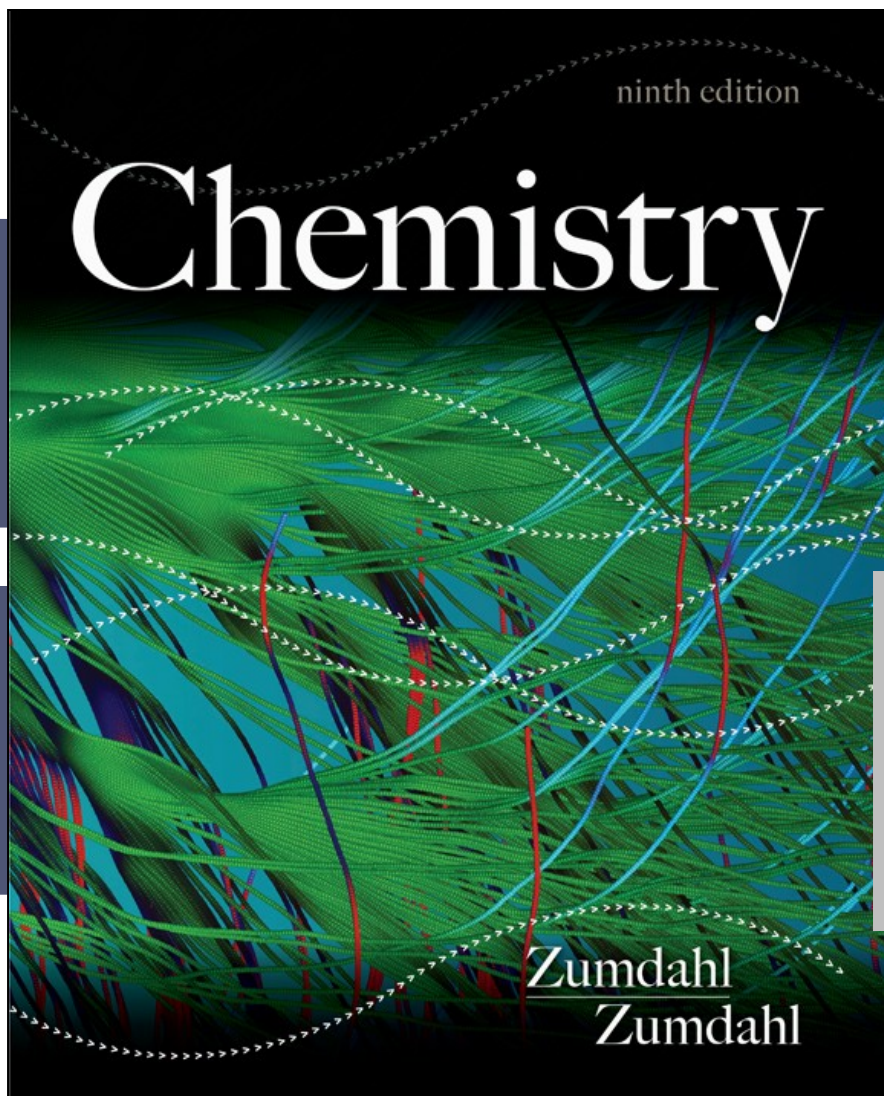
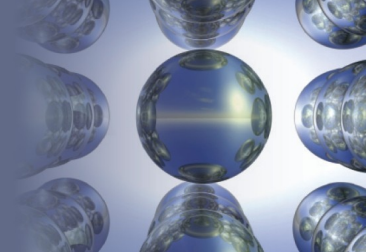




Chapter Eight

ORGANIC CHEMISTR Y

Chapter 8



Organic Chemistry

- The study of carbon-containing compounds and their properties.
- The vast majority of organic compounds contain chains or rings of carbon atoms.

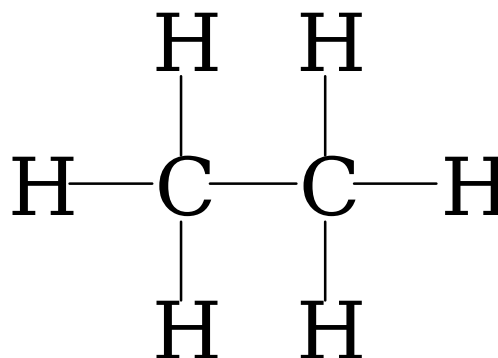
Section

8.1 Alkanes: Saturated Hydrocarbons

Hydrocarbons

- Compounds composed of carbon and hydrogen.
- Saturated: C—C bonds are all single bonds.

alkanes [C_nH_{2n+2}]



Section

8.1 Alkanes: Saturated Hydrocarbons

Alkanes

Alkanes have the general formula C_nH_{2n+2} where $n = 1, 2, 3, \dots$

- only single covalent bonds
- **saturated hydrocarbons** because they contain the **maximum** number of hydrogen atoms that can bond with the number of carbon atoms in the molecule



