Chapter 1: Organic Compounds

Organic chemistry is the study of carbon-containing compounds and their properties. There are a few carbon compounds, including carbon oxides and carbonates that we consider to be inorganic. Understanding how carbon atoms bond to each other and to other atoms helps explain why organic compounds enable life to exist on Earth.

Alkanes are saturated hydrocarbons in which the atoms of carbon are bonded to each other by single bonds. Alkenes and alkynes are unsaturated hydrocarbons with multiple bonds, and they are more reactive than alkanes. They may participate in addition reactions, including hydrogenation, halogenation, hydrohalogenation, and hydration.

A naming scheme has been established by the International Union of Pure and Applied Chemistry (IUPAC) to name the organic compounds. Structural isomers are compounds that have the same molecular formula but different molecular geometry. Cis and trans isomers are compounds that are identical except for the position of groups on either side of a double bond.

Aromatic hydrocarbons are a class of cyclic unsaturated hydrocarbons that have a ring structure and bonding that causes them to be chemically stable. Other major classes of organic compounds include alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, and amides. Their properties and reactions are determined by their structures and specific functional groups.

Chapter 2: Polymers

Many of the objects that we use today are made of plastic, at least in part. Plastics are synthetic polymers. Other polymers occur naturally. Silk, spiderwebs, hair, muscle, cotton, and wood are all composed of polymers made by living organisms.

Polymers are large molecules—natural or synthetic—made up of many monomers linked together. Homopolymers are polymers made of only a single type of monomer. Copolymers are polymers made of two or more types of monomers.

Addition polymers form when monomers link during addition reactions. Condensation polymers are polymers formed when monomers join during condensation reactions. The properties of addition polymers can be varied by selecting monomers with certain substituent atoms or groups. Polyesters are formed by condensation reactions between carboxylic acids and alcohols that result in ester linkages. Polyamides are formed by condensation reactions between carboxylic acids and amines that result in amide linkages.

Starch, cellulose, and glycogen are polymers of glucose. Proteins and nucleic acids are condensation polymers. The shape of a protein molecule depends on intermolecular and intramolecular forces. DNA stores information for amino acid sequences, enabling the cell to assemble proteins.

Disposal of used plastics has been a serious environmental problem. Many plastics cannot be recycled. The most effective solution is to reduce the quantity of waste produced.

BIG IDEAS

- Organic compounds have predictable chemical and physical properties determined by their respective structures.
- Organic chemical reactions and their applications have significant implications for society, human health, and the environment.
Alkanes

Vocabulary

<table>
<thead>
<tr>
<th>organic compound</th>
<th>cyclic alkane</th>
<th>structural isomer</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrocarbon</td>
<td>alkyl group</td>
<td>complete combustion</td>
</tr>
<tr>
<td>saturated hydrocarbon</td>
<td>substituent group</td>
<td>alkyl halide</td>
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<tr>
<td>alkanes</td>
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</table>

**MAIN IDEA:** Hydrocarbons contain hydrogen and carbon. In a saturated hydrocarbon, the atoms of carbon are bonded to each other by single bonds. Structural isomers are compounds that have the same molecular formula but different molecular geometry. Alkanes may have a straight-chain structure or a ring structure. Substituent groups may be attached to the parent structure. Alkyl halides are alkanes in which halogen atoms have substituted for one or more hydrogen atoms.

1. Name two alkanes that are used as fuels to heat homes and solder torches.  

2. Name and describe three common ways of depicting the structures of organic compounds.  

3. Indicate whether each of the following statements is true or false. If you think a statement is false, rewrite it to make it true.
   (a) A substituent group is any atom or group that replaces carbon in an organic molecule.
   (b) A structural isomer is a compound that has the same molecular formula as another compound, but a different structure.

4. An alkyl group consisting of a 3-carbon chain and 7 hydrogen atoms is called a(n) ________ group.  

5. Which of the following is *not* a saturated hydrocarbon?
   (a) 1,3-dichlorobutane
   (b) 2,4-dimethylpentane
   (c) 2,3,4-trimethyloctane
   (d) 1,4-diethylcyclohexane
6. Write the name of each of the following compounds.

