SI Chemistry - Full Discipline Demo

Drawing Organic Compounds

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each type of formula with the best description of what they are used to illustrate.

- Ball and stick
- Dash-wedge
- Lewis structure
- Line-angle
- Molecular

Description	
Illustrates all of the bonds in a molecule	1
Illustrates the differences between *cis/trans*-isomers of cyclic compounds	2
Show the bonds between atoms without writing the symbol for C and H	3
Molecular model demonstrating the 3D position of atoms and the bonds between them	4
Includes each element and the number of atoms of each element without showing the bonds between atoms	5

Correct answers:

1 Lewis structure 2 Dash-wedge 3 Line-angle 4 Ball and stick

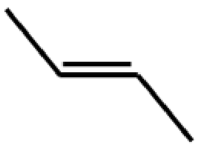
5 Molecular

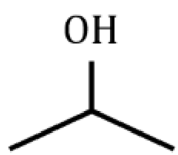
Categorize the following pairs of formulas as representing potentially the same or different compounds

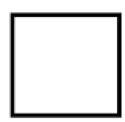
 and 

$CH_3CH_2CH_2CH_2CH_3$ and 

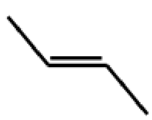
C_4H_{10} and 

C_4H_8 and 

C_3H_8O and 

 and 

C_3H_8O and 

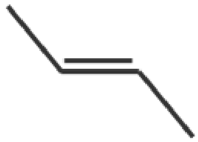
 and 

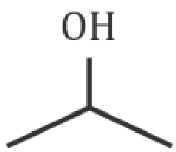
Same Compounds	Different Compounds
1	2

Correct answers:

1

C_4H_{10} and 

C_4H_8 and 

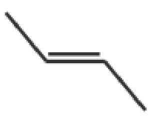
C_3H_8O and 

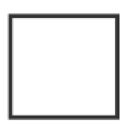
 and 

C_3H_8O and 

2

$CH_3CH_2CH_2CH_2CH_3$ and 

 and 

 and 

Exploration

_____ show all bonds and any non-bonded valence electrons as lone pairs.

- Lewis structures ✔
- Line-angle formula
- Condensed molecular formulas
- Molecular formulas

Condensed structural formulas are the most efficient method of drawing organic compounds because they do not explicitly show the symbols for carbon and hydrogen.

- True
- False ✔

_____ structures include atoms represented by spheres and bonds represented by rods.

- Lewis
- Dash-wedge
- Line-angle
- Ball and stick ✔

_____ occur when compounds with the same formula have atoms arranged in different orders.

- Structural isomers ✔
- Stereoisomers
- Lewis isomers
- Condensed structures

Carbon atoms in cyclic compounds cannot rotate around the bonds within the ring without breaking bonds.

- True ✔
- False

When drawing structures from compound names, _____ are given priority in numbering carbons over _____.

- substituents; double and triple bonds
- single bonds; substituents
- single bonds; double and triple bonds
- double and triple bonds; substituents ✔

Cyclohexane is an isomer of 1-hexene and 2-hexene.

- True ✔
- False

Cyclic alkanes have the same general formula as _____.

- hexenes ✔
- hexanes
- hexynes

Exercise 1

When drawing a condensed structural formula, how do you determine how many hydrogen atoms to include with each carbon atom?

Each carbon atom must make a total of four bonds, either 4 single bonds, 2 single bonds and one double bond, 2 double bonds or 1 single and a triple bond. If there are fewer than 4 bonds, then hydrogen atoms would be included to match the missing number of bonds.

Describe how you would figure out the number of lines to draw in a line-angle drawing for:

a. 1-propanol

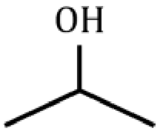
b. 2-methylpentane

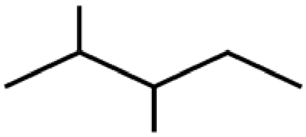
a) prop- means three carbon atoms, which require 2 lines between them. The “ol” ending indicates an alcohol functional group, so there would be a line between one of the carbon atoms and an oxygen atom, for a total of 3 lines.
b) pent- means 5 carbon atoms that require 4 lines between them. The “methyl” indicates a branch containing one carbon atom that would be connected to the main chain by an additional line for 5 lines total.

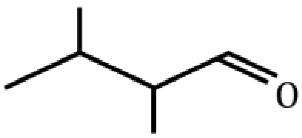
Explain why chemists might use a line-angle formula instead of a condensed structural formula.

Line-angle structures are faster to draw and give a better idea of the overall shape of the structure than a condensed structural formula.

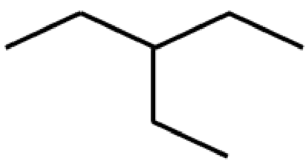
Record the IUPAC names for each of the structures shown below in Data Table 1.

a) 

b) 

c) 

d) 

e) 

a. 2-propanol
b. 2,3-dimethylpentane
c. 2,3-dimethylbutanal
d. 1-propanol
e. 3-ethylpentane

Photo 1: 1-propanamine – Condensed Structural Formula
(SAMPLE ANSWER BELOW)

$$CH_3CH_2CH_2NH_2$$

Photo 2: 1-propanamine – Line-angle Formula
(SAMPLE ANSWER BELOW)