methane



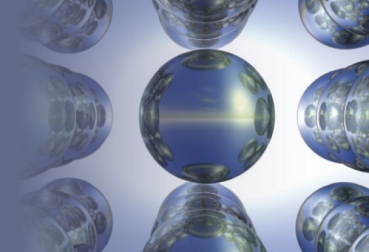
ethane



propane

Section

8.1 Alkanes: Saturated Hydrocarbons



First Ten Normal Alkanes

Table 22.1 | Selected Properties of the First Ten Normal Alkanes

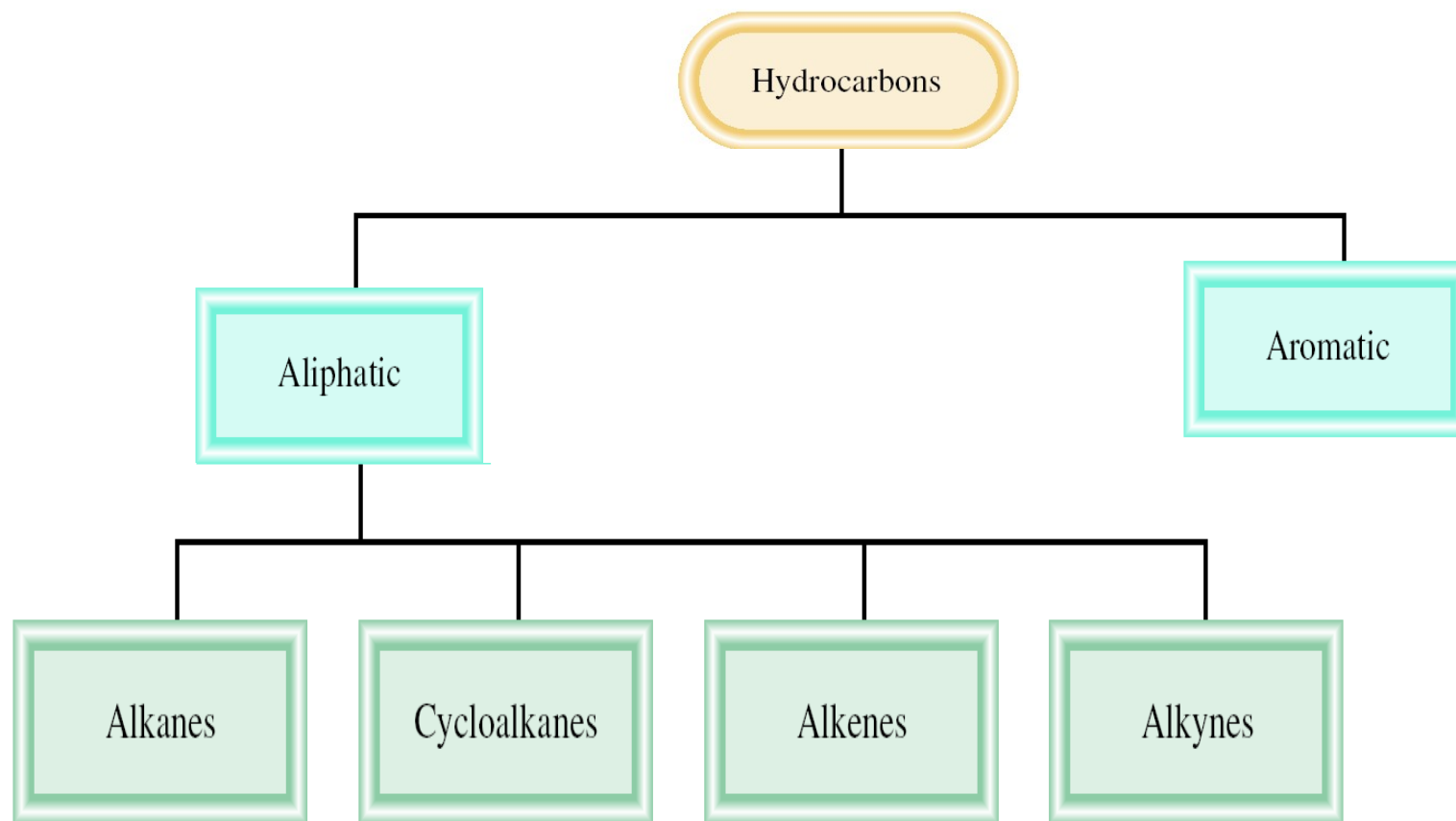
Name	Formula	Molar Mass	Melting Point (°C)	Boiling Point (°C)	Number of Structural Isomers
Methane	CH ₄	16	−182	−162	1
Ethane	C ₂ H ₆	30	−183	−89	1
Propane	C ₃ H ₈	44	−187	−42	1
Butane	C ₄ H ₁₀	58	−138	0	2
Pentane	C ₅ H ₁₂	72	−130	36	3
Hexane	C ₆ H ₁₄	86	−95	68	5
Heptane	C ₇ H ₁₆	100	−91	98	9
Octane	C ₈ H ₁₈	114	−57	126	18
Nonane	C ₉ H ₂₀	128	−54	151	35
Decane	C ₁₀ H ₂₂	142	−30	174	75

Section

8.1

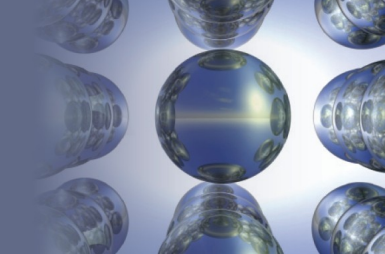
Classification of Hydrocarbons

Alkenes: Saturated Hydrocarbons



Section .1

8.1: Saturated Hydrocarbons



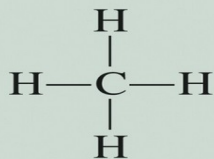
Isomerism in Alkanes

- **Structural isomerism** – occurs when two molecules have the same atoms but different bonds.
- Butane and all succeeding members of the alkanes exhibit structural isomerism.

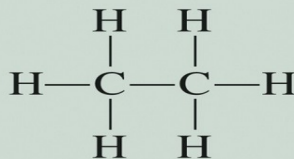
Section 8.1

Alkanes: Saturated Hydrocarbons

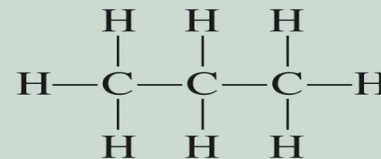
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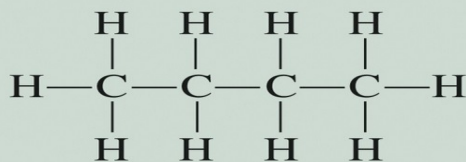
Methane



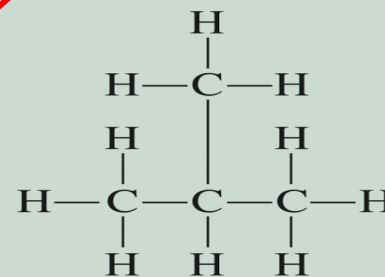
Ethane



Propane



n-Butane



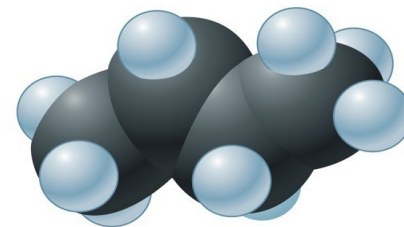
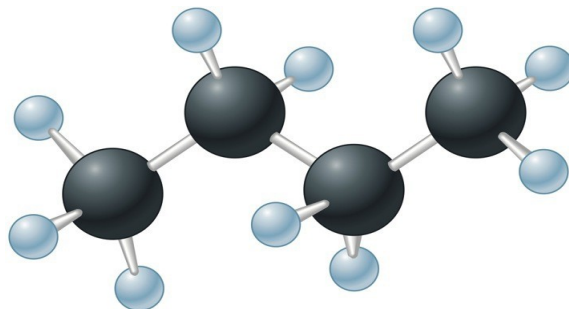
Isobutane

- **Structural isomers** are molecules that have the same molecular formula but different structures.

