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ACTIVE LEARNING IN CHEMISTRY EDUCATION

CHAPTER 25

INTRODUCTION TO ORGANIC COMPOUNDS

(Part 1)

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SECTION 25.1 Introduction to Carbon Compounds

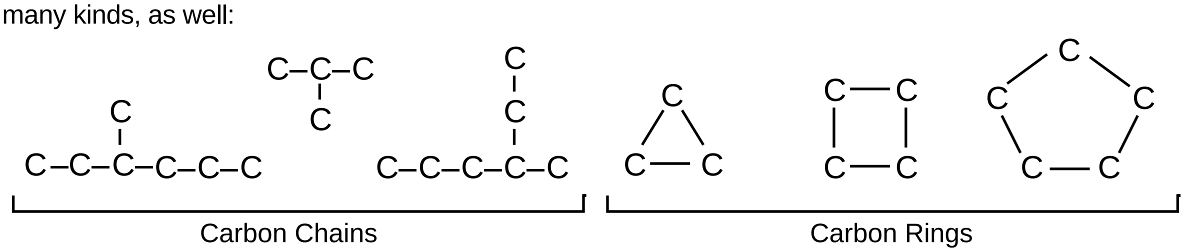
All substances can be classified as being either *organic* or *inorganic*. So far, our study of chemistry has dealt mainly with inorganic compounds. Originally, organic substances were considered to be those carbon compounds that were extracted from living things, while inorganic ones were compounds that did not originate in living systems. *An organic compound is defined as a substance that contains the element carbon.* However, some compounds that contain carbon are considered to be inorganic. A better definition may be that organic compounds have a carbon base, that carbon is the "backbone" of the compounds.

Organic chemistry plays a very important role in our daily lives. Many of the clothes we wear are made of rayon, dacron, nylon and orlon. These are all synthetic (man-made) organic compounds. Plastics of all sorts are synthetic organic compounds, too. Petroleum is a naturally occurring organic substance, but synthetic rubber and plastics are two of the by-products of petroleum.

A large number of modern chemical materials have been developed from by-products of petroleum. In addition to these items, other materials such as sulfa drugs, penicillin, cortisone, perfumes, detergents, vitamins, pesticides, anesthetics, and many of the more modern antibiotics are among the contributions made to society through a study of organic chemistry.

Throughout the 18th century, early chemists unsuccessfully tried to synthesize organic substances, starting with inorganic materials in their laboratories. Their failures gave rise to the "vital force theory" which stated that organic compounds could only be produced by a "vital force" which was responsible for life itself. This conclusion was closely tied to religious beliefs at the time. However, in 1828, the German chemist, Friedrich Wohler, succeeded in synthesizing an organic compound known as urea, starting with two inorganic compounds. Thereafter, many other organic compounds were synthesized in the same way in laboratories around the world. By 1850, the "vital force theory" was discredited. From that time on, organic and inorganic chemistry were recognized as two major fields of the science. There are over 90,000 known inorganic compounds. However, there are well over one million known organic compounds, and many more are being synthesized by chemists every year!

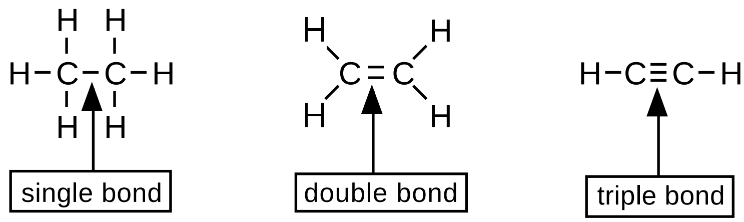
Why are there so many organic compounds? Well, carbon atoms can attach themselves to each other in wide variety of ways. They can join together to form short or long chains, and they can form rings of many kinds, as well:



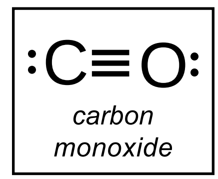
The chains and rings can have branches and cross-links with atoms of other elements (mainly hydrogen) attached to the carbon atoms. Different arrangements of carbon atoms correspond to different compounds, and each compound has its own characteristic properties.

We are going to approach the subject of organic chemistry in terms of organic nomenclature. Nomenclature involves the naming of compounds. We will restrict ourselves to the simpler organic compounds, because the more complex ones can get really complicated. You will be given a set of rules to follow as you name compounds. These rules must be followed very carefully. Success in learning organic nomenclature will involve some memorization on your part, but it will rely mainly on a logical approach to the problems presented.

The second most abundant element found in organic compounds is hydrogen. This chapter will deal exclusively with compounds composed of only carbon and hydrogen. These are called hydrocarbons. These two elements can combine in countless ways. The structures of some hydrocarbons are shown below. The lines between the atomic symbols represent bonds. There are three types of carbon to carbon bonds:



In each case you will note that carbon has a total of four bonds. This is because carbon has four valence electrons. There are only a few carbon compounds in which carbon does not have four bonds. One example is carbon monoxide. In this chapter, however, we will deal only with organic compounds in which the carbon atoms have four bonds. After we have studied the hydrocarbons, Chapters 26 and 27 will introduce you to the names and structures of organic compounds which contain other elements in addition to carbon and hydrogen.



Section 25.2 The Alkanes

The *alkane* family represents the simplest of the hydrocarbons. The general formula for the compounds in this family is C_nH_{2n+2}, where "n" equals the number of carbon atoms in the molecule. For example, if you substitute a 1 into this formula you will get CH_4. Substitute a 2 and you will get C_2H_6. These are the first two members of the family. The compounds in the alkane family are often called *saturated* compounds, which means that the molecules contain only single bonds between the carbon atoms.

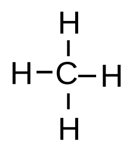
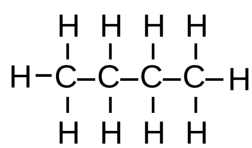
Naming alkanes is fairly simple. The prefix in the name of each compound indicates the number of carbon atoms present. All alkanes have a suffix of *-ane*. A list of alkane prefixes is shown in Problem 1 which has been partially completed for you. To make writing formulas or drawing structures easier, the hydrogens on the carbons are not always shown (note the structures on page 25-3); however, you should assume that enough hydrogen atoms are present to give each carbon atom 4 bonds.