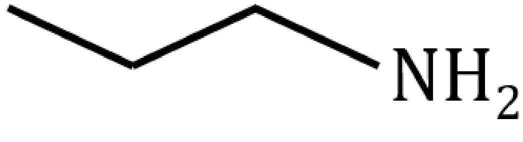
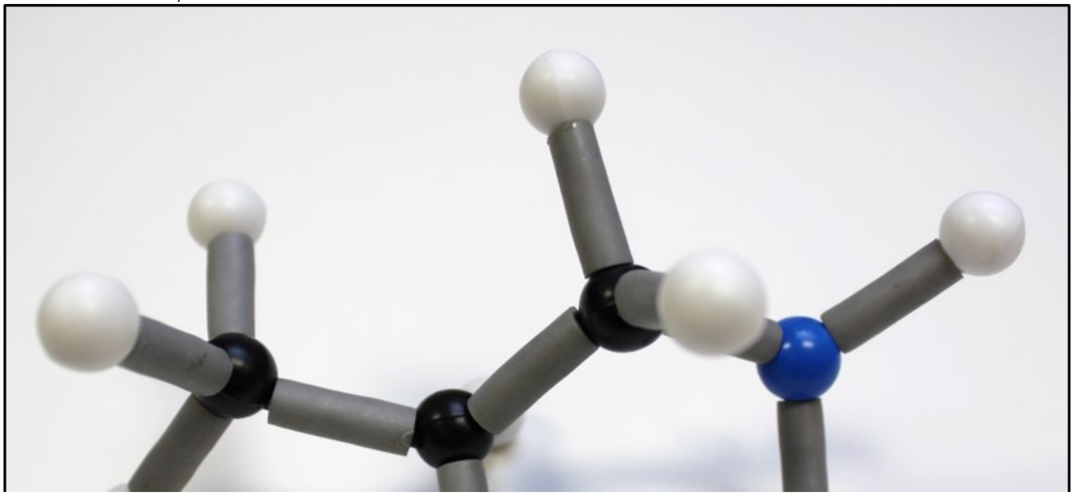


Photo 3: Optional: 1-propanamine – Molecular Model

(SAMPLE ANSWER BELOW)



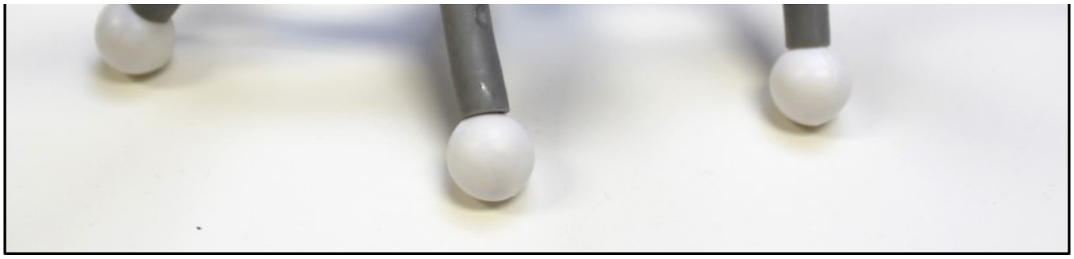


Photo 4: 2,3-dimethylheptane – Condensed Structural Formula
(SAMPLE ANSWER BELOW)

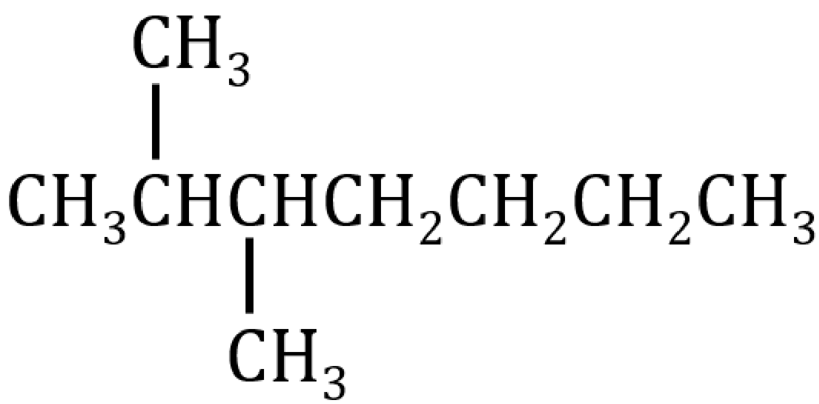


Photo 5: 2,3-dimethylheptane – Line-angle Formula
(SAMPLE ANSWER BELOW)

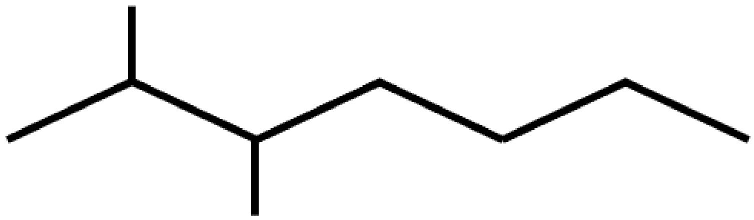


Photo 6: Optional: 2,3-dimethylheptane – Molecular Model

(SAMPLE ANSWER BELOW)