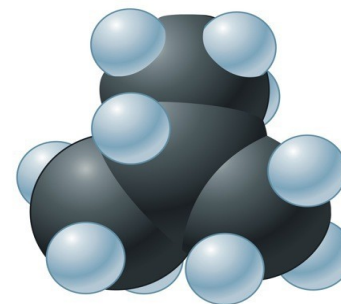
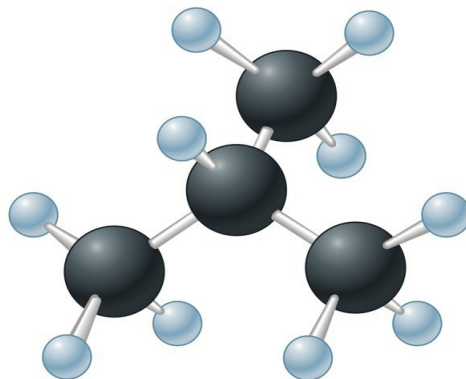
Section .1

8.1: Saturated Hydrocarbons

Butane



a



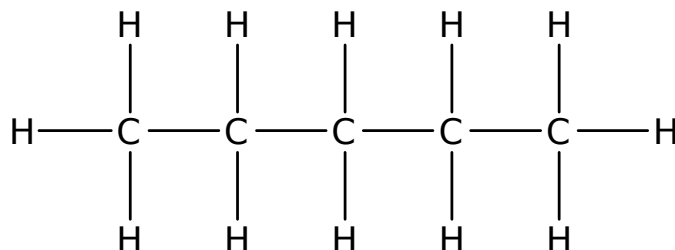
b

Section 8.1

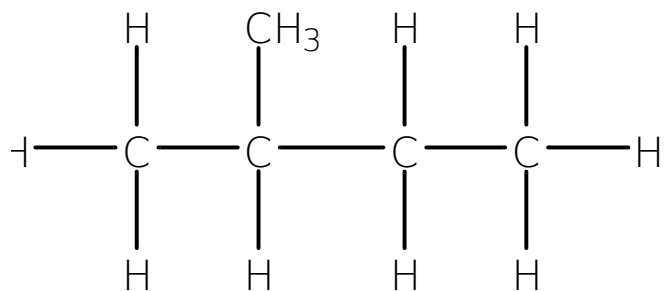
Alkanes: Saturated Hydrocarbons

Structural Isomers of Pentane

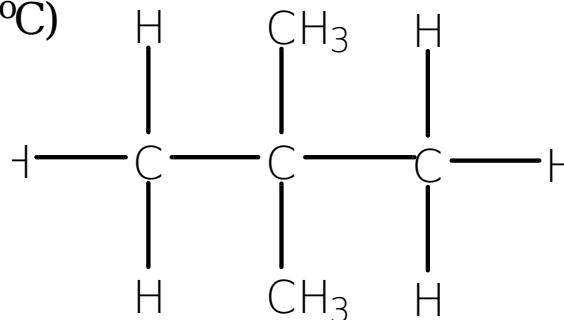
- n-Pentane, Isopentane, and neopentane



n-pentane
(b.p. 36.1 °C)



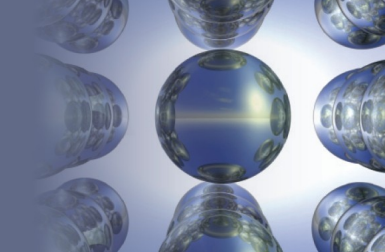
Isopentane
2-methylbutane
(b.p. 27.9 °C)



Neopentane
2, 2-dimethylpropane
(b.p. 9.5 °C)

Section .1

8.1: Saturated Hydrocarbons



Rules for Naming Alkanes

1. For alkanes beyond butane, add *-ane* to the Greek root for the number of carbons.

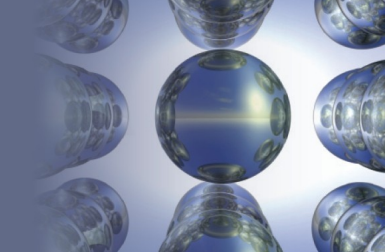


2. Alkyl substituents: drop the *-ane* and add *-yl*.

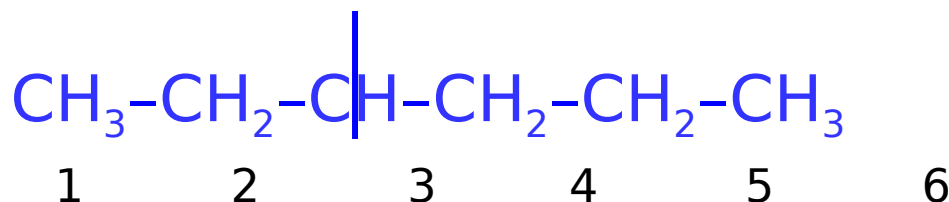
- C_2H_6 is ethane
- C_2H_5 is ethyl

Section 8.1

Alkanes: Saturated Hydrocarbons



3. Positions of substituent groups are specified by numbering the longest chain sequentially. The numbering is such that substituents are at lowest possible number along chain.