Problem 1. Give the name and molecular formula for each compound below. Use the formula C_nH_{2n+2} to determine the formula, and add the suffix "ane" to the prefixes to obtain the names.

	Prefix	*No. of Carbons*	*Name*	*Molecular Formula*
a.	meth-	1	methane	CH_4
b.	eth-	2	____________	____________
c.	prop-	3	____________	C_3H_8
d.	but-	4	____________	____________
e.	pent-	5	pentane	____________
f.	hex-	6	____________	____________
g.	hept-	7	____________	____________

h.	oct-	8	______________	____________
i.	non-	9	______________	____________
j.	dec-	10	______________	____ $C_{10}H_{22}$ ____

In problem 1, you were writing *molecular formulas*. The kinds of formulas seen at the top of page 25-4 are known as *structural* formulas. Writing structural formulas for organic compounds can become very cumbersome when all of the chemical bonds are included in the drawings. To remedy this problem, chemists have developed a shorthand method of writing structural formulas that involves condensing the structures. In this shorthand method, the carbon atoms are still written separately (separated by hyphens), but the hydrogens which are bound to carbons are not. Instead, the hydrogens are written to the right of the carbon atoms to which they are bonded. This method of representing organic compounds is known as the *condensed structural formula*. Study the examples of condensed structural formulas below.

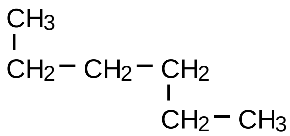
Compound	*Molecular Formula*	*Structural Formula*	*Condensed Structural Formula*
methane	CH_4		CH_4
butane	C_4H_{10}		CH_3-CH_2-CH_2-CH_3

Problem 2. Complete the exercise below.

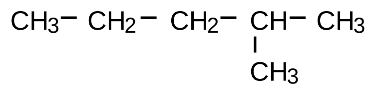
Compound Name	*Molecular Formula*	*Condensed Structural Formula*
a. methane	______ CH_4 _______	______________ CH_4 ______________
b. ethane	_________________	_________________________________
c. propane	_________________	_________________________________
d. butane	_____ C_4H_{10} ______	_________ CH_3-CH_2-CH_2-CH_3 _________
e. pentane	_________________	_________________________________
f. hexane	_________________	_________________________________
g. heptane	_________________	_________________________________
h. octane	_________________	_________________________________
i. nonane	_________________	_________________________________
j. decane	_________________	_________________________________

Section 25.3 Alkyl Groups

Carbon chains are not rigid structures. They can bend and flex freely. When we say that an alkane has a "straight" chain, we don't really mean straight. We mean that it is a continuous chain, rather than a branched chain. The two structures below both contain six carbon atoms. The one on the left is "straight," while the one on the right is branched.

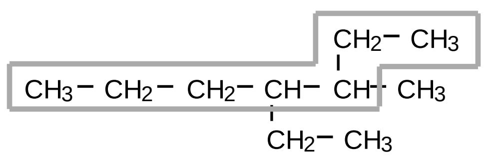


This is one continuous chain of carbon atoms.



This is a branched chain of carbon atoms.

Now that you have mastered the straight-chain (or should we say "continuous" chain) alkanes, it is time to try something more challenging. Most alkanes exist as "branched" molecules such as the one shown below. The longest continuous chain of carbon atoms in the molecule below is 7 (enclosed by box). Therefore, the parent compound here is heptane. (Remember, the longest continuous chain is not necessarily straight!)



The longest continuous chain contains 7 carbon's.

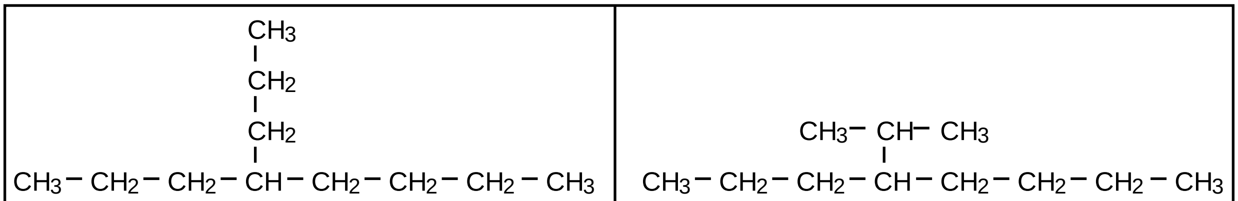
Having identified the parent compound, we must next identify the *side chains*. These side chains are commonly called *alkyl groups*. Alkyl groups are attached to the longest continuous chain. When written alone, they are usually shown with a free-bonding site represented by a dash (like this: $-CH_3$). This bonding site represents a spot where a hydrogen atom has been removed. Thus, the general formula for the alkyl groups is C_nH_{2n+1}. The free bonding site is what allows the alkyl group to bond to the parent compound. Alkyl groups are named with the same prefixes as the alkanes themselves. The suffix is changed from "ane" to "yl." Complete Problem 3 below by entering the formulas and condensed structural formulas of the first six alkyl groups.

Problem 3. Complete the exercise below.

	Name of Alkyl group	Condensed Structural Formula
a.	methyl	$-CH_3$
b.	____________	____________________________
c.	____________	____________________________
d.	butyl	$-CH_2-CH_2-CH_2-CH_3$
e.	____________	____________________________
f.	____________	____________________________

Depending on where the hydrogen atom is removed, the bonding site on some alkyl groups can change position. This would change the way in which the alkyl group bonds to the parent compound. For example, note the two alkyl groups shown below. Both are composed of three-carbon chains, but the bonding site differs:

The compound on the left below has a propyl group attached to the parent compound which is octane. The compound on the right has an isopropyl group attached to the parent compound (heptane). Note that all carbons in the molecules have four bonds.