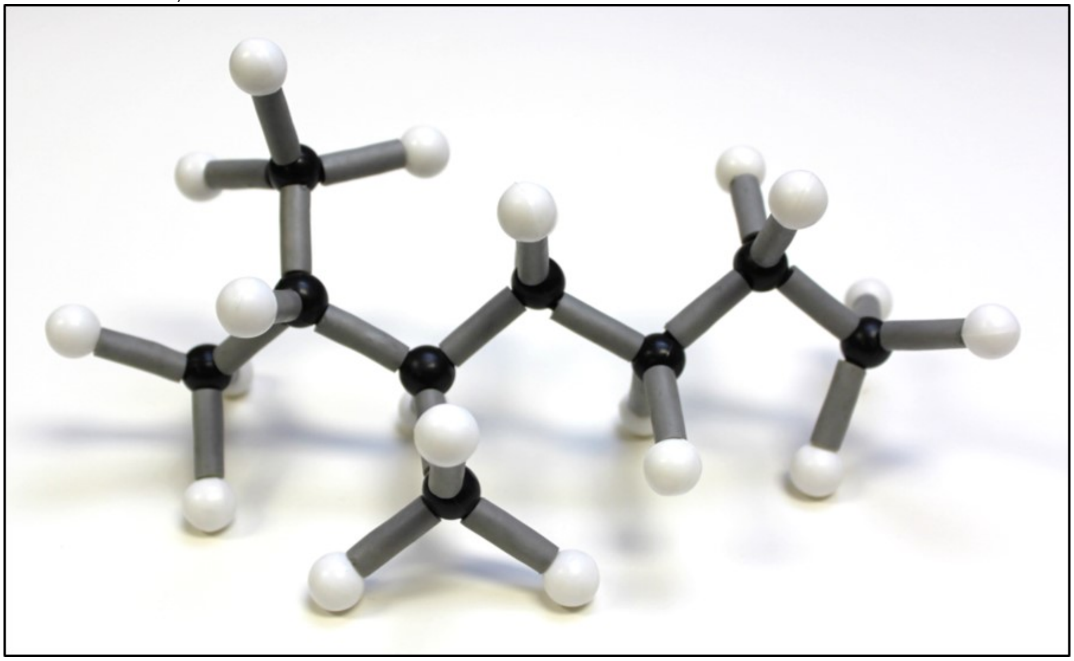


Photo 7: 3-bromo-2-pentanol – Condensed Structural Formula
(SAMPLE ANSWER BELOW)

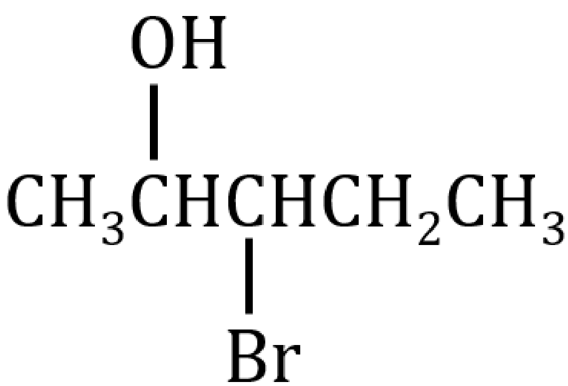


Photo 8: 3-bromo-2-pentanol – Line-angle Formula
(SAMPLE ANSWER BELOW)

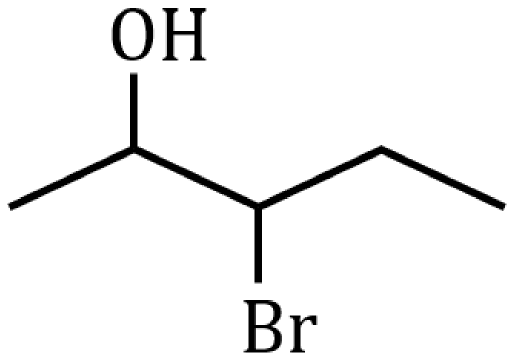


Photo 9: Optional: 3-bromo-2-pentanol – Molecular Model

(SAMPLE ANSWER BELOW)