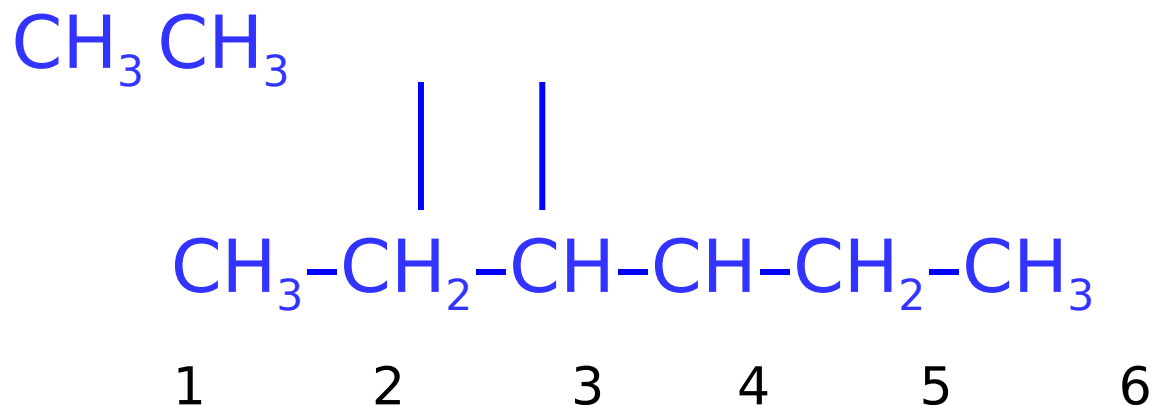


3-methylhexane

Section 8.1

Alkanes: Saturated Hydrocarbons

4. Location and name are followed by root alkane name. Substituents in alphabetical order and use *di-*, *tri-*, etc.



3,4-dimethylhexane

Section 8.1

Alkanes: Saturated Hydrocarbons

The Most Common Alkyl Substituents and Their Names

Table 22.2 | The Most Common Alkyl Substituents and Their Names

Structure*	Name†
—CH_3	Methyl
$\text{—CH}_2\text{CH}_3$	Ethyl
$\text{—CH}_2\text{CH}_2\text{CH}_3$	Propyl
$\begin{array}{c} \\ \text{CH}_3\text{CHCH}_3 \end{array}$	Isopropyl
$\text{—CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	Butyl
$\begin{array}{c} \\ \text{CH}_3\text{CHCH}_2\text{CH}_3 \end{array}$	<i>sec</i> -Butyl
$\begin{array}{c} \text{H} \\ \\ \text{—CH}_2\text{—C—CH}_3 \\ \\ \text{CH}_3 \end{array}$	Isobutyl
$\begin{array}{c} \text{CH}_3 \\ \\ \text{—C—CH}_3 \\ \\ \text{CH}_3 \end{array}$	<i>tert</i> -Butyl

*The bond with one end open shows the point of attachment of the substituent to the carbon chain.

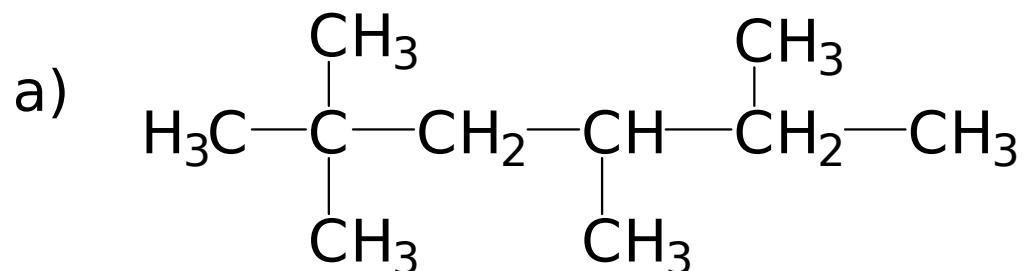
†For the butyl groups, *sec*- indicates attachment to the chain through a secondary carbon, a carbon atom attached to *two* other carbon atoms. The designation *tert*- signifies attachment through a tertiary carbon, a carbon attached to *three* other carbon atoms.

Section 8.1

Alkanes: Saturated Hydrocarbons

EXERCISE!

Name each of the following:



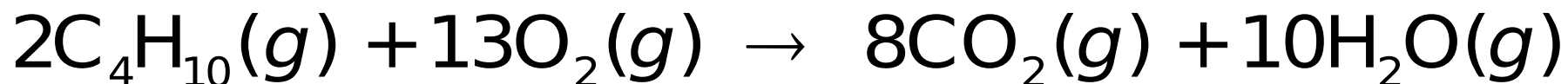
Answer: 2,2,4,5-tetramethylhexane

Section 8.1

Alkanes: Saturated Hydrocarbons

Combustion Reactions of Alkanes

- At a high temperature, alkanes react vigorously and exothermically with oxygen.
- Basis for use as fuels.

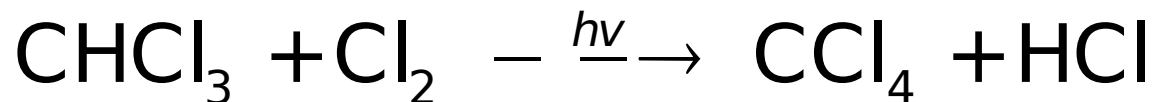
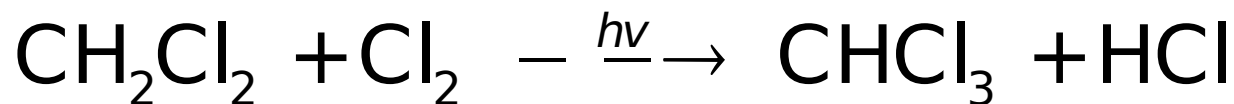
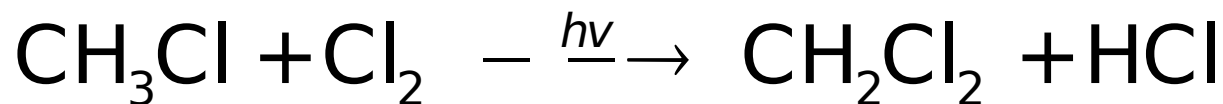
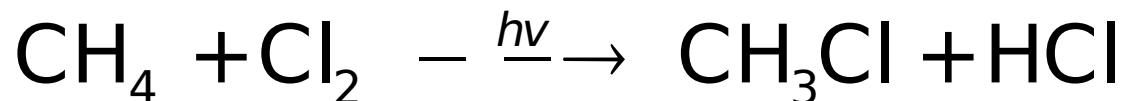


Section 8.1

Alkanes: Saturated Hydrocarbons

Substitution Reactions of Alkanes

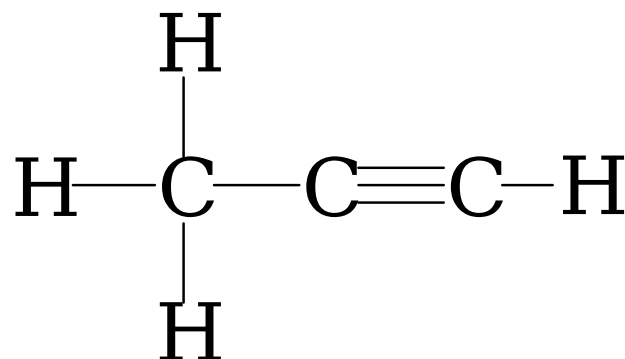
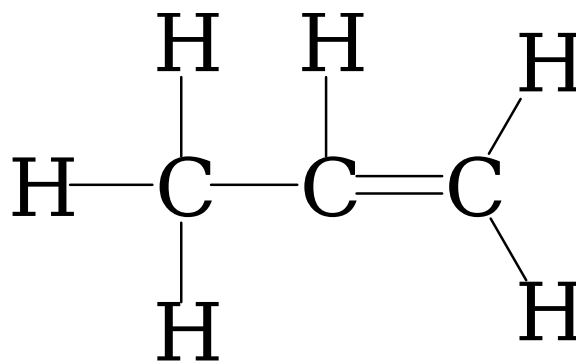
- Primarily where halogen atoms replace hydrogen atoms.