Propyl group attached to an 8-carbon chain

Isopropyl group attached to an 8-carbon chain

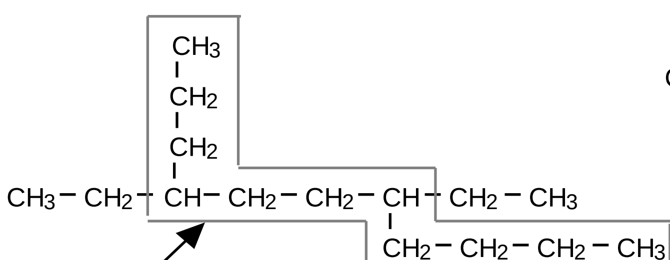
The carbon atoms on the end of the chain are called *terminal* carbons. When the bonding site of an alkyl group occurs on a terminal carbon, the alkyl group is said to be "normal" and its name is sometimes preceded by the letter n. Thus, the propyl group above could also be called n-propyl (pronounced "normal propyl"). We will consider the use of this "n" prefix as optional. The other structure with the bonding site on the center carbon is called *isopropyl*.

SECTION 25.4 IUPAC Rules for Naming Alkanes

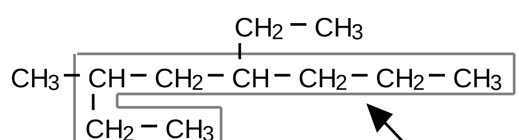
A system for naming organic compounds has been developed by the *International Union of Pure and Applied Chemists (IUPAC)*. The system is accepted and used throughout the world. There is also a method by which many organic compounds are given "common" names, but we will use only the IUPAC system in this chapter. We will consider the rules one at a time and apply them to some practice problems.

RULE 1: Locate the longest continuous chain of carbon atoms. This will give you the name of the "parent" compound.

For example, if the longest chain contains four carbons, the parent compound is butane. The longest chains in the following two molecules are enclosed by a box:

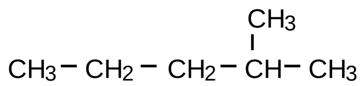


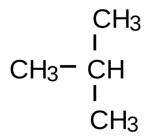
longest continuous chain = 11 carbons

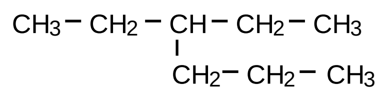


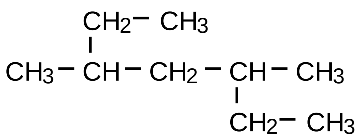
longest continuous chain = 8 carbons

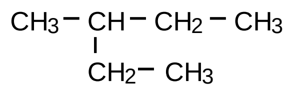
Problem 4. Draw a box around the longest continuous chain of carbon atoms in the structures below, and name the parent compound for each one.

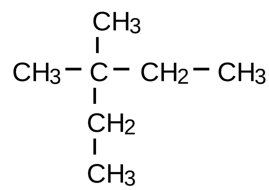
a. 

b. 

c. 

d. 

e. 

f. 

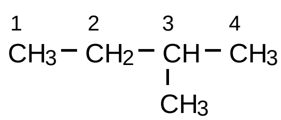
a. parent: ____________________________ d. parent: ____________________________

b. parent: ____________________________ e. parent: ____________________________

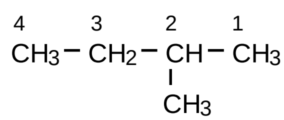
c. parent: ____________________________ f. parent: ____________________________

RULE 2: The name of the parent compound is modified by noting what alkyl groups are attached to the chain. Number the longest chain so that the alkyl group(s) will be on the lowest numbered carbons.

Note in the molecules shown below, that the longest chain should be numbered from right to left in order to give the carbon which is bonded to the methyl group the lowest possible number:



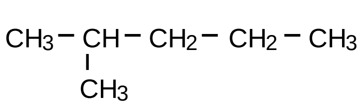
Incorrect Numbering



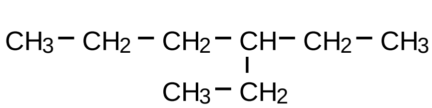
Correct Numbering

The correct name of this compound is 2-methylbutane. The "2-" indicates that the methyl group is attached to the second carbon in the longest chain. Note that the name of the alkyl group is added to that of the parent compound (butane) to form one word, and that hyphens are used to separate numbers from alphabetical parts of the name.

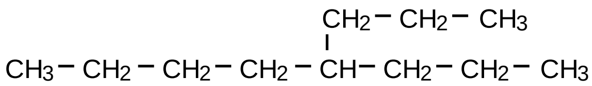
Problem 5. For the following compounds, draw a box around the longest continuous carbon chain and name each molecule. The name of the molecule in part "b" is given to help you.

a. 

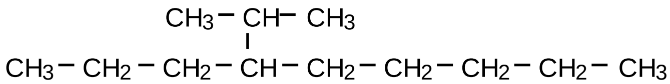
Name: ______________________________________

b. 

Name: __3-ethylhexane________________________

c. 

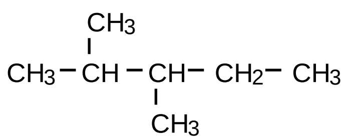
Name: ____

d. 

Name: ____

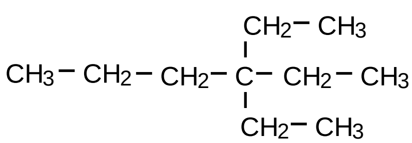
<u>RULE 3:</u> When the same alkyl group occurs more than once in a molecule, the numbers of the carbons to which they are attached are all included in the name. The number of the carbon is <u>repeated</u> as many times as the group appears. The number of repeating alkyl groups is indicated in the name by the use of Greek prefixes for 2, 3, 4, 5, etc. (di, tri, tetra, penta, etc.).

To better understand rule 3, study the following examples.



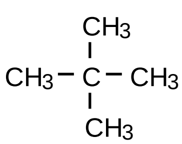
is called 2,3-dimethylpentane

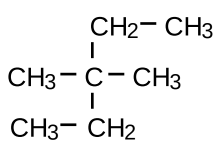
Note that numbers used in the name are separated from each other by commas, and note that the numbers are separated from the rest of the name with a hyphen.