(a) \( \text{CH}_3\text{CH}_2\text{CH}_3 \)
(b) \( \text{CH}_3\text{C}_2\text{H}_5 \)
(c) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \)
(d) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{Cl} \)
(e) \( \text{CH}_3\text{CH}_2\text{C}_2\text{H}_5 \)
(f) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \)

7. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: Cyclohexane contains 6 carbon atoms with each carbon atom bonded to 4 atoms, so one molecule of cyclohexane contains a total of 24 atoms.

8. Which of the following is a property of alkanes?
   (a) The combustion reactions are endothermic.
   (b) The molecules are polar and form hydrogen bonding.
   (c) The boiling point decreases with the length of the carbon chain.
   (d) Van der Waal forces are the main intermolecular forces between molecules.
9. Draw a structural formula and write the molecular formula for each of the following compounds.

(a) 3-ethyl-4-methylhexane

(b) 1-bromo-3-ethylcyclohexane

(c) 4-propan-2-yloctane

10. Draw and name three structural isomers that have the molecular formula $C_5H_{12}$.
Alkenes and Alkynes

Vocabulary

<table>
<thead>
<tr>
<th>Unsaturated hydrocarbon</th>
<th>Stereoisomer</th>
<th>Functional group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkene</td>
<td>cis isomer</td>
<td>Addition reaction</td>
</tr>
<tr>
<td>Alkyne</td>
<td>trans isomer</td>
<td>Markovnikov's rule</td>
</tr>
<tr>
<td>Aliphatic hydrocarbon</td>
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</tbody>
</table>

**MAIN IDEA:** An alkene is a hydrocarbon that has at least one double bond between two carbon atoms. The carbon chain is numbered using the lowest number for the double bond. The root name ends in -ene. An alkyne is a hydrocarbon that has at least one triple bond between two carbon atoms. Naming alkynes is similar to naming alkenes. The root name ends in -yne. Cis and trans isomers are compounds that are identical except for the positions of groups on either side of a double bond. In cis isomers, the groups are located on the same side of the double bond. In trans isomers, the groups are located on the opposite sides of the double bond.

1. Indicate whether each of the following statements is true or false. If you think a statement is false, rewrite it to make it true.

   (a) Each molecule of a hydrocarbon containing carbon–carbon double or triple bonds contains fewer than the maximum number of hydrogen atoms.

   (b) Other than the use of cis and trans to describe the positions of the groups around the double bond, stereoisomers have the same molecular formula and chemical name.

   (c) cis-hex-2-ene and trans-hex-3-ene are stereoisomers.

2. Name the following compounds.

   (a) \( \text{CH}_3\text{CH}==\text{CH}==\text{CH}_2 \)

   (b) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{C}==\text{C}==\text{CH}_2 \)

   (c) \( \text{H}_3\text{C} \)

   (d) \( \text{Cl} \)}
3. Draw the structures of the following compounds.

(a) 3-methylhexa-1,3-diene

(b) 5-ethyl-2-methylhept-3-yne

(c) 1-ethylcyclobut-1-ene

4. Match the condensed formula on the left with the possible alkene or alkyne on the right.

(a) CH₂CH₂CCCH₂CH₃    (i) hex-3-ene
(b) CH₂CH₂CH₂CH₂CCH    (ii) hex-2,4-diene
(c) CH₂CHCHCHCHCH₃    (iii) hex-1-yne
(d) CH₂CH₂CHCHCH₂CH₃    (iv) hex-3-yne
5. An aliphatic hydrocarbon has molecular formula C₅H₁₀. (a) Draw all possible non-cyclic structural isomers of the compound. Write the name of each structure.

(b) Identify if any of the structures in part (a) have stereoisomers. Draw and name the cis and trans isomers of the compound.

6. Draw the cis and trans isomers of the following compounds.

(a) 3-chlorohex-3-ene

(b) 1,2-dimethylcyclobut-1-ene
**MAIN IDEA:** Hydrocarbons with multiple bonds are more reactive than alkanes and participate in addition reactions in which atoms from one molecule are added to another molecule. Addition reactions include hydrogenation, halogenation, hydrohalogenation, and hydration. Markovnikov’s rule states that, when two non-identical entities are added at a double bond, the major product will be formed by the hydrogen atom bonding to the carbon atom with more hydrogen atoms attached.

7. A ______________ group is a specific group of atoms within a molecule that affects the properties of the compound such as the chemical reactivity with other elements or compounds.