Section 8.1

Alkenes: Saturated Hydrocarbons

 **Unsaturated:** contains carbon-carbon multiple bonds.



Section 8.1

Alkanes: Saturated Hydrocarbons

Dehydrogenation Reactions of Alkanes

- Hydrogen atoms are removed and the product is an unsaturated hydrocarbon.

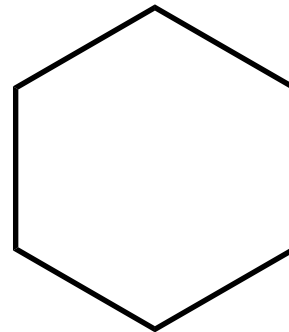
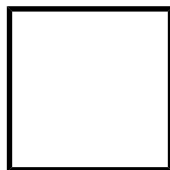
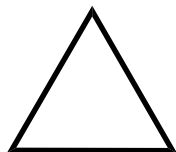
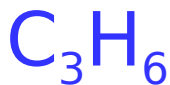


Section 8.1

Alkanes: Saturated Hydrocarbons

Cyclic Alkanes

- Carbon atoms can form rings containing only C—C single bonds.
- General formula: C_nH_{2n}

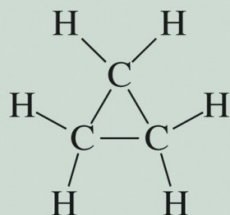


Section 8.1 Cycloalkanes

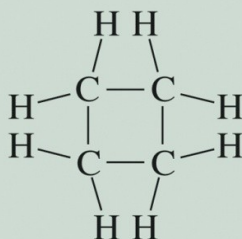
Alkanes: Saturated Hydrocarbons

- Alkanes whose carbon atoms are joined in rings are called **cycloalkanes**.
- They have the general formula C_nH_{2n} where $n = 3, 4, \dots$

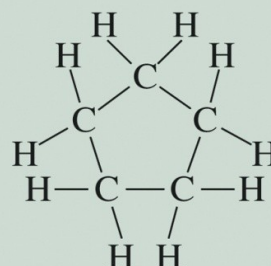
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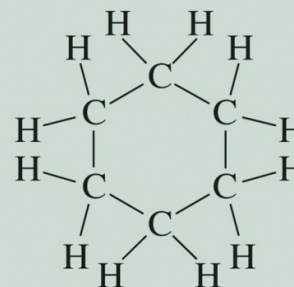
Cyclopropane



Cyclobutane



Cyclopentane

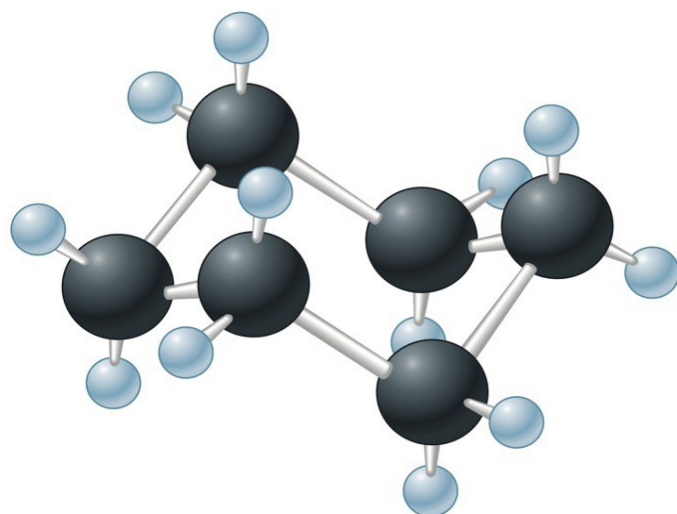


Cyclohexane

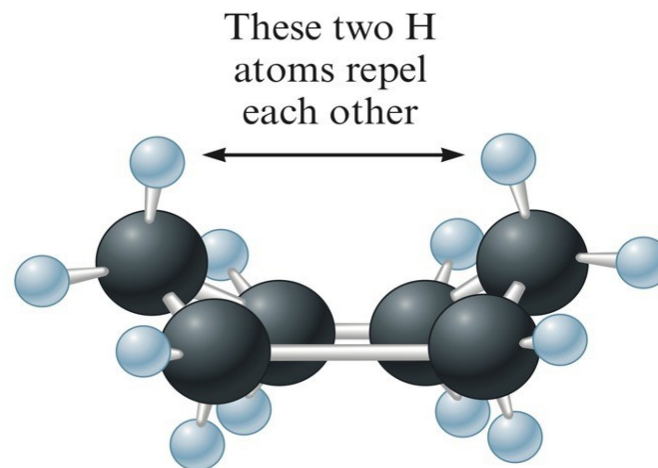
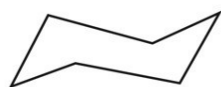
Section 8.1

Alkanes: Saturated Hydrocarbons

The Chair and Boat Forms of Cyclohexane



Chair



Boat

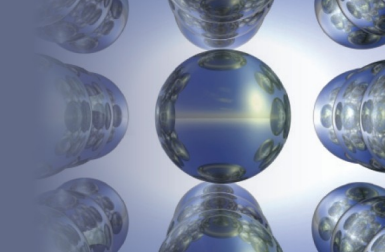


a

b

Section 8.2

Alkenes and Alkynes



- **Alkenes**: hydrocarbons that contain at least one carbon-carbon double bond. **$[C_nH_{2n}]$**

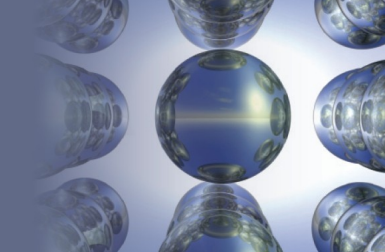


- **Alkynes**: hydrocarbons containing at least one carbon-carbon triple bond. **$[C_nH_n]$**