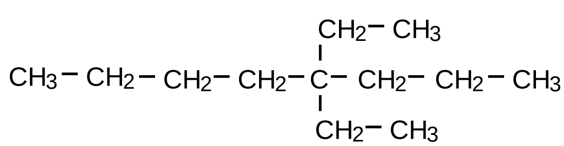


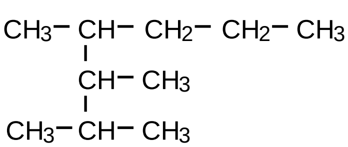
is called 3,3-diethylhexane

Problem 6. Name the four molecules whose structures are drawn below.

a. 

b. 

c. 

d. 

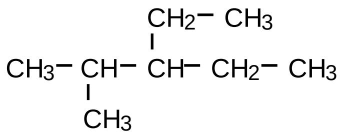
a. ____

b. ____

c. ____

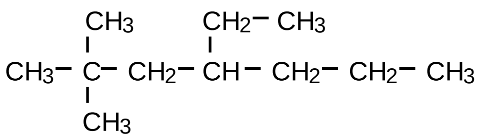
d. ____

RULE 4: If there are two or more different kinds of alkyl groups attached to the parent chain, name them in alphabetical order.

For example:  is called 3-ethyl-2-methylpentane

It is NOT called 2-methyl-3-ethylpentane

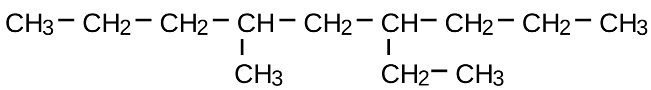
However, when you are determining the alphabetical order, do not consider any Greek prefixes that are being used. For example:



is called 4-ethyl-2,2-dimethylheptane

It is NOT called 2,2-dimethyl-4-ethylheptane

Problem 7. Name the four molecules drawn below.

a. 

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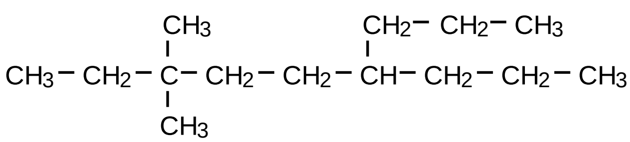
b. 

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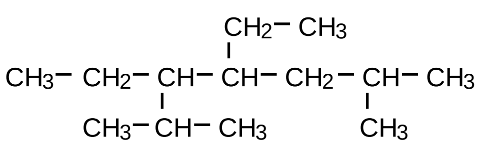
c. 

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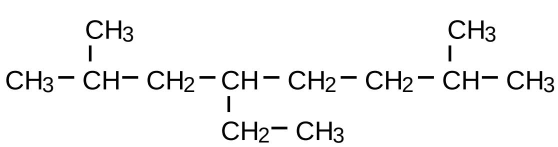
d. 

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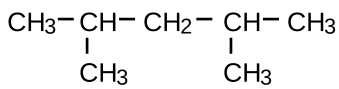
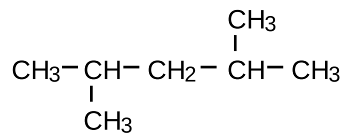
RULE 5: To put the finishing touches on the name of an alkane, keep the following points in mind: (a) hyphens are used to separate numbers from names of substituents; (b) numbers are separated from each other by commas; (c) the last alkyl group to be named is prefixed to the name of the parent alkane, forming one word; and (d) the suffix "-ane" indicates that the molecule is an alkane.

ACTIVITY 25.5 Using Molecular Models

The structure of alkanes is more understandable if you see them in three dimensions. We will use molecular model kits for this purpose. Obtain a box containing a molecular model kit and determine which parts represent carbon atoms, hydrogen atoms, carbon to carbon bonds, and carbon to hydrogen bonds. When you have done this, assemble models of the six molecules drawn in Problem 4. Pick up one of your models and rotate one section of the model while holding the other. Do you see how rotation is possible around a single bond?______________. Holding the model with both hands, bend and flex it a bit. Note the bond angles between the carbons themselves and between the carbons and the hydrogens. Do you see why these molecules are not really "straight" chains? _______________.

Because free rotation is possible around a single bond, what can you conclude about the 2 molecules shown below?{1}______________________________ If you named these two molecules, what would you discover?{2}__________________________ What is the name?{3}______________________________

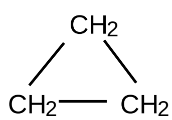




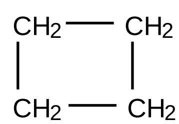
SECTION 25.6 Cyclic Alkanes

The compounds we have studied so far have been either "straight" or "branched" chains. Carbon atoms can also form rings which result in the formation of *cyclic* alkane molecules with the general formula, C_nH_{2n}. Naming the cyclic alkanes is not difficult, but the rules do differ a bit from those used to name the straight and branched chained compounds.

The name of a cyclic molecule requires the addition of the prefix "cyclo" to the name of the hydrocarbon. Note the two condensed structural formulas below.



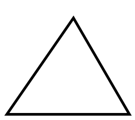
cyclopropane



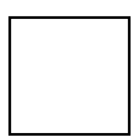
cyclobutane

To make cyclic compounds easier to draw, a shorthand notation is used in which the hydrogens and carbons which are part of the ring are not represented at all. The rings are represented by lines, and a carbon atom is assumed to be present at each angle in the ring. The proper number of hydrogen atoms is assumed to be attached to each carbon.

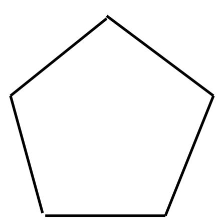
For example:



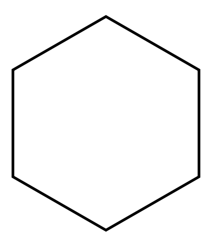
cyclopropane
C_3H_6



cyclobutane
C_4H_8

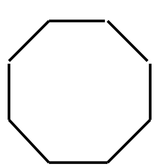


cyclopentane
C_5H_{10}



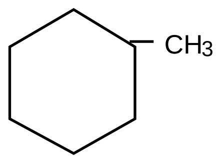
cyclohexane
C_6H_{12}

Name this compound →



{4}______________________________

Like the "straight-chained" compounds, cyclic molecules can also contain alkyl side chains. The same general rules for alkane nomenclature apply to the cyclics, except that all positions in a ring are equivalent, so a number is not needed to indicate the position of the alkyl group if there is only one alkyl group on the ring. For example:

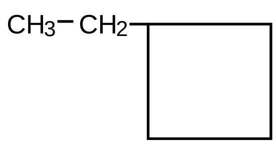


This is called methylcyclohexane

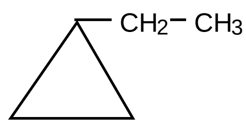
(It is NOT called 1-methylcyclohexane)

The carbon on which the alkyl group is located is automatically assumed to be number 1.

