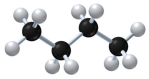
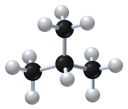
11.3 Alkanes with Substituents

When an alkane has four or more carbon atoms, the atoms can be arranged so that a side group called a branch or **substituent** is attached to a carbon chain.



$CH_3-CH_2-CH_2-CH_3$



$$CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$$

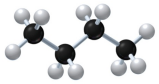
Learning Goal Write the IUPAC names for alkanes with substituents and draw their condensed structural formulas and skeletal formulas.

Structural Isomers

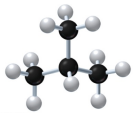
Structural isomers

- have the same molecular formula with a different arrangement of atoms
- have the same number of atoms bonded in a different order

Butane, C_4H_{10}, has two structural isomers: a **straight chain** and a **branched chain**.



$CH_3-CH_2-CH_2-CH_3$



$$CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$$

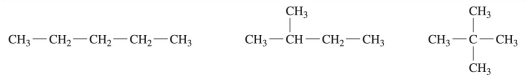
Study Check

Draw three possible structural isomers of pentane, C_5H_{12}.

Solution

Draw three possible structural isomers of pentane, C_5H_{12}.

Structural Isomers of C_5H_{12}



Alkane Substituents

Substituents are atoms or groups of atoms attached to the carbon chain and include alkyl and halo groups.

Alkyl groups are

- groups of carbon atoms attached to carbon chains
- named in the IUPAC system with an ***yl*** ending

Halo substituents are

- halogen atoms attached to the carbon chain
- named in the IUPAC system as **fluoro**, **chloro**, **bromo**, **or iodo**.

Substituents and Alkyl Groups

TABLE 11.5 Names and Formulas for Some Common Substituents

Substituent	Name
CH_3-	Methyl
CH_3-CH_2-	Ethyl
$CH_3-CH_2-CH_2-$	Propyl
$CH_3-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-$	Isopropyl
F—, Cl—, Br—, I—	Fluoro, chloro, bromo, iodo

Guide to Naming Alkanes with Substituents

Guide to Naming Alkanes

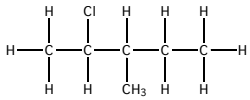
STEP 1
Write the alkane name for the longest chain of carbon atoms.

STEP 2
Number the carbon atoms starting from the end nearer a substituent.

STEP 3
Give the location and name for each substituent (alphabetical order) as a prefix to the name of the main chain.

Study Check

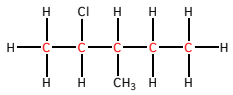
Give the IUPAC name for the following compound:



Solution

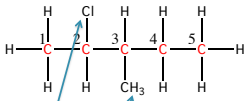
ANALYZE THE PROBLEM	Type of Compound	Substituents	IUPAC Naming
	alkane	one methyl group one halo group	number chain for substituents

STEP 1 Write the alkane name of the longest chain of carbon atoms.
The longest chain has five carbons—pentane.



Solution

STEP 2 **Number the carbon atoms starting from the end nearest to a substituent.**



pentane

STEP 3 **Give the location and name of each substituent (in alphabetical order) as a prefix to the name of the main chain.**

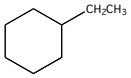
2-chloro-3-methylpentane

Naming Cycloalkanes with Substituents

When one substituent is attached to a carbon atom in a cycloalkane,

- the name of the substituent is placed in front of the cycloalkane name
- no number is needed for a single alkyl group or halogen atom

The IUPAC name for the following cycloalkane is ethylcyclohexane.



Naming Haloalkanes

Haloalkanes

- are alkanes with a halogen atom that replaces a hydrogen atom
- are named by putting the substituents in alphabetical order
- have the halo group numbered according to the carbon where it is attached to the alkane

	$CH_3—Cl$	$CH_3—CH_2—Br$	$CH_3—CH_2—CH_2—F$
IUPAC	Chloromethane	Bromoethane	1-Fluoropropane
Common	Methyl chloride	Ethyl bromide	Propyl fluoride

Drawing Formulas for Alkanes

The IUPAC name gives all the information needed to draw the condensed structural formula for an alkane.

di means "two"

Draw the structure for 1-chloro-1,2-dimethylheptane

heptane: seven-carbon chain

methyl group on carbons 1 and 2

chlorine on carbon 1

Guide to Drawing Formulas for Alkanes

Guide to Drawing Alkane Formulas

STEP 1
Draw the main chain of carbon atoms.

STEP 2
Number the chain and place the substituents on the carbons indicated by the numbers.

STEP 3
Add the correct number of hydrogen atoms to give four bonds to each C atom.

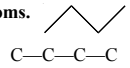
Study Check

Draw the condensed structural formula for 3-bromo-1-chlorobutane.

Solution

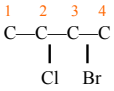
Draw the condensed structural formula for 3-bromo-1-chlorobutane.

STEP 1 **Draw the main chain of carbon atoms.**
The longest chain in butane has four carbon atoms.



STEP 2 **Number the chain and place the substituents on the carbons indicated by the numbers.**
3-bromo: — Br goes on carbon 3

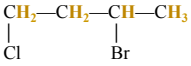
1-chloro: — Cl goes on carbon 1

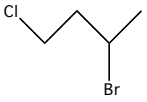


Solution

Draw the condensed structural formula for 3-bromo-1-chlorobutane.

STEP 3 **Add the correct number of hydrogen atoms to give four bonds to each C atom.**





3-bromo-1-chlorobutane

Study Check

Name each of the following alkanes:

A.

B.

Solution

Name each of the following alkanes:

STEP 1 **Write the alkane name of the longest chain of carbon atoms.**

A. 

The longest chain in pentane has five carbon atoms.

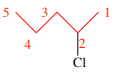
B. 

The longest chain in pentane has five carbon atoms.

Solution

Name each of the following alkanes:

STEP 2 **Number the carbon atoms starting from the end nearer a substituent.**

A. 

2-chloro: — Cl goes on carbon 2.

B. 

2,3-dimethyl: — CH_3 goes on carbons 2 and 3.

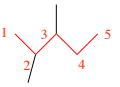
Solution

Name each of the following alkanes:

STEP 3 **Give the location and name of each substituent (alphabetical order) as a prefix to the name of the main chain.**

A. 

2-chloropentane

B. 

2,3-dimethylpentane