Section 8.2

Alkenes and Alkynes

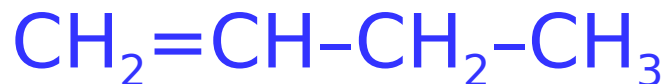


Rules for Naming Alkenes

1. Root hydrocarbon name ends in **-ene**.



2. With more than 3 carbons, double bond is indicated by the lowest-numbered carbon atom in the bond.

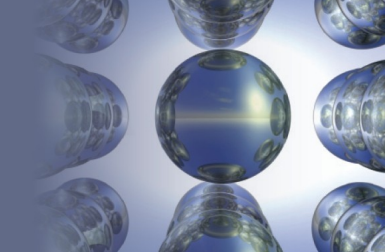


1 2 3 4

1-butene

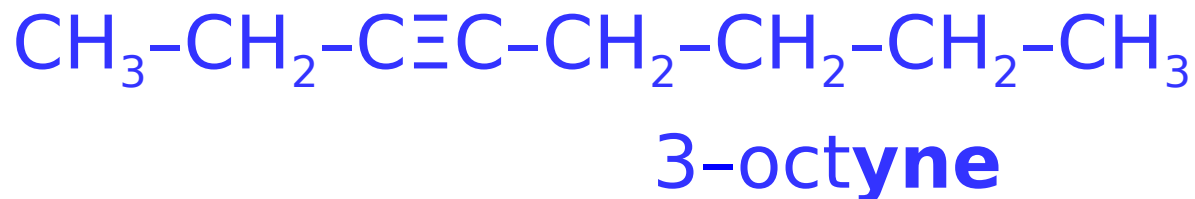
Section 8.2

Alkenes and Alkynes



Rules for Naming Alkynes

- Same as for alkenes except use *-yne* as suffix.

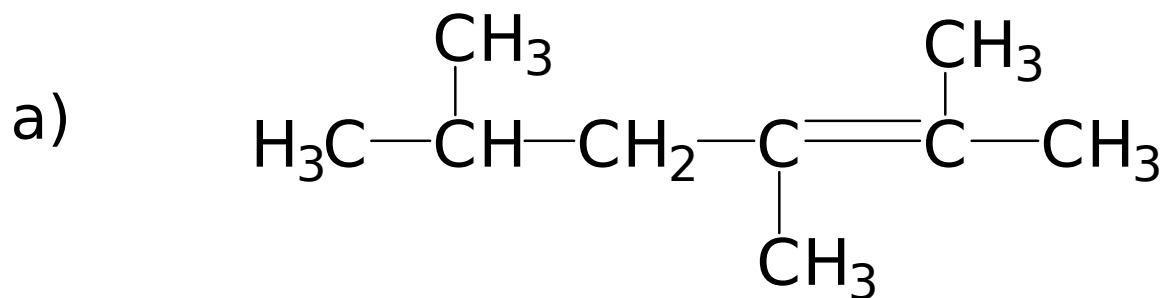


Section 8.2

Alkenes and Alkynes

EXERCISE!

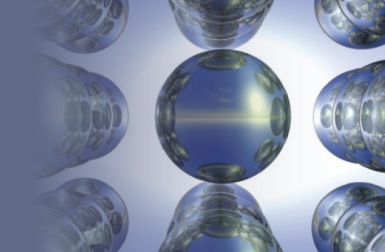
Name each of the following:



2,3,5-trimethyl-2-hexene

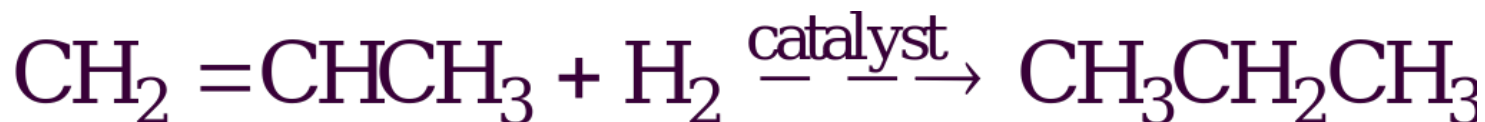
Section 8.2

Alkenes and Alkynes



Addition Reactions

- Pi Bonds (which are weaker than the C—C bonds), are broken, and new bonds are formed to the atoms being added.

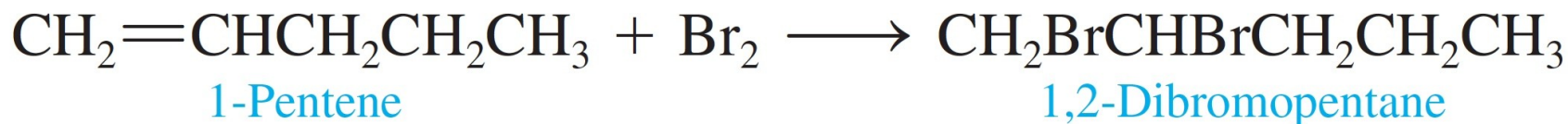


Section 8.2

Alkenes and Alkynes

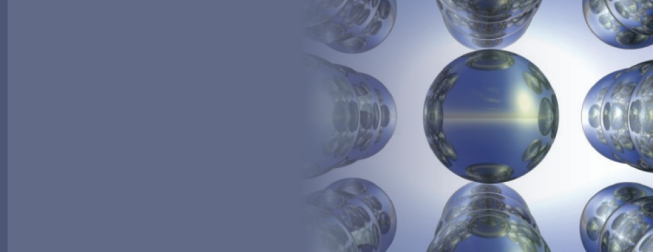
Halogenation Reactions

- Addition of halogen atoms of alkenes and alkynes.



Section 8.3

Aromatic Hydrocarbons



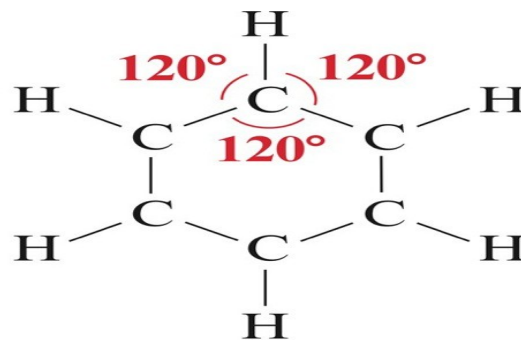
Aromatic Hydrocarbons

- A special class of cyclic unsaturated hydrocarbons.
- Simplest of these is benzene (**C₆H₆**).
- The delocalization of the π electrons makes the benzene ring behave differently from a typical unsaturated hydrocarbon.

