Alkanes and Cycloalkanes

Alkanes—molecules consisting of carbons and hydrogens in the following ratio: C_nH_{2n+2}

Therefore, an alkane having 4 carbons would have 2(4) + 2 hydrogens, which equals 10 hydrogens. This molecule would have the general formula C_4H_{10}.

Physical Properties of Alkanes

1) Nonpolar
2) Insoluble in water
3) Relatively low BP when compared to other compounds of similar molecular mass (due to weak intermolecular forces).
4) Increased branching lowers BP (approx. 10 degrees per branch)
5) Increased chain length raises BP (approx. 30 degrees per CH_2)

Nomenclature

Names consist of a *Prefix—Parent-Suffix.* The prefix indicates what are where the substituents are located. The parent indicates how many carbons are in the longest continuous chain. The suffix is a specific ending for the class of compounds. For alkanes, the suffix is –ane.

Unbranched Alkanes

In the skeleton drawing, each point is a C and the number of H's on each C is obtained by subtracting the number of bond to each point from 4.

Number of Carbon Atoms in Chain	Formula	Skeletal Drawing	Name
1	CH_4		methane
2	C_2H_6		ethane
3	C_3H_8		propane
4	C_4H_{10}		butane
5	C_5H_{12}		pentane
6	C_6H_{14}		hexane
7	C_7H_{16}		heptane
8	C_8H_{18}		octane
9	C_9H_{20}		nonane
10	$C_{10}H_{22}$		decane

Removing one hydrogen from the above alkanes turns them into alkyl groups, which can act as substituents when bonded to other atoms. To name alkyl groups replace the -ane ending with -yl.

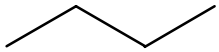
Example: Methane (CH_4) loses one hydrogen to become methyl (CH_3—).

Branched Alkanes

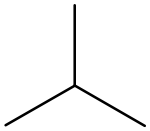
There are different ways to connect 4 carbons and 10 hydrogens. The different ways are known as constitutional isomers. Constitutional isomers have the same general formula, but have different atomic connections.

Examples of C_4H_{10}

The smallest alkane to exhibit isomerism is butane with 2 isomers:



Isomer A

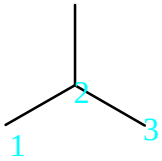


Isomer B

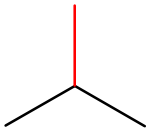
A has the four carbons in a continuous chain, and so it is called butane. B has three carbons in a chain and the fourth carbon branching off from the center carbon.

To name branched alkanes:

1) Find the longest continuous chain of carbons. This is the parent chain.
   In the case of B, the parent chain is propane.
2) Number the carbons on the parent chain beginning with the carbon that is closest to the first branch point.



3) Identify and number the substituents. (This is the prefix.)



This branch is a methyl group (CH_3), so the prefix is methyl. It is bonded to carbon #2 of the propane chain so it is numbered 2-methyl.

Write the name as one word. Include the suffix.
2-methylpropane (Note: since on a 3-C chain, a methyl group substituent must be on a C-2. Otherwise, the longest chain would be four carbons, and the chain would be a butane. Thus, in this example, the 2- is understood and may be deleted to give the name methylpropane.)

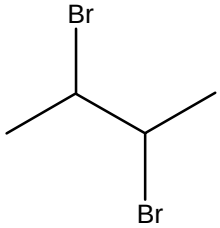
Pracitice Problems:

1) Name the following isomers of pentane:

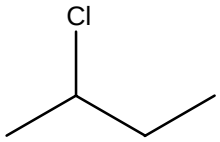
Answer

2) Name the following molecules:

a.



b.