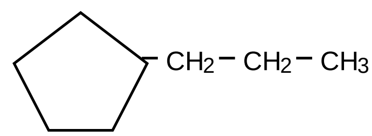
Problem 8. Name the cyclic molecules below.



a.________________________

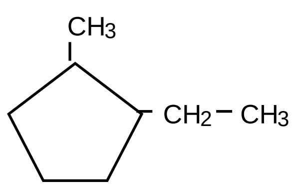


b.________________________

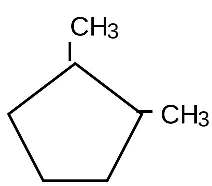


c.________________________

If there are two or more substituents on a ring, numbers must be used to indicate their positions. One of the substituents is always assigned position number 1, and starting at position 1, the chain is numbered either clockwise or counterclockwise so as to give the other substituents on the ring the smallest possible numbers. For example:

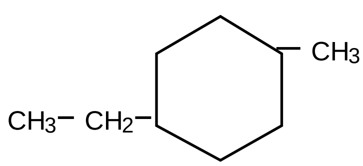


This is called 1-ethyl-2-methylcyclopentane



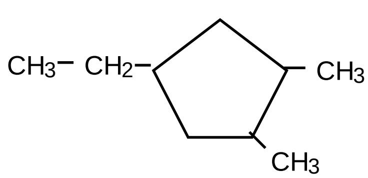
This is called 1,2-dimethylcyclopentane

(It is NOT called 1,5-dimethylcyclopentane)



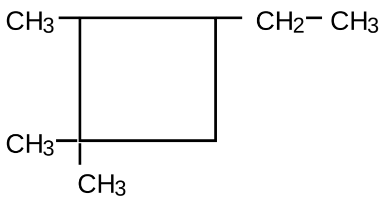
This is called 1-ethyl-4-methylcyclohexane

(You may have wanted to call it 4-ethyl-1-methylcyclohexane, but we chose to assign the number 1 position to ethyl since it comes first, alphabetically, and since we get the same numbers,1 and 4, either way.)



This is called 4-ethyl-1,2-dimethylcyclopentane

In the last example, we assign position 1 to the carbon in the lower right corner and number the ring counterclockwise. This gives the lowest possible set of numbers for the three substitutents on the ring.

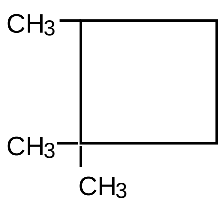


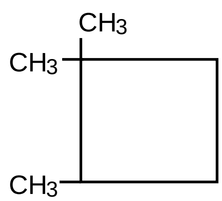
This is called 3-ethyl-1,1,2-trimethylcyclobutane

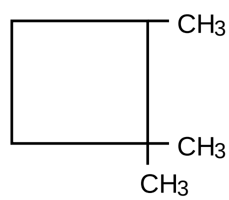
(We numbered clockwise this time)

In the molecule drawn above, if we assigned position #1 to the carbon which is bonded to the ethyl group, we would have had to number counterclockwise and name the molecule: 1-ethyl-2,3,3-trimethylbutane. This was avoided because it resulted in higher numbers.

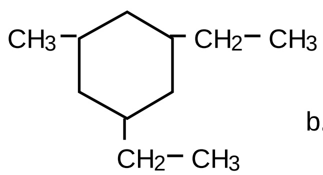
The three structures drawn below are <u>identical</u>. Write the name: {5}________________________________

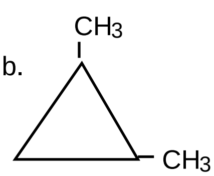


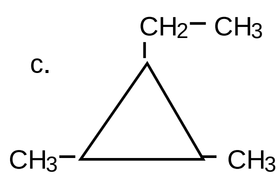


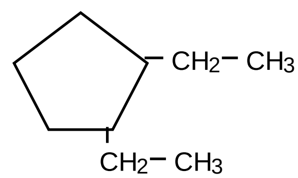


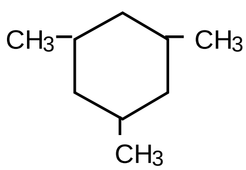
Problem 9. Name the cyclic alkanes shown below:

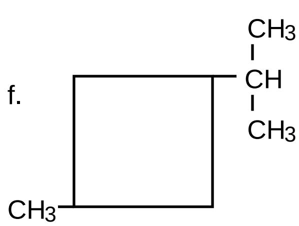
a.


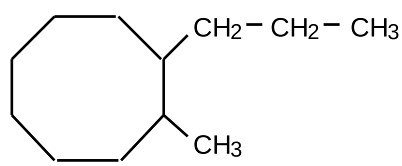
b.


c.


d.


e.


f.


g.


a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

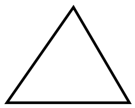
e. ________________________________

f. ________________________________

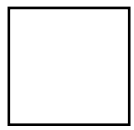
g. ________________________________

ACTIVITY 25.7 Models of Cyclic Alkanes

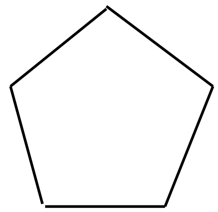
Using a molecular model kit, construct the four cyclic molecules drawn below. The models give you some idea of what these cyclic compounds look like in three dimensions. You will also see the effects of the bond angles on the shapes of the molecules. Be sure to include all needed hydrogen atoms, even if they are not shown on the drawings.



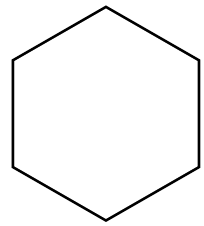
cyclopropane
C_3H_6



cyclobutane
C_4H_8



cyclopentane
C_5H_{10}



cyclohexane
C_6H_{12}

Do any of these cyclic compounds have what you might consider to be flat rings? If so, which one(s)?