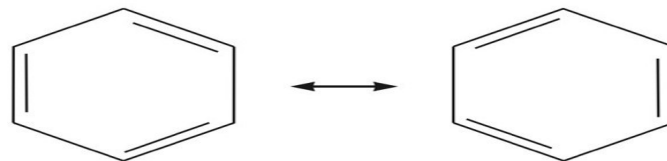
Section 8.3

Aromatic Hydrocarbons

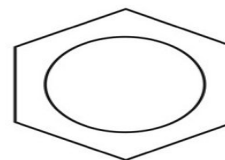
Benzene (Aromatic Hydrocarbon)



a



b

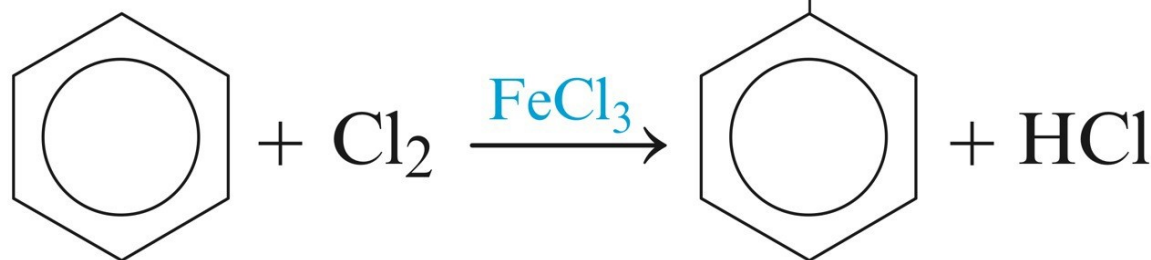


c

Section 8.3

Aromatic Hydrocarbons

- Unsaturated hydrocarbons generally undergo rapid addition reactions, but benzene does not.
- Benzene undergoes substitution reactions in which hydrogen atoms are replaced by other atoms.



Benze
ne

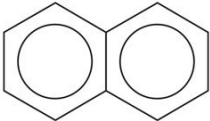
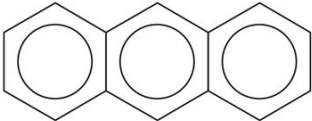
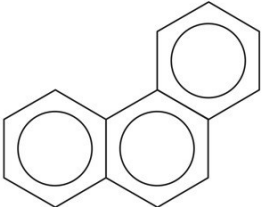
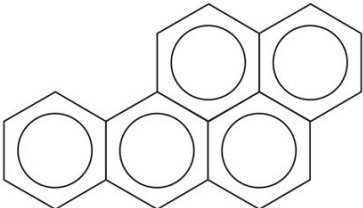
Chlorobenzene

Section 8.3

Aromatic Hydrocarbons

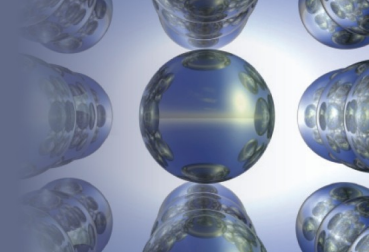
More Complex Aromatic Systems

Table 22.3 | More Complex Aromatic Systems

Structural Formula	Name	Use of Effect
	Naphthalene	Formerly used in mothballs
	Anthracene	Dyes
	Phenanthrene	Dyes, explosives, and synthesis of drugs
	3,4-Benzpyrene	Active carcinogen found in smoke and smog

Section 8.4

Hydrocarbon Derivatives



- **Molecules that are fundamentally hydrocarbons but have additional atoms or groups of atoms called functional groups.**

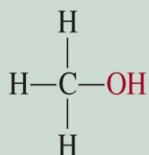
Section 8.4

Hydrocarbon Derivatives

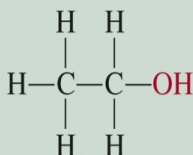
Functional Group Chemistry

Alcohols: contain the hydroxyl functional group and have the general formula **R-OH**.

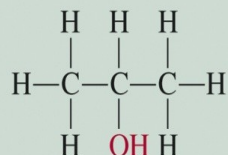
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Methanol
(methyl alcohol)



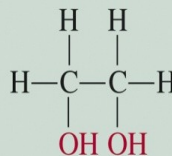
Ethanol
(ethyl alcohol)



2-Propanol
(isopropyl alcohol)

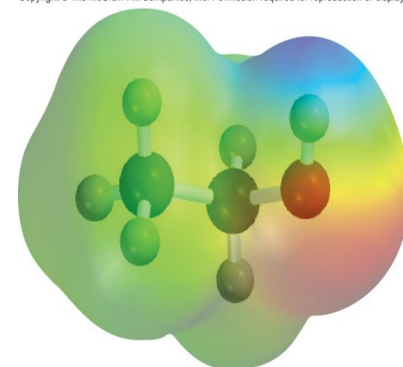


Phenol



Ethylene glycol

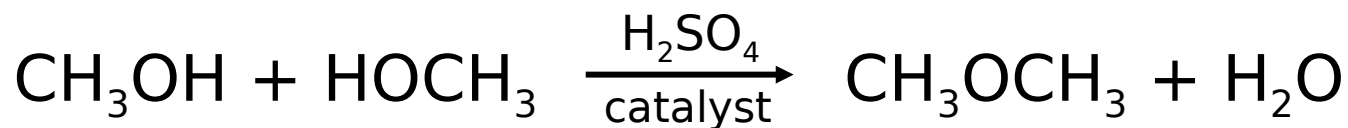
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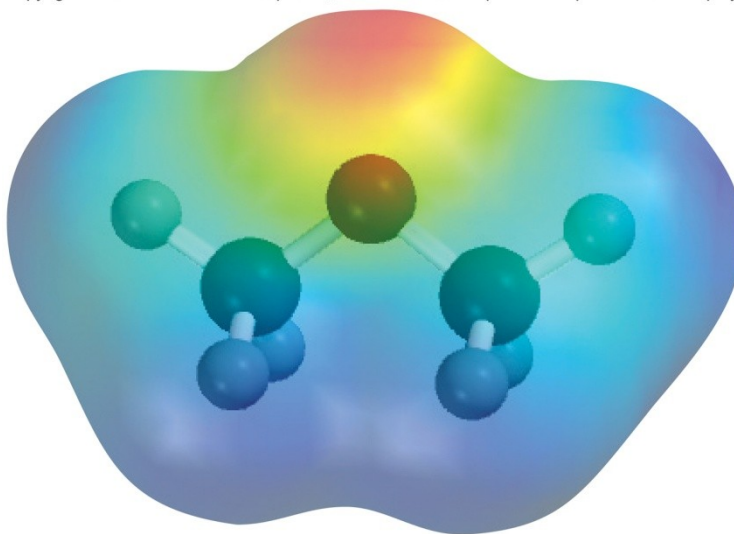
C₂H₅OH

✚ **Ethers** have the general formula R–O–R'.