8. Which of the following is not true for the addition reactions of alkenes or alkynes with water?
   (a) The double-bonded or triple-bonded carbon atoms take part in the reaction.
   (b) The alkene or alkyne gains atoms but does not lose any atoms.
   (c) There is only one product resulting from the reaction.
   (d) Two molecules react to form one molecule.

9. Draw the structure of the product of each of the following reactions. Write the IUPAC names of the reactant and the product, and identify the type of addition reaction. Apply Markovnikov’s rule if needed.

   (a) \[ \text{CH}_3 \quad \text{CH}_3-C\equiv CH-CH_3 + H_2 \rightarrow \]

   (b) \[ \text{CH}_3+\text{Br}_2 \rightarrow \]

   (c) \[ \text{CH}_3 \quad \text{CH}_3-C\equiv CH-CH_3-\text{CH}_3 + \text{HCl} \rightarrow \]

   (d) \[ \text{CH}_3-\text{CH}_2-C-\text{CH}_2-\text{CH}_2+\text{H}_2\text{O} \rightarrow \]
MAIN IDEA: Aromatic hydrocarbons are a class of cyclic unsaturated hydrocarbons that have a ring structure and bonding that causes them to be chemically stable. Measurements show that the bonds in a benzene ring are all equal in length.

1. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: The commercial use of benzene has discontinued because benzene contains caffeine.

2. The structural diagram of benzene shows that a benzene molecule has three double bonds and three single bonds.

   (a) Experiments indicate that all six bonds are equal in length. Explain how this can occur.

   (b) Draw a common representation of benzene.

3. (a) Name a commercial solvent that has replaced benzene as a solvent used in industrial processes and for dry-cleaning clothes.

   (b) Draw the structure of the compound and write its IUPAC name.
4. Name the following compounds.

(a) \( \text{CH}_3 \text{CH}_3 \)

(b) \( \text{Cl} \text{CH}_3 \text{H}_3 \text{C} \)

(c) 
\[ \text{Br} \text{CH}_3 \text{CH} = \text{CH}_2 \]

5. Draw a structural formula to represent each of the following compounds.

(a) metadiethylbenzene

(b) 5-chloro-7-phenyloct-1-yne

**MAIN IDEA:** Benzene is less reactive than alkenes but more reactive than alkanes. Since it participates in substitution reactions, benzene behaves more like an alkane.

6. Which of the following compound is the least reactive?

(a) benzene

(b) hex-1-yn

(c) hex-1-ene

(d) hexane

7. Draw the chemical equation for the following reactions. Include the names of the organic reactant and product.

(a) hydrogenation of benzene

(b) substitution reaction of benzene using hydrochloric acid, HCl(aq)
Alcohols, Ethers, and Thiols

Vocabulary

<table>
<thead>
<tr>
<th>alcohol</th>
<th>tertiary alcohol</th>
<th>ether</th>
</tr>
</thead>
<tbody>
<tr>
<td>primary alcohol</td>
<td>hydrogen bonding</td>
<td>dehydration reaction</td>
</tr>
<tr>
<td>secondary alcohol</td>
<td></td>
<td>thiol</td>
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</tbody>
</table>

MAIN IDEA: Alcohols contain a hydroxyl group, −OH. The hydroxyl group allows alcohols to form hydrogen bonds. Alcohols can be further classified as primary, secondary, and tertiary.

1. What are two reactions that can be used for the commercial preparation of ethanol?  

2. Since the electronegativity difference between carbon and hydrogen is ____________ than that between carbon and oxygen, the C—H bond is ____________ polar than the C—O bond. Also, the bond between carbon and ____________ is polar, so alcohol molecules are polar.

3. Match each alcohol on the left with the description and use on the right.
   (a) ethanol
   (b) propan-1-ol
   (c) propan-2-ol
   (d) ethane-1,2-diol
   (e) propane-1,2,3-triol
   (i) polylcohol with three −OH groups used in pharmaceutical preparations to help dissolve less polar compounds
   (ii) primary alcohol used as a solvent for lacquers and waxes, and as brake fluid
   (iii) polylcohol with two −OH groups used as antifreeze in automobile engines
   (iv) secondary alcohol used as an antiseptic to clean the skin before injections
   (v) primary alcohol used in alcoholic beverages

4. Indicate whether each of the following statements is true or false. If you think a statement is false, rewrite it to make it true.
   (a) The simplest aromatic alcohol has one hydroxyl group bonded to cyclohexane.
   (b) As the size of the carbon chain of a simple alcohol grows, the alcohol becomes less soluble in water because the hydrocarbon region of an alcohol molecule is non-polar.