{6}____

Here is a summary of the rules used to name alkanes:

RULE 1: Locate the longest continuous chain of carbon atoms. This will give you the name of the "parent" compound.

RULE 2: The name of the parent compound is modified by noting what alkyl groups are attached to the chain. Number the longest chain so that the alkyl group(s) will be on the lowest numbered carbons.

RULE 3: When the same alkyl group occurs more than once in a molecule, the numbers of the carbons to which they are attached are all included in the name. The number of the carbon is repeated as many times as the group appears. The number of repeating alkyl groups is indicated in the name by the use of Greek prefixes for 2, 3, 4, 5, etc. (di, tri, tetra, penta, etc.).

RULE 4: If there are two or more different kinds of alkyl groups attached to the parent chain, name them in alphabetical order.

RULE 5: The put the finishing touches on the name of an alkane, keep the following points in mind: (a) hyphens are used to separate numbers from names of substitutents; (b) numbers are separated from each other by commas; (c) the last alkyl group to be named is prefixed to the name of the parent alkane, forming one word; and (d) the suffix "-ane" indicates that the molecule is an alkane.

SECTION 25.8 Naming Alkenes

Now that you are an expert on alkanes, let's take a look at the *alkene* functional group. A functional group is a feature of a class of compounds that is responsible for its characteristic properties. The functional group of the alkanes is the single bond. The functional group of the alkenes is the *double bond*. Alkenes contain at least one double bond which exists between a pair of carbon atoms. The general formula for the straight-chained alkenes is C_nH_{2n}. The suffix to be used in the names of alkenes is "-ene." The rules for naming alkenes are the same as those for alkanes with a few additional restrictions.

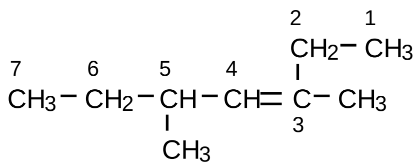
Additional Rules for the Nomenclature of Alkenes:

RULE 1: The chain chosen as the parent chain must contain the carbon–carbon double bond (C=C).

RULE 2: The parent chain must be numbered to give the carbon-carbon double bond the lowest possible number.

RULE 3: The name of the alkene must contain a number to indicate the position of the double bond.

Note the example below. The longest carbon chain alkene is numbered correctly, giving the double bond the lowest possible number.



3,5-dimethyl-3-heptene

As we number the carbons, the first carbon involved in the double bond is #3, so the parent chain is called 3-heptene. Methyl groups are located on carbons #3 and #5.

A number is not used to locate the double bond in chains which are shorter than four carbons. Two examples are below.

$CH_2=CH_2$ ← This is called ethene, not 1-ethene

$CH_3-CH=CH_2$ ← This is called propene, not 1-propene

Why is it that these two molecules do not require the use of the number? {7}________________________

____

Problem 10. Name the alkenes below. After you have located the longest chain containing the double bond, be sure to number the chain so that the double bond gets the lowest possible number.

a. $CH_3-CH_2-CH=CH_2$ ______________________________

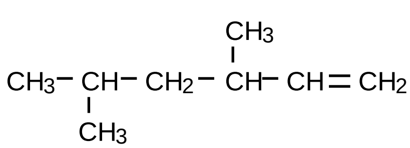
b. $CH_3-CH=CH-CH_3$ ______________________________

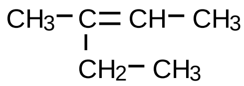
c. $CH_3-CH_2-CH=CH-CH_3$ ______________________________

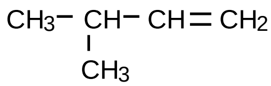
d. $CH_3-CH_2-CH=CH-CH_2-CH_3$ ______________________________

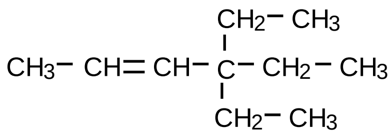
e. $CH_2=CH_2$ ______________________________

f. $CH_3-CH=CH_2$ ______________________________

g.  ______________________________

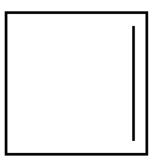
h. 

i. 

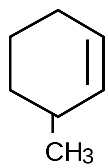
j. 

SECTION 25.9 Naming Cycloalkenes

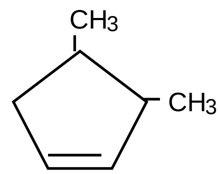
Cycloalkenes are named similarly to straight chained alkenes. The carbons in the ring that contain the double bond are always assigned the #1 and #2 positions, so numbers are used only to locate the positions of substitutents attached to the ring - not to locate the position of the double bond. The general formula for cyclic alkenes in C_nH_{2n-2}. Study the examples below.



cyclobutene

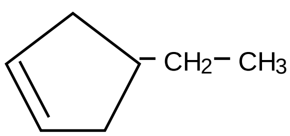


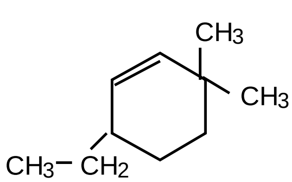
3-methylcyclohexene

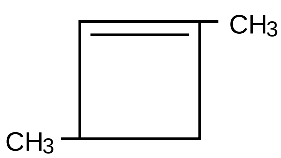


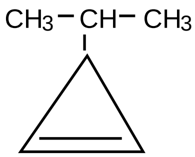
3,4-dimethylcyclopentene

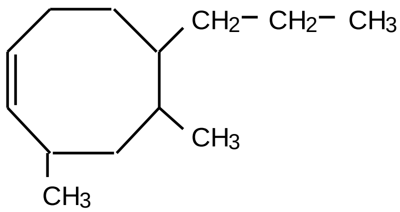
Problem 11. Name the following cycloalkenes.

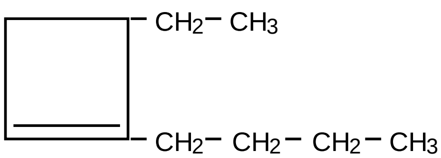
a. 

b. 

c. 

d. 

e. 

f. 