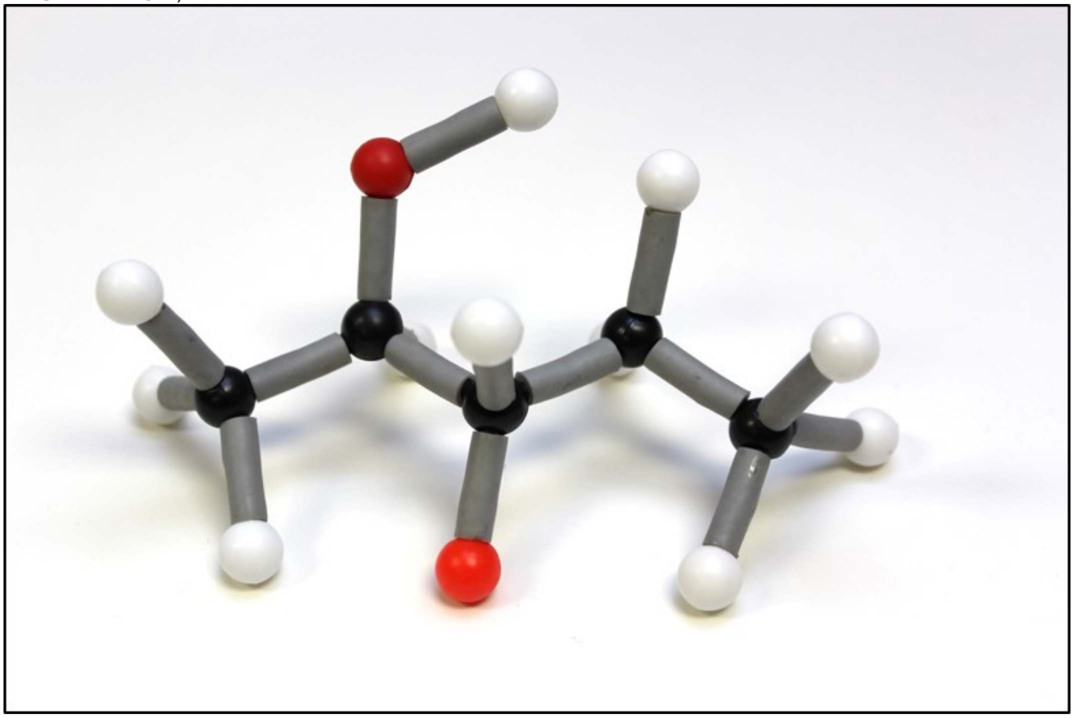


Photo 10: 3-isopropyl-2-hexene – Condensed Structural Formula
(SAMPLE ANSWER BELOW)

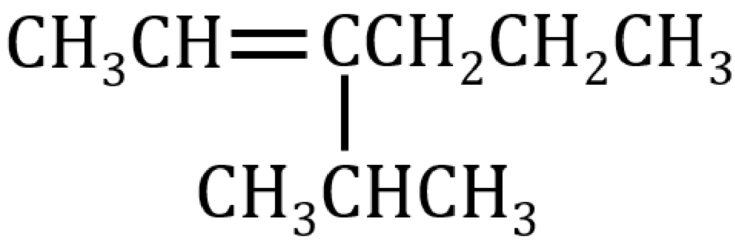


Photo 11: 3-isopropyl-2-hexene – Line-angle Formula
(SAMPLE ANSWER BELOW)

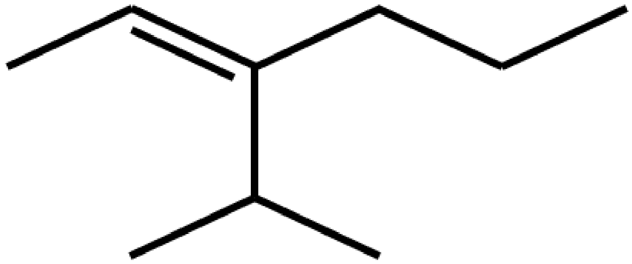


Photo 12: Optional: 3-isopropyl-2-hexene – Molecular Model

(SAMPLE ANSWER BELOW)

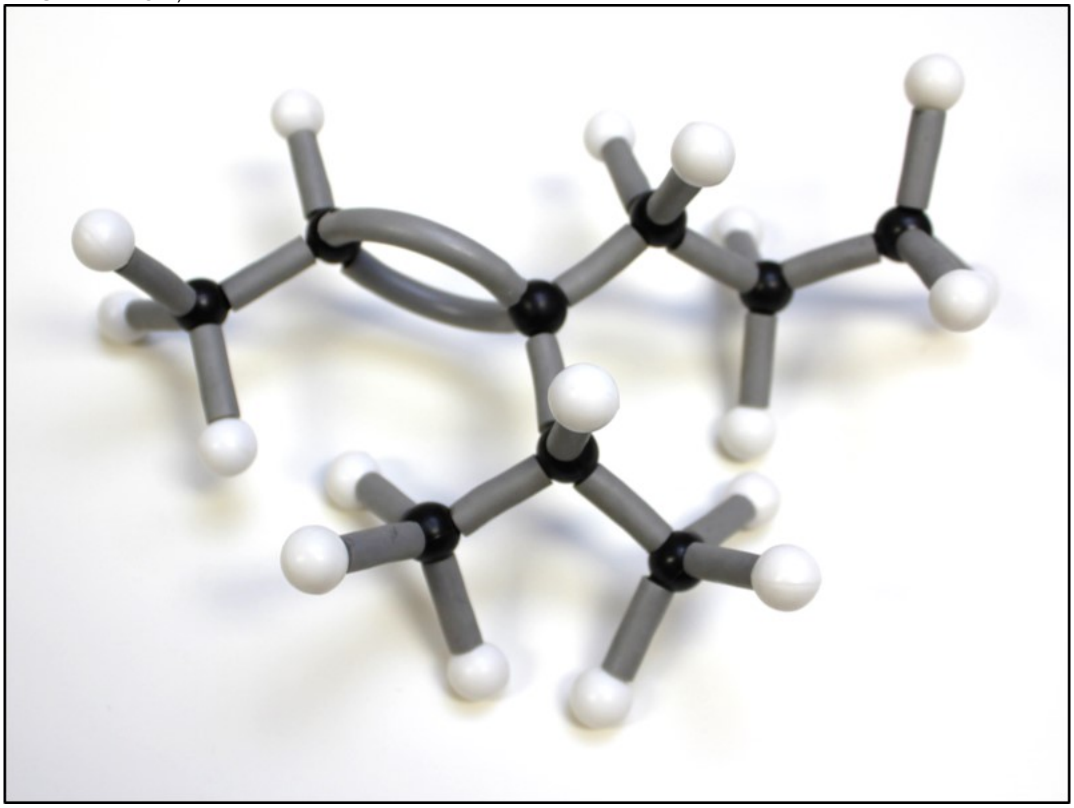


Photo 13: 4-chlorobutanoic acid – Condensed Structural Formula
(SAMPLE ANSWER BELOW)