5. Which of the following compounds is a tertiary alcohol?
   (a) 2,4-dimethylpentan-3-ol
   (b) 3-ethylhexan-3-ol
   (c) 4-methylheptan-3-ol
   (d) 3,5-diethyloctan-4-ol

Classifying Alcohols
Alcohols are classified according to the number of other carbon atoms that are directly bonded to the carbon atom attached to the hydroxyl group, −OH. A primary alcohol has the −OH group attached to the carbon atom at the end of the carbon chain, which has only 1 carbon atom attached to it. A secondary alcohol has the −OH group bonded to a carbon atom that is attached to 2 other carbon atoms. A tertiary alcohol has the −OH group bonded to a carbon atom that is attached to 3 other carbon atoms.
6. Write the name of each of the following compounds.

(a) \( \text{CH}_3 \text{CH} = \text{CH} \text{CH} = \text{CH} \text{CH}_2 \text{CH}_3 \)

(b) \( \text{OH OH OH} \)

(c) \( \text{H}_2\text{C} \text{OH} \text{CH} = \text{CH} \text{CH} = \text{CH} \text{CH}_3 \text{CH}_2 \text{CH}_3 \)

(d) \( \text{H}_2\text{C} \text{CH} = \text{CH} \text{CH} = \text{CH} \text{CH}_2 \text{OH} \text{OH} \)

7. Draw a structural formula for each of the following compounds.

(a) 3-methylpentane-2,4-diol

(b) 5-bromo-3-ethylhexan-2-ol

(c) 3-chloro-2-methylcyclohexanol

8. Explain why methanol has a higher boiling point than methane.
**MAIN IDEA:** Alcohols can be produced by hydration reactions of alkenes. Dehydration reactions use a catalyst and acid to change the alcohol back to an alkene and water. In a combustion reaction an alcohol reacts with oxygen, producing carbon dioxide and water.

9. Write a chemical equation for each of the following reactions. Classify the reaction type.

(a) butan-2-ol from but-2-ene

(b) but-1-ene from butan-1-ol

(c) water and carbon dioxide from ethanol

(d) methoxybutane from butan-1-ol and methanol

**MAIN IDEA:** Ethers can be produced from the condensation reaction of alcohols. Ethers are widely used as solvents because of their ability to dissolve both polar and non-polar substances. Thiols contain the sulfhydryl functional group, –SH. They typically have strong odours and react similarly to alcohols.

10. Ethoxyethane is an effective anesthetic that has been used successfully for decades. Why is it being replaced? What is the current major use of this compound?

11. Which of the following is not true of thiols?

(a) Thiols generally have strong odours.

(b) Gas delivery companies add thiols to natural gas to detect leaks.

(c) Hydrogen peroxide reacts with thiols to form disulfide compounds with a strong odour.

(d) The reaction of thiol is similar to that of alcohols as the sulfhydryl group, –SH, is similar to the hydroxy group, –OH.
1.5

Aldehydes and Ketones

Textbook pp. 40–46

Vocabulary

| carbonyl group | aldehyde | ketone |

MAIN IDEA: If a carbonyl group (C=O) is attached to at least 1 hydrogen atom, the molecule is an aldehyde. It is named using the suffix -al. If a carbonyl group is attached to 2 carbon atoms, the molecule is a ketone. It is named using the suffix -one. The carbonyl group makes organic molecules polar, giving them higher boiling points and greater water solubility than the corresponding alkanes.

1. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: In an aldehyde other than methanal, the carbonyl group is bonded to only one hydrogen atom.

2. Name each of the following aldehydes and ketones.

   (a) \( \text{CH}_3\text{CH}-\text{CH}-\text{CH}-\text{C}=\text{O} \)

   (b) \( \text{CH}_3\text{CH}-\text{CH}-\text{C}=\text{O} \)

   (c) \( \text{Br}\text{CH}-\text{CH}-\text{CH}-\text{C}=\text{O} \)

   (d) \( \text{C}=\text{O} \)

   (e) \( \text{CH}_3\text{CH}_2\text{CH}(-\text{CH}_3)\text{CH}_2\text{CHO} \)

   (f) \( \text{CH}_3\text{C}(-\text{Cl})_2\text{CH}_2\text{COCH}_3 \)

3. Draw a structural formula for each of the following compounds.

   (a) 2,2-dimethylpropanal

   (b) 1-hydroxyhexan-3-one
4. Draw a line diagram for 2-ethylpentanal.