SECTION 25.10 Naming Alkynes

The functional group of the compounds known as the *alkynes* is a triple bond. The general formula for straight-chained alkynes is C_nH_{2n-2}. Alkynes are named in much the same way as the alkenes, except that their names end with the suffix "-yne", signifying the triple bond. Once again, the triple bond must be located within the parent chain, and it should be assigned the lowest possible number.

Additional Rules for the Nomenclature of Alkynes:

RULE 1: The chain chosen as the parent chain must contain the carbon- carbon triple bond.

RULE 2: The parent chain must be numbered to give the carbon-carbon triple bond the lowest possible number.

RULE 3: The name of the alkyne must contain a number to indicate the position of the triple bond.

As was the case with the alkenes, no number is used to locate the triple bond if the parent chain is shorter than four carbons:

$CH \equiv CH$	$CH \equiv C-CH_3$	$CH \equiv C-CH_2-CH_3$	$CH_3-C \equiv C-CH_3$
ethyne	propyne	1-butyne	2-butyne

For the example at right, the correct name is 5-methyl-2-hexyne ⟶

$$\overset{1}{CH_3}-\overset{2}{C}\equiv\overset{3}{C}-\overset{4}{CH_2}-\underset{\displaystyle CH_3}{\overset{5}{C}}-\overset{6}{CH_3}$$

Problem 12. Name the alkynes drawn below. Be sure to number the parent chain so as to give the triple bond the lowest possible number.

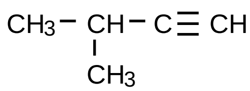
a. $CH \equiv C - CH_2 - CH_2 - CH_3$ ____________________________________

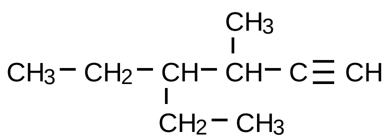
b. $CH_3 - CH_2 - CH_2 - C \equiv C - CH_3$ ____________________________________

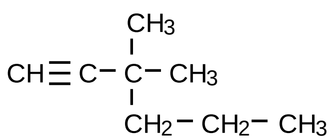
c. $CH_3 - CH_2 - C \equiv C - CH_3$ ____________________________________

d. $CH_3 - CH_2 - CH_2 - C \equiv CH$ ____________________________________

e. $CH_3 - C \equiv C - CH_2 - CH_2 - CH_2 - CH_3$ ____________________________________

f.  ____________________________________

g.  ____________________________________

h.  ____________________________________

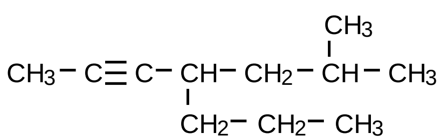
i.  ____________________________________

Table 25.1
Summary of General Formulas for Alkanes, Alkenes, and Alkynes

Class of Compound	*General Formula*
Straight-chained alkanes	C_nH_{2n+2}
Cycloalkanes	C_nH_{2n}
Alkenes	C_nH_{2n}
Cycloalkenes	C_nH_{2n-2}
Alkynes	C_nH_{2n-2}

SECTION 25.11 Review Problems

Problem 13. The names of the compounds listed below are NOT correct. Using the incorrect name, draw the structural formula in the work area. Then write the correct name of each compound on the line provided.

Incorrect Name	*Correct Name*	*Work Area*
a. 4,4-dimethylhexane	__________________________	
b. 2-n-propylpentane	__________________________	
c. 1,1-diethylbutane	__________________________	
d. 1,4-dimethylcyclobutane	__________________________	
e. 3-methyl-2-butene	__________________________	
f. 5-ethylcyclopentene	__________________________	
g. 2-n-propyl-1-propene	__________________________	
h. 2-isopropyl-3-heptene	__________________________	
i. 2,2-dimethyl-3-butyne	__________________________	
j. 5-octyne	__________________________	

Problem 14. Write condensed structural formulas for the following:

Name	*Condensed Structural Formula*
a. 4-isopropyloctane	
b. 3,4-dimethyl-4-n-propylheptane	
c. 1,1-dimethylcyclobutane	
d. 3-ethyl-3-heptene	
e. 3-ethyl-2-methyl-1-hexene	
f. 3-octene	
g. 3,3-dimethyl-1-butyne	
h. 4,4-dimethyl-2-pentyne	
i. 3-n-butyl-2-ethylcyclohexene	
j. 3,4-diethyl-4,6-dimethylnonane	

SECTION 25.12 Learning Outcomes

Before leaving this chapter, read through the learning outcomes listed below. Place a check before each outcome when you feel you have mastered it. When you have completed this task, arrange to take any quizzes or exams on this chapter, and move on to Chapter 26.

_____1. Distinguish between organic and inorganic compounds.

_____2. Distinguish between alkanes, alkenes, and alkynes.

_____3. Determine the number of carbon atoms in the longest chain of any alkane, alkene, or alkyne.

_____4. Use the IUPAC system to name alkanes, alkenes, and alkynes, given their condensed structural formulas.

_____5. Given the IUPAC names, be able to draw condensed structural formulas for alkanes, alkenes, and alkynes.

SECTION 25.13 Answers to Questions and Problems

Questions**:**

{1} They are identical; {2} They would have the same name; {3} 2,4-dimethylpentane; {4} cyclooctane; {5} 1,1,2-trimethylcyclobutane; {6} cyclopropane and cyclobutane; {7} the double bond can only be in the #1 position

Problems:

1.

a.	meth-	1	methane	CH_4
b.	eth-	2	ethane	C_2H_6
c.	prop-	3	propane	C_3H_8
d.	but-	4	butane	C_4H_{10}
e.	pent-	5	pentane	C_5H_{12}
f.	hex-	6	hexane	C_6H_{14}
g.	hept-	7	heptane	C_7H_{16}
h.	oct-	8	octane	C_8H_{18}
i.	non-	9	nonane	C_9H_{20}
j.	dec-	10	decane	$C_{10}H_{22}$

2.

a.	methane	CH_4	CH_4
b.	ethane	C_2H_6	$CH_3–CH_3$
c.	propane	C_3H_8	$CH_3–CH_2–CH_3$
d.	butane	C_4H_{10}	$CH_3–CH_2–CH_2–CH_3$
e.	pentane	C_5H_{12}	$CH_3–CH_2–CH_2–CH_2–CH_3$
f.	hexane	C_6H_{14}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_3$
g.	heptane	C_7H_{16}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$
h.	octane	C_8H_{18}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$
i.	nonane	C_9H_{20}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$
j.	decane	$C_{10}H_{22}$	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$

3.

a.	methyl	$–CH_3$
b.	ethyl	$–CH_2–CH_3$
c.	propyl	$–CH_2–CH_2–CH_3$
d.	butyl	$–CH_2–CH_2–CH_2–CH_3$
e.	pentyl	$–CH_2–CH_2–CH_2–CH_2–CH_3$
f.	hexyl	$–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$

4. a. pentane; b. propane; c. hexane; d. heptane; e. pentane; f. pentane

5. a. 2-methylpentane; b. 3-ethylhexane; c. 4-propyloctane; d. 4-isopropylnonane

6. a. 2,2-dimethylpropane; b. 2,2-dimethylpentane; c. 4,4-diethyloctane; d. 2,3,4-trimethylheptane

7. a. 4-ethyl-6-methylnonane; b. 6-propyl-3,3-dimethylnonane; c. 4-ethyl-5-isopropyl-2-methylheptane; d. 4-ethyl-2,7-dimethyloctane

8. a. ethylcyclobutane; b. ethylcyclopropane; c. propylcyclopentane (or n-propylcyclopentane)

9. a. 1,3-diethyl-5-methylcyclohexane; b. 1,2-dimethylcyclopropane;
c. 1-ethyl-2,3-dimethylcyclopropane; d. 1,2-diethylcyclopentane; e. 1,3,5-trimethylcyclohexane;
f. 1-isopropyl-3-methylcyclobutane; g. 1-methyl-2-propylcyclooctane

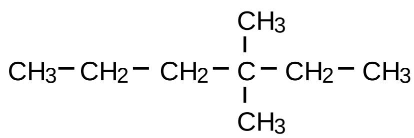
10. a. 1-butene; b. 2-butene; c. 2-pentene; d. 3-hexene; e. ethene; f. propene;
g. 3,5-dimethyl-1-hexene; h. 3-methyl-2-pentene; i. 3-methyl-1-butene; j. 4,4-diethyl-2-hexene

11. a. 4-ethylcyclopentene; b. 6-ethyl-3,3-dimethylcyclohexene; c. 1,3-dimethylcyclobutene;
d. 3-isopropylcyclopropene; e. 3,5-dimethyl-6-propylcyclooctene; f. 2-butyl-3-ethylcyclobutene

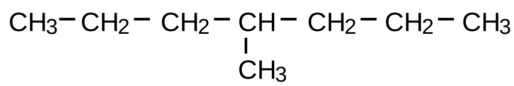
12. a. 1-pentyne; b. 2-hexyne; c. 2-pentyne; d. 1-pentyne; e. 2-heptyne; f. 3-methyl-1-butyne;
g. 4-ethyl-3-methyl1-hexyne; h. 3,3-dimethyl-1-hexyne; i. 6-methyl-4-propyl-2-heptyne

13.

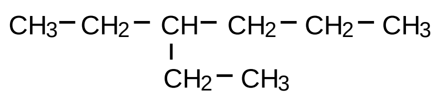
a. 3,3-dimethylhexane



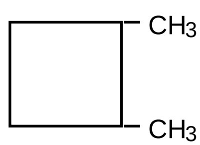
b. 4-methylheptane



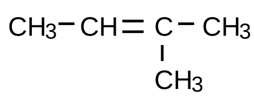
c. 3-ethylhexane



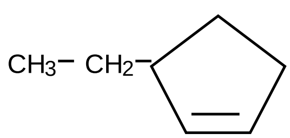
d. 1,2-dimethylcyclobutane



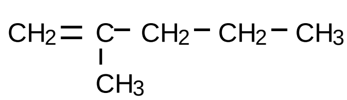
e. 2-methyl-2-butene



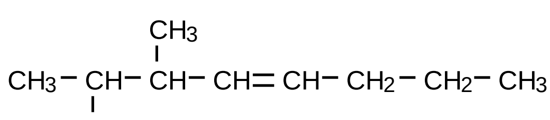
f. 3-ethylcyclopentene



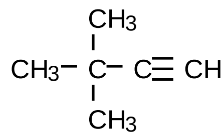
g. 2-methyl-1-pentene



h. 2,3-dimethyl-4-octene



i. 3,3-dimethyl-1-butyne

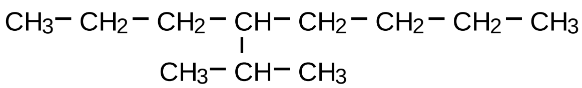


j. 3-octyne

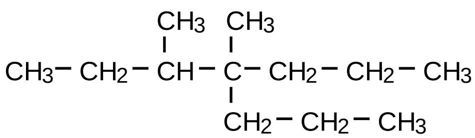
$CH_3-CH_2-CH_2-CH_2-C\equiv C-CH_2-CH_3$

14.

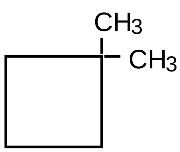
a.



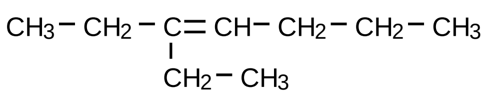
b.



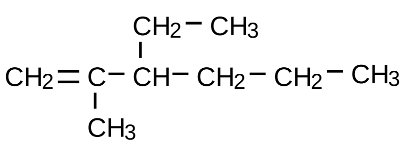
c.



d.



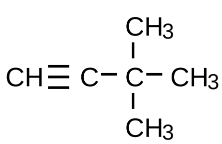
e.



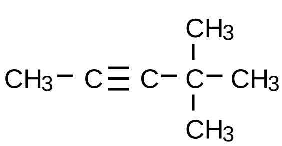
f.

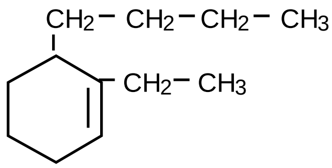
$CH_3-CH_2-CH=CH-CH_2-CH_2-CH_2-CH_3$

g.



h.



i. 

j.