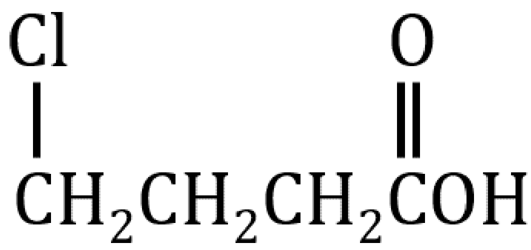


Photo 14: 4-chlorobutanoic acid – Line-angle Formula
(SAMPLE ANSWER BELOW)

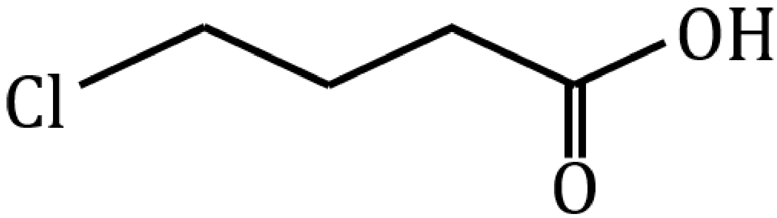
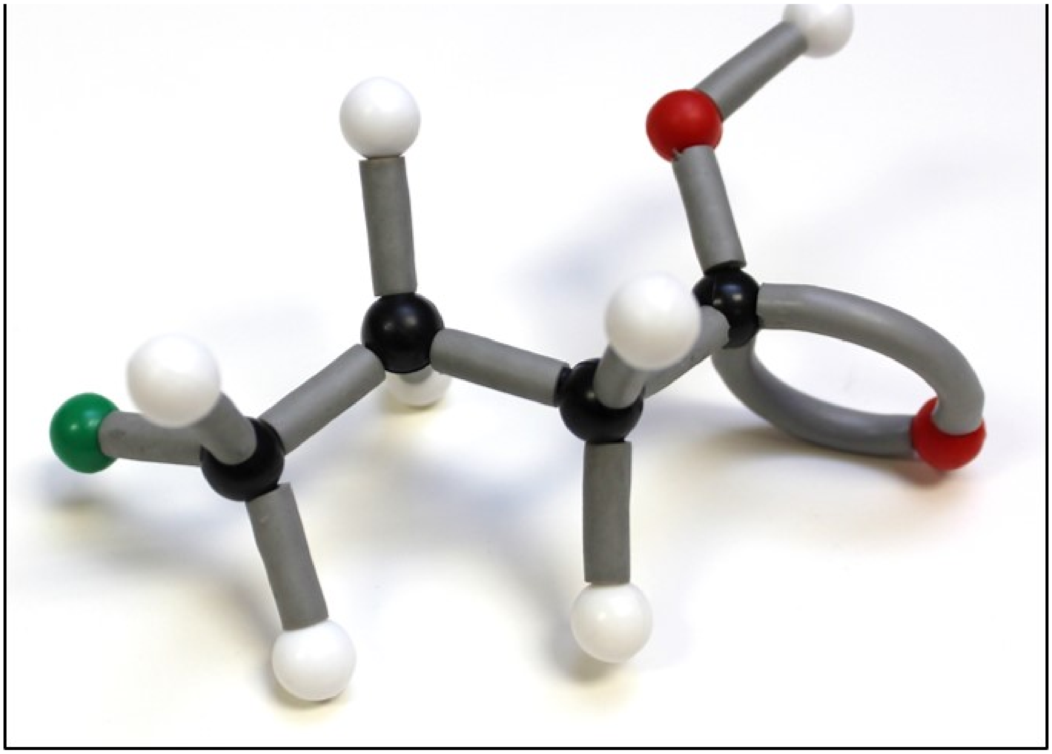


Photo 15: Optional: 4-chlorobutanoic acid – Molecular Model
(SAMPLE ANSWER BELOW)



Exercise 2

Explain why the following names of the structures are incorrect.

a. 2-ethyl-2-pentene

b. 2-methyl-4-pentene

a. The longest continuous chain contains 6 carbon atoms, not 5. This is correctly named 3-methyl-3-hexene.
b. Functional groups get priority over lower numbers. This is correctly named 4-methyl-1-pentene.

Considering compounds that have the same number of carbon atoms, explain why alkanes and cycloalkanes have different molecular formulas but alkenes and cycloalkanes have the same molecular formulas.

Alkanes have 2 bonds to hydrogen atoms for every carbon in the chain, except for the end carbon atoms, which have 3 bonds to hydrogen atoms. Cycloalkanes have no end carbon atoms as they are bonded in a ring, and have 2 fewer total bonds to hydrogen than alkanes with the same number of carbon atoms. Alkenes contain a double bond between 2 carbon atoms, which means that they have 2 fewer total bonds to hydrogen than alkanes with the same number of carbon atoms. Alkanes have a general molecular formula of C_nH_{2n+2}, while alkenes and cycloalkanes have the same general molecular formula, C_nH_{2n}.