5. Which of the following is a property of aldehydes and ketones?
   (a) Their boiling points are higher than similar alcohols.
   (b) The molecules are polar and form hydrogen bonds with one another.
   (c) The molecules are more soluble in water than similar-sized alcohol molecules.
   (d) The solubility in water decreases as additional carbons are added to the chain.

**MAIN IDEA:** The controlled oxidation of a primary alcohol produces an aldehyde. The controlled oxidation of a secondary alcohol produces a ketone. Tertiary alcohols do not readily undergo controlled oxidation. The hydrogenation of an aldehyde produces a primary alcohol. The hydrogenation of a ketone produces a secondary alcohol.

6. Complete the chemical equation for each of the following controlled oxidations of alcohol. Draw the structure of the product and write the IUPAC names of the reactant and product.

   (a) 
   \[
   \text{Reactant: CH}_3\text{CHCH}_2\text{CH}=\text{C(OH)(O)} \quad \rightarrow \quad \text{Product: CH}_3\text{CHCH}_2\text{CH}=\text{CHO} \\
   \]

   (b) 
   \[
   \text{Reactant: CH}_3\text{CHCH}_2\text{CH}=\text{C(OH)(O)} \quad \rightarrow \quad \text{Product: CH}_3\text{CHCH}_2\text{CHO} \\
   \]

   (c) 
   \[
   \text{Reactant: CH}_3\text{CHCH}_2\text{CH}=\text{C(OH)(O)} \quad \rightarrow \quad \text{Product: CH}_3\text{CHCH}_2\text{CHO} \\
   \]

   Reactant: 
   Product:
7. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: When a primary alcohol is hydrogenated, the carbonyl group forms on the terminal carbon atom, resulting in an aldehyde.

8. Which of the following is a condensed formula for 4-methylhexan-2-one?
   (a) \( \text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{COCH}_3 \)
   (b) \( \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{COCH}_2\text{CH}_3 \)
   (c) \( \text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3 \)
   (d) \( \text{HCOCH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3 \)

9. Complete Table 1 for the hydrogenation reactions of aldehydes and ketones.

<table>
<thead>
<tr>
<th>Reactant</th>
<th>Product</th>
<th>1° or 2° alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Name:</td>
<td>Name:</td>
</tr>
<tr>
<td>(b)</td>
<td>Name:</td>
<td>Name:</td>
</tr>
<tr>
<td>(c)</td>
<td>Name:</td>
<td>Name:</td>
</tr>
</tbody>
</table>
Carboxylic Acid, Esters, and Fats

**Vocabulary**
- carboxylic acid
- carboxyl group
- ester
- esterification
- hydrolysis
- lipid
- fatty acid
- triglyceride
- saponification

**MAIN IDEA:** A carboxyl group is a combination of a carbonyl group, \( C=O \), and a hydroxyl group, \( -OH \). Carboxylic acids are named by replacing the \(-e\) ending of the alkane with \(-oic\ acid\). Carboxylic acids are formed by the controlled oxidation of aldehydes.

1. Write two common uses of each carboxylic acid.
   (a) methanoic acid
   (b) ethanoic acid

2. Name each of the following carboxylic acids.
   (a) \( \begin{align*} &\text{H} \\
&\text{O} \\
&\text{C}\big|\text{CH}_3 \\
&\text{HO}\big|\text{CH}_2\big|\text{CH}_2\big|\text{CH}_2\big|\text{CH} \\
&\text{Cl} \end{align*} \)
   (b) \( \text{HOOCCH}_2\text{CH}_2\text{COOH} \)
   (c) \( \text{HO} \)

3. Draw a structural formula for each of the following carboxylic acids.
   (a) 2,2-dimethylpropanoic acid
   (b) 3-methylbenzoic acid
   (c) 2-ethyl-3-methylbutanoic acid
4. Which of the following compound has the highest melting point? 
   (a) butane 
   (b) propane 
   (c) butanoic acid 
   (d) propanoic acid 

5. Use condensed formulas to write a chemical equation for the controlled oxidation of 2-methylpropanal to produce a carboxylic acid. Also write the IUPAC name of the product.