Condensation Reaction



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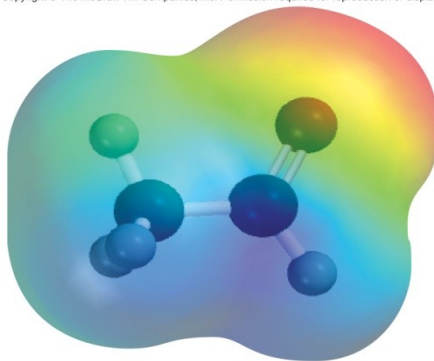
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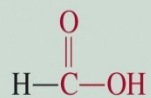
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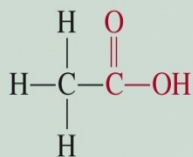




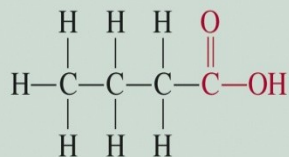
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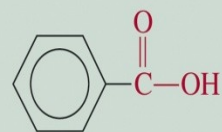
Formic acid



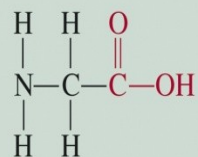
Acetic acid



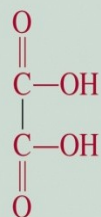
Butyric acid



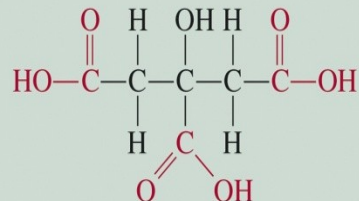
Benzoic acid



Glycine

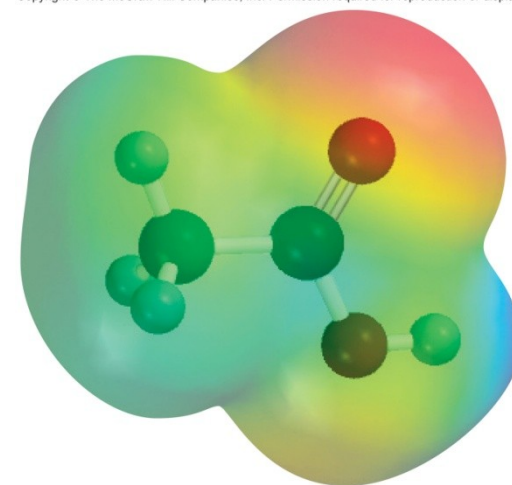


Oxalic acid

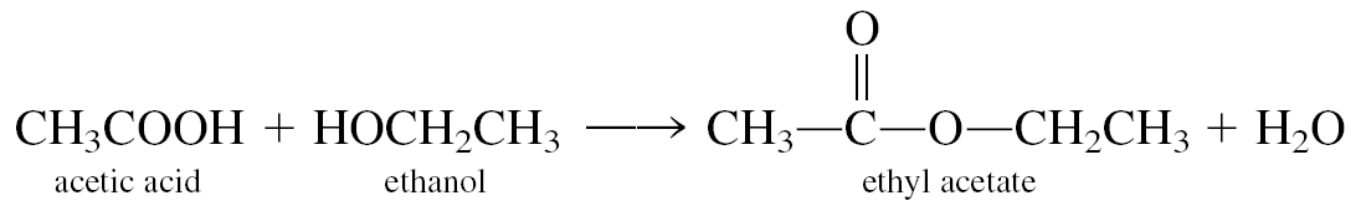


Citric acid

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CH₃COOH



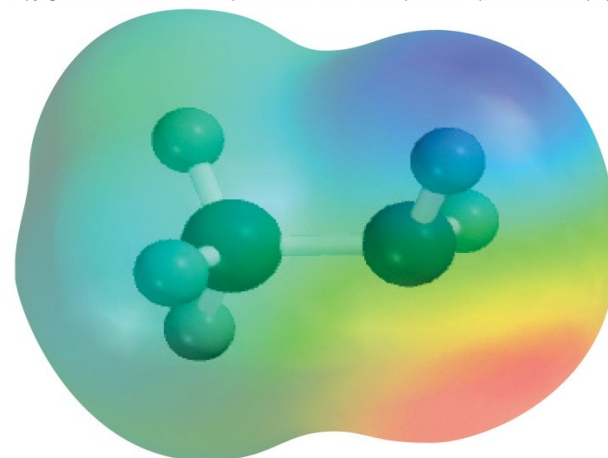
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Section 8.4

Hydrocarbon Derivatives

The Common Functional Groups

Table 22.4 | The Common Functional Groups

Class	Functional Group	General Formula*	Example
Halohydrocarbons	—X (F, Cl, Br, I)	R—X	CH_3I Iodomethane (methyl iodide)
Alcohols	—OH	R—OH	CH_3OH Methanol (methyl alcohol)
Ethers	—O—	R—O—R'	CH_3OCH_3 Dimethyl ether
Aldehydes	$\begin{array}{c} \text{O} \\ \parallel \\ \text{—C—H} \end{array}$	$\begin{array}{c} \text{O} \\ \parallel \\ \text{R—C—H} \end{array}$	CH_2O Methanal (formaldehyde)
Ketones	$\begin{array}{c} \text{O} \\ \parallel \\ \text{—C—} \end{array}$	$\begin{array}{c} \text{O} \\ \parallel \\ \text{R—C—R'} \end{array}$	CH_3COCH_3 Propanone (dimethyl ketone or acetone)
Carboxylic acids	$\begin{array}{c} \text{O} \\ \parallel \\ \text{—C—OH} \end{array}$	$\begin{array}{c} \text{O} \\ \parallel \\ \text{R—C—OH} \end{array}$	CH_3COOH Ethanoic acid (acetic acid)
Esters	$\begin{array}{c} \text{O} \\ \parallel \\ \text{—C—O—} \end{array}$	$\begin{array}{c} \text{O} \\ \parallel \\ \text{R—C—O—R'} \end{array}$	$\text{CH}_3\text{COOCH}_2\text{CH}_3$ Ethyl acetate
Amines	—NH_2	R—NH_2	CH_3NH_2 Aminomethane (methylamine)

*R and R' represent hydrocarbon fragments.

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A close-up photograph of a human hand, palm up, holding a small, vibrant flame. The flame transitions through a spectrum of colors: red at the base, then orange, yellow, green, blue, and finally purple at the top. Wisps of smoke or vapor rise from the flame. The background is solid black. Overlaid on the image is the text 'Thank You' in a large, white, sans-serif font. The word 'Thank' is on the top line, and 'You' is on the bottom line, centered horizontally.

**Thank
You**