Photo 16: C5H10 Alkene #1 – Condensed Structural Formula
(SAMPLE ANSWER BELOW)

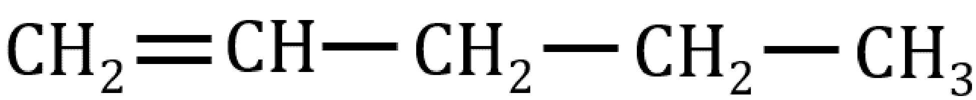


Photo 17: Optional: C_5H_{10} Alkene #1 – Molecular Model

(SAMPLE ANSWER BELOW)

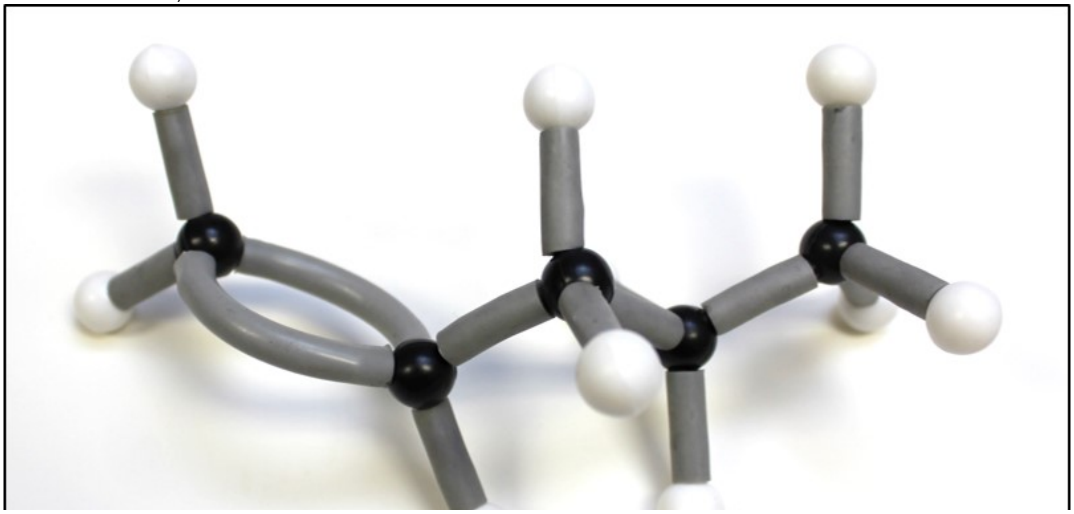


Photo 18: C5H10 Alkene #2 – Condensed Structural Formula
(SAMPLE ANSWER BELOW)

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

Photo 19: Optional: C5H10 Alkene #2 – Molecular Model
(SAMPLE ANSWER BELOW)

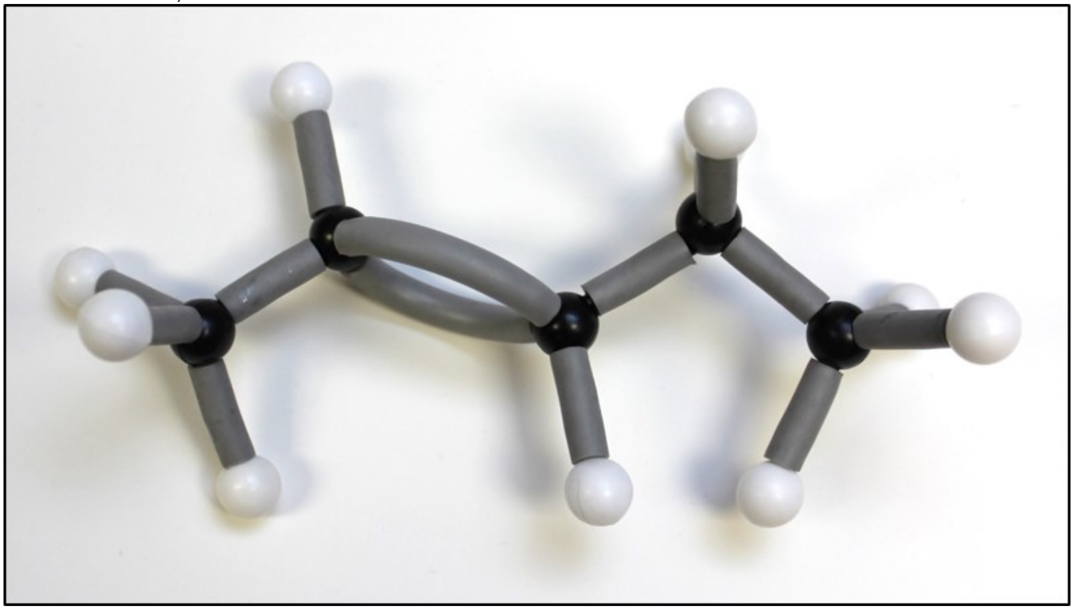
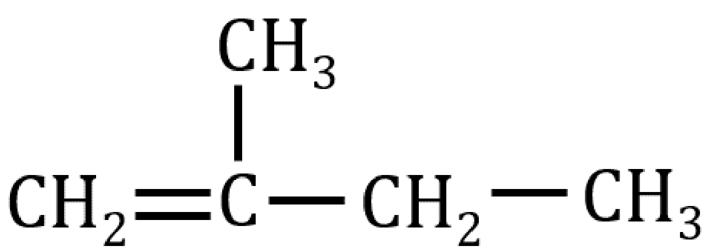


Photo 20: C5H10 Alkene #3 – Condensed Structural Formula
(SAMPLE ANSWER BELOW)