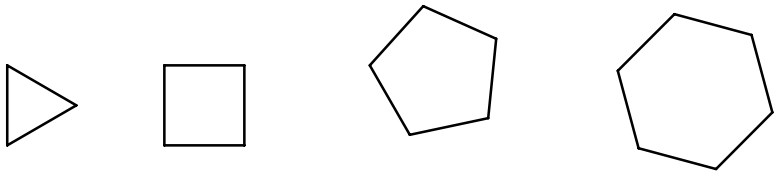


Answer

Cycloalkanes—consist of rings of —CH_2 units. Cycloalkanes have the formula: C_nH_{2n}

Nomenclature

To name a molecule as a cycloalkane, the number of carbons in the ring must be greater than the number of carbons in any substituent. The number of carbons in the ring is the parent chain. Number the subsituients so that the substituents get the lowest possible number.



cyclopropane cyclobutane cyclopentane cyclohexane

Practice problems:

3) What is the structure of isopropylcyclohexane?

Answer

4) What is the structure of 1-bromo-2-iodocyclohexane?

Answer

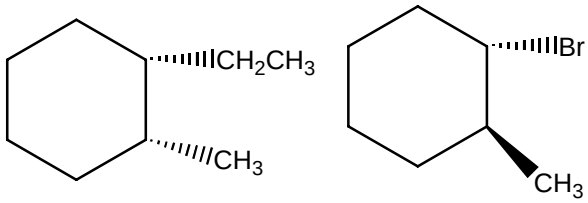
Cis-Trans Isomerism in Cycloalkanes—Alkanes are free to rotate around the carbon-carbon bonds, however, cycloalkanes are less flexible. No bond rotation can take place around the carbon-carbon bonds without breaking the ring. Because of this, cycloalkanes have two sides, a "top" and a "bottom," leading to isomerism in substituted cycloalkanes.

> If substituents are on the same side of the ring, they are *cis*. If they are on opposite faces of the ring, they are *trans*.

Cis and Trans isomers are examples of stereoisomers. Stereoisomers have the same atomic connections but are arranged differently three dimensionally.

Practice Problems

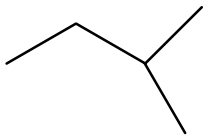
5) Name the following molecules, indicating *cis*- and *trans*- with prefixes as needed.



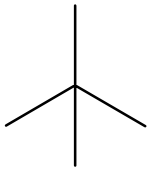
Answer

Answer:

1) Name the following isomers of pentane:



2-methylbutane



2,2-dimethylpropane

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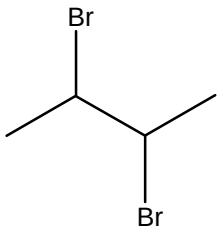
Answer

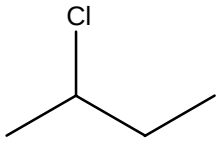
2) Name the following molecules:

a.



2,3-dibromobutane

b.



2-chlorobutane

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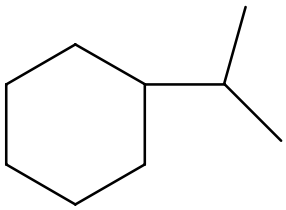
Answer

3) What is the structure of isopropylcyclohexane?



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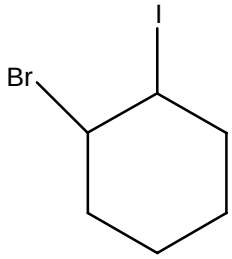
Answer

4) What is the structure of 1-bromo-2-iodocyclohexane?



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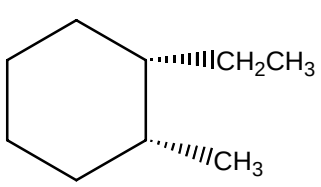
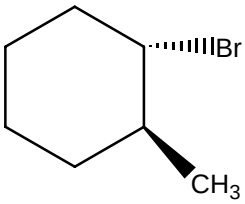
Answer

5) Name the following molecules, indicating *cis*- and *trans*- with prefixes as needed.



cis-1-ethyl-2-methylcyclohexane



trans-1-bromo-2-methylcyclohexane

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