**MAIN IDEA:** An ester's name is derived from the name of the alkyl group of alcohol followed by the name of the alkyl group of the carboxylic acid with the ending -oate. Esterification is the formation of an ester from a carboxylic acid and an alcohol. Hydrolysis of esters is the breaking down of the ester by a strong base to form the carboxylic acid and alcohol.

6. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: The functional group of an ester is similar to a carboxyl group except that the carbonyl group is replaced with an alkyl group.

7. Name each of the following esters.
   (a) \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{C}\equiv\text{O} \text{O} \text{CH}_2\text{CH}_3 \]
   (b) \[ \text{OS} \text{OS} \]

8. The IUPAC name of this ester is ethyl 2-methylpropanoate.
   (a) Write a condensed formula for the ester.
   (b) Draw a line diagram for the ester.
9. Use structural formulas to write a chemical equation for the preparation of ethyl pentanoate from an acid and an alcohol. Name the reactants and products, and state the type of reaction.

10. What are the products from the hydrolysis of methyl propanoate?

**MAIN IDEA:** Fats and oils are triglycerides. They are esters made from long chains of fatty acids. Saponification is the process by which a fatty acid reacts with a strong base to form a salt of the fatty acid: soap. Saponification is a type of esterification.

11. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: Fats and oils are large ester molecules known as lipids. Fats and oils have the same general structure, with fats referring to solids and oils referring to liquids at room temperature.

12. Soap is a sodium salt of a ______________________. It is formed together with glycerol when an ester called ______________________ is heated with the strong base sodium hydroxide in a type of reaction classified as ______________________.

13. Which of the following is not true for trans fats?
   (a) They have unsaturated hydrocarbon chains containing double bonds that cannot be rotated.
   (b) Their melting points are lower than the corresponding cis forms, since their molecules are more tightly packed together.
   (c) Eating foods containing them could lead to health problems as they are not easily digested as saturated fats.
   (d) They are not water soluble because of the non-polar nature of the long hydrocarbon chains in their molecules.
Amines and Amides

Vocabulary
amine amide

MAIN IDEA: Amines can be viewed as alkyl groups bonded to a nitrogen atom or an amino group bonded to an alkane. Primary amines have one alkyl group attached to the nitrogen atom; secondary amines have two; tertiary amines have three. Amines are named by adding the suffix –amine to the root of the name of the longest alkyl group attached to the nitrogen atom. The prefix N- indicates that a second (or third) alkyl group is also attached to the nitrogen atom.

1. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: The IUPAC name for an aromatic amine consisting of an amine group attached to a benzene ring is benzamine.

2. Name each of the following amines.

(a) \[
\text{CH}_3\text{CH}_2\text{CH}_2\text{N}^+\text{H}^-
\]

(b) \[
\text{CH}_3\text{N}\text{CH}_3
\]

3. Draw the structural formulas for all primary amines with the molecular formula C_4H_11N. Write the names of the isomers.
4. Name each of the following isomers of an amine with molecular formula C₄H₁₁N. Classify the amine as secondary or tertiary.

(a) \(\text{CH}_3\text{CH}_2\text{CH}_2\text{NCH}_3\)

(b) \(\text{CH}_3\text{CH}_2\text{NCH}_2\text{CH}_3\)

(c) \(\text{CH}_3\text{CH}_2\text{NCH}_3\)

(d) \(\text{CH}_3\text{CH}_2\text{NCH}_3\)

5. Draw the structure of a tertiary amine with molecular formula C₅H₁₃N that has only one methyl group attached to the nitrogen atom. Write the name of this amine.

6. Is the following statement true or false? If you think the statement is false, rewrite it to make it true: The boiling points of amines of similar size increases from primary to secondary to tertiary as the number of hydrogen bonds that the amine can form increases.
7. An amine can generally be synthesized from the reaction of ____________ and ammonia. The reaction gives a mixture of primary, secondary, and tertiary amines, which are separated using the process of ____________ since they all have different boiling points.

MAIN IDEA: Amides are formed from the reaction of carboxylic acid and amines. Amides can be hydrolyzed to reform the amine and carboxylic acid. Amides are named with the root of the name of the carboxylic acid first, followed by the root of the name of the amine, and ending with -amide.