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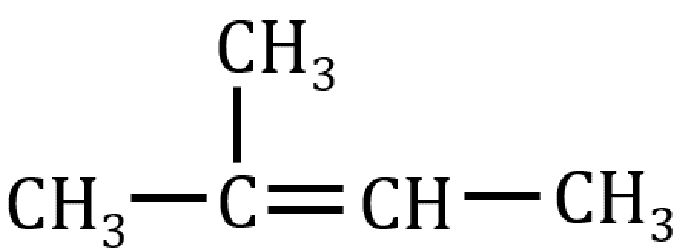
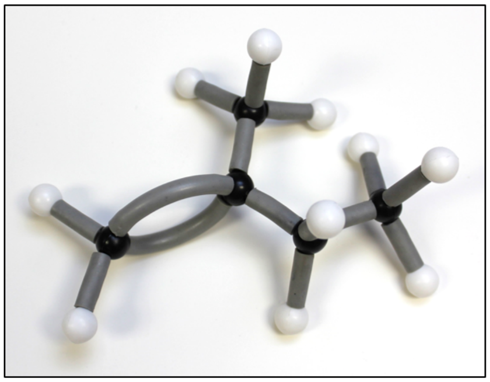


Photo 21: Optional: C5H10 Alkene #3 – Molecular Model

(SAMPLE ANSWER BELOW)



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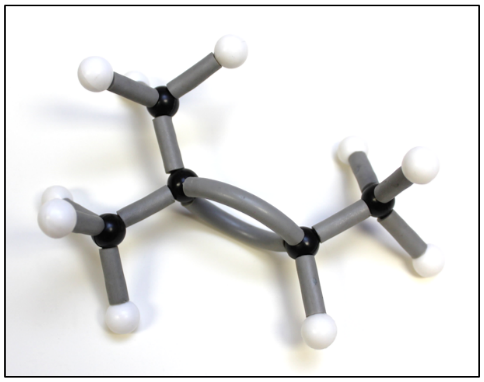


Photo 22: C_5H_{10} Cyclic Isomer #1 – Line-Angle Formula
(SAMPLE ANSWER BELOW)

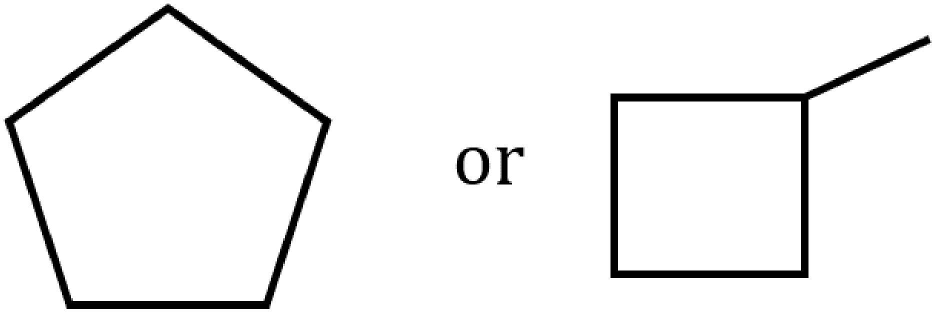
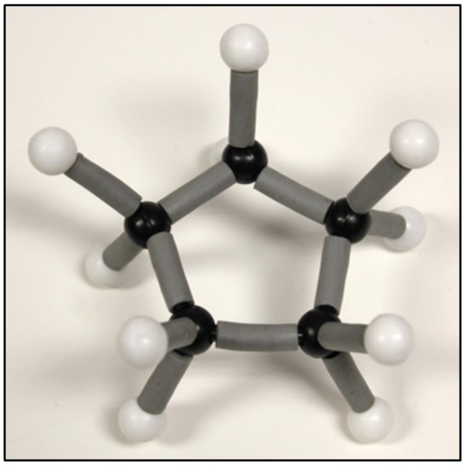


Photo 23: Optional: C_5H_{10} Cyclic Isomer #1 – Molecular Model
(SAMPLE ANSWER BELOW)



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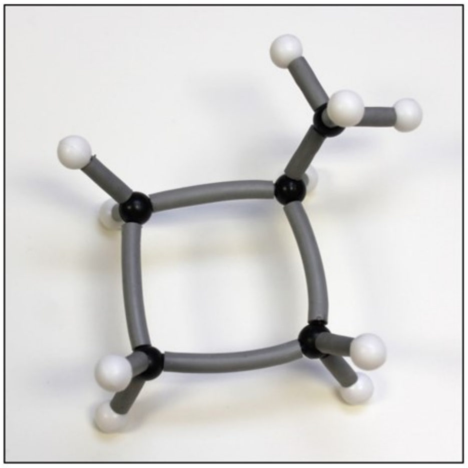
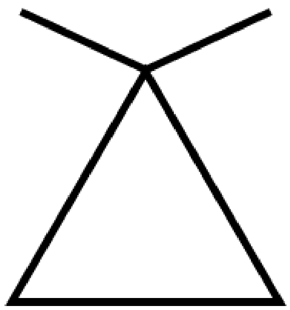


Photo 24: C5H10 Cyclic Isomer #2 – Line-Angle Formula

(SAMPLE ANSWER BELOW)



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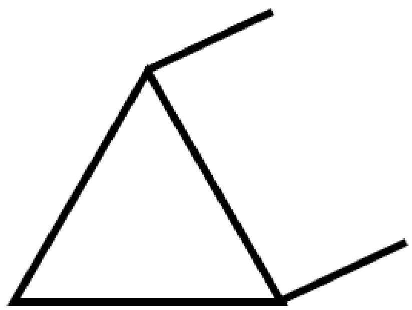
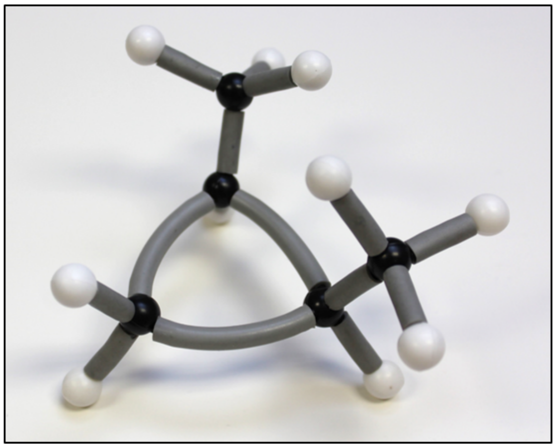


Photo 25: Optional: C_5H_{10} Cyclic Isomer #2 – Molecular Model

(SAMPLE ANSWER BELOW)

or



Data Table 1: Structural Isomers of C5H10
(SAMPLE ANSWER BELOW)

C_5H_{10} Isomers	Name
Alkene #1	1-pentene
Alkene #2	2-pentene
Alkene #3	2-methyl-1-butene or 2-methyl-2-butene
Cycloalkane #1	Cyclopentane or Methylcyclobutane
Cycloalkane #2	1,1-dimethylcyclopropane or 1,2-dimethylcyclopropane

Exercise 3

Describe how geometric isomers are different from structural isomers.

Structural isomers differ in how the atoms are bonded to each other, such as a straight chain vs. a branched compound with the same number of carbon atoms. Geometric isomers have all the same connections, but differ in the arrangement in 3D space.

Why is it possible for alkenes and cylcoalkanes to have *cis-trans* isomers but not alkanes?

Alkanes, with all single bonds and no cyclic structures, have free rotation around all bonds and have many possible different 3D shapes or conformers. The double bond in an alkene and the cyclic structure in cycloalkanes cannot be rotated around without breaking these connections. Thus, it is possible for alkenes and cycloalkanes to exist as cis-trans isomers.

How are *cis-trans* isomers shown in diagrams?

Cis-trans isomers of alkenes can be drawn as line-angle structures. *Cis-trans* isomers of cycloalkanes can be drawn using dash-wedge drawings.

Photo 26: cis-2,3-dichloro-2-pentene – Line-angle Formula
(SAMPLE ANSWER BELOW)

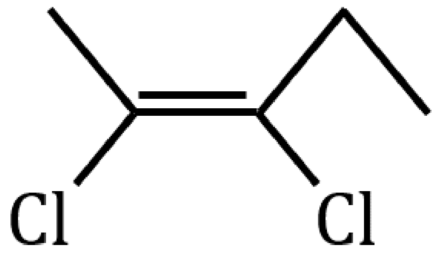


Photo 27: Optional: cis-2,3-dichloro-2-pentene – Molecular Model
(SAMPLE ANSWER BELOW)

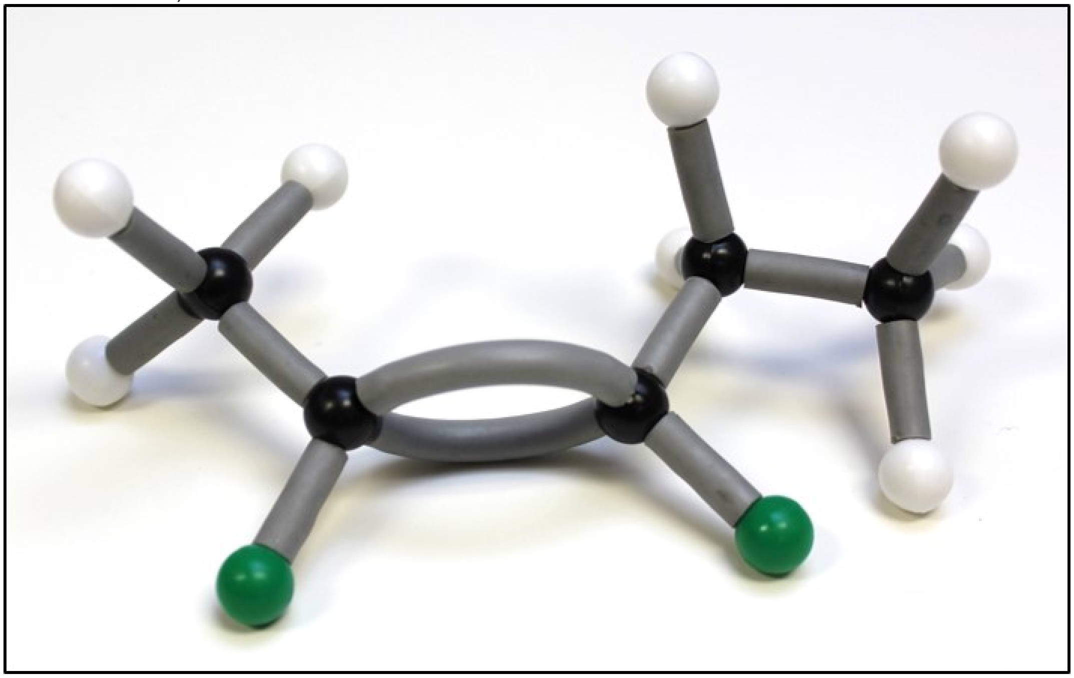


Photo 28: trans-2,3-dichloro-2-pentene – Line-angle Formula
(SAMPLE ANSWER BELOW)

