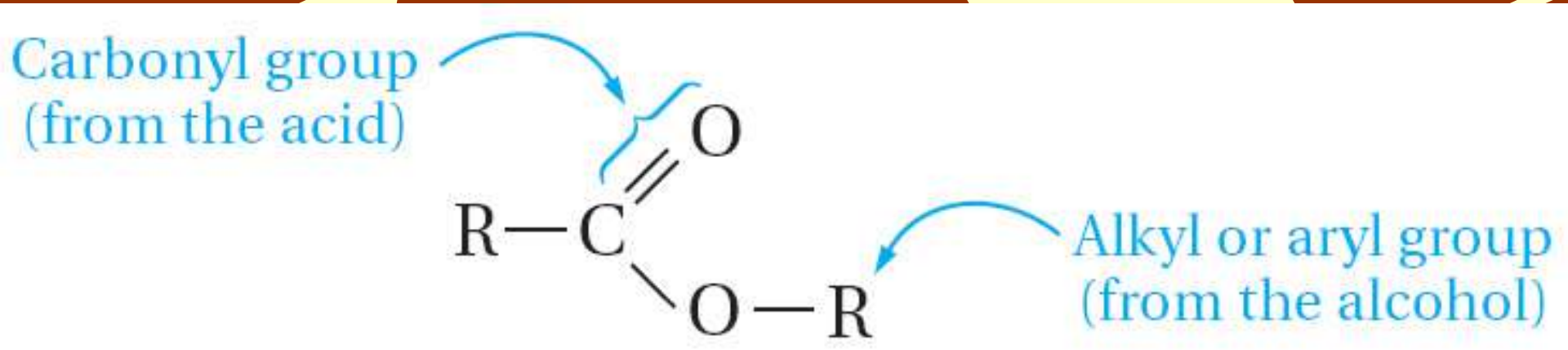
- Stearic acid, an 18-carbon acid obtained from beef fat, is used to make inexpensive wax candles.

Esters

- Esters contain a _____ group and an _____ link to the carbonyl carbon. The general formula for an ester is RCOOR.

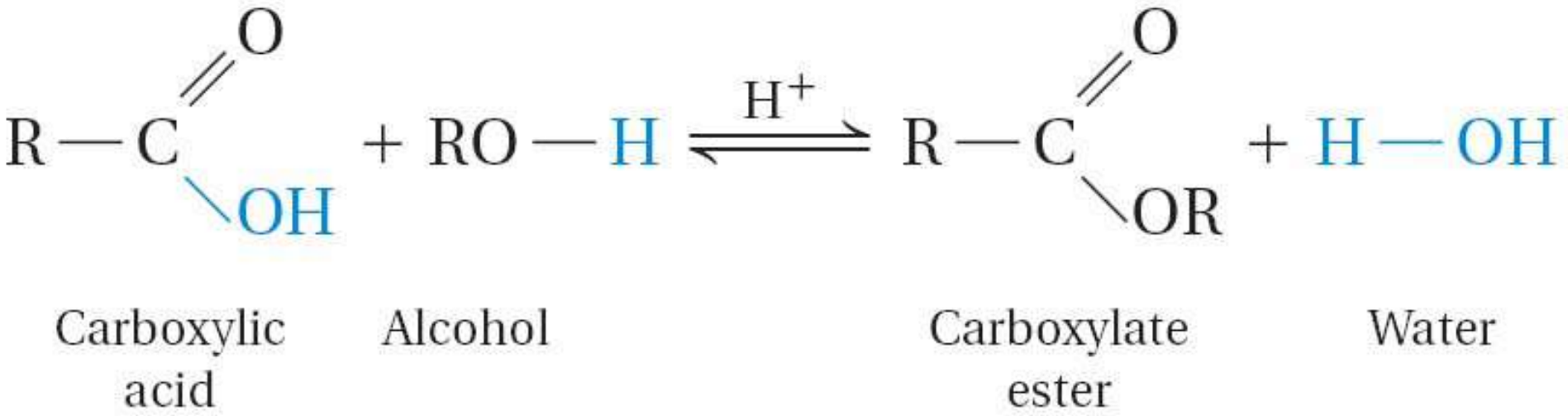
Esters

Esters are derivatives of carboxylic acids in which the —OH of the carboxyl group has been replaced by an —OR from an _____.



Esters

- Esters may be prepared from a _____ _____ and an _____.



23.3 Section Quiz

1. Which compound is a ketone?
   - CH_3COOH
   - CH_3CH_2OH
   - CH_3CHO
   - CH_3COCH_3

23.3 Section Quiz.

2. The IUPAC name for the structure CH_3CH_2COOH is

- ethanoic acid.
- acetic acid.
- propanoic acid.
- propionic acid.

23.3 Section Quiz.

3. The product of the reaction between an alcohol and a carboxylic acid is called
   - a ketone.
   - an ether.
   - an ester.
   - an aldehyde.

Chapter 23

23.4 Polymerization

Addition Polymers

- A **polymer** is a large molecule formed by the covalent bonding of _____ smaller molecules.
- The _____ _____ that combine to form a polymer are called **monomers**.