8. Write the IUPAC name of each of the following amides.

(a) \[\text{CH}_3\text{CH_2CH_2C} = \text{NHCH_3}\]

(b) \[\text{CH}_3\text{CH_2C} = \text{NHCH_2CH_3}\]

9. Which of the following is true for amides?

(a) The solubility in water increases with the length of the carbon chain.
(b) Amides are structurally similar to esters, so they generally have a pleasant odour.
(c) Primary amides have higher melting points and boiling points than similar amides.
(d) Amides can be prepared by the hydrolysis reaction of a carboxylic acid with ammonia or an amine.

10. Name a carboxylic acid and an amine that can be used to prepare \(\text{N,N-dimethyl-3-methylbutanamide}\). Write a chemical equation to show the reaction.
Organic Compounds

Organic chemistry is defined as the study of carbon-containing compounds and their properties. There are a few carbon compounds, including carbon oxides and carbonates, that we consider to be inorganic. Organic molecules may contain one carbon atom or tens of thousands of carbon atoms. The following graphic organizer summarizes some of the main ideas from Chapter 1. Add to it to create your own study notes.
1. Name each of the following compounds. (1.1, 1.2, 1.3, 1.5, 1.6, 1.7) 
(a) \[ \text{Cl} \quad \text{CH}_3 \quad \text{CH}_2 \quad \text{CH}_3 \]
(b) \[ \text{CH}_3 \quad \text{CH}_2 \quad \text{C} \quad \text{O} \quad \text{OH} \]
(c) \[ \text{CH}_3 \quad \text{CH}_2 \quad \text{CH} \quad \text{Br} \]
(d) \[ \text{N} \quad \text{O} \]
(e) \[ \text{HO} \quad \text{CO} \quad \text{OH} \]
(f) \[ \text{CH}_3\text{CH}_2\text{COCH}_2\text{OH} \]
(g) \[ \text{HCCCH}_2\text{CHBrCH}_2\text{CH(CH}_3\text{)}\text{CH}_3 \]
(h) \[ \text{H}_2\text{NCH}_2\text{CH}_2\text{CHNH}_2\text{CH}_3 \]

2. Draw a structure for each of the following compounds. (1.4, 1.6) 
(a) line diagram for 3,5-diethyloctan-4-ol
(b) condensed formula for 3-chloro-2-methylbutanoic acid
3. Which of the following compounds does not form hydrogen bonds with water? (1.4, 1.5, 1.6, 1.7) 
   (a) ketone  
   (b) primary amine  
   (c) carboxylic acid  
   (d) primary alcohol  
4. Which of the following compounds is an ether? (1.4, 1.6, 1.7) 
   (a) aniline  
   (b) ethanamide  
   (c) methoxyethane  
   (d) methyl ethanoate  
5. Indicate whether each of the following statements is true or false. If you think a statement is false, rewrite it to make it true. (1.1, 1.2, 1.3, 1.7) 
   (a) Bonds between carbon and hydrogen in saturated hydrocarbons are almost non-polar, so these compounds have lower melting points and boiling points than compounds of similar sizes. 
   (b) The melting points of trans isomers are lower than the corresponding cis forms because their molecules are more tightly packed together. 
   (c) An aromatic hydrocarbon is an unsaturated hydrocarbon that has a ring structure and a bonding arrangement that causes it to be chemically stable. 
   (d) Since nitrogen is more electronegative than either carbon or oxygen, the N–C bonds and any N–H bonds in amines are polar. 
6. Complete Table 1 for simple organic compounds and their reactions. (1.1–1.7) 

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Reactants</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>methane + oxygen</td>
<td>carbon dioxide + water</td>
<td></td>
</tr>
<tr>
<td>ethene + hydrogen</td>
<td>chlorobenzene</td>
<td></td>
</tr>
<tr>
<td>substitution</td>
<td>propanol</td>
<td></td>
</tr>
<tr>
<td>dehydration</td>
<td>methanol + ethanol</td>
<td>methoxyethane + water</td>
</tr>
<tr>
<td></td>
<td>ethanol + oxygen</td>
<td>ethanal + water</td>
</tr>
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<td>esterification</td>
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<td>condensation</td>
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<td></td>
</tr>
<tr>
<td>condensation</td>
<td>ethanoic acid + ammonia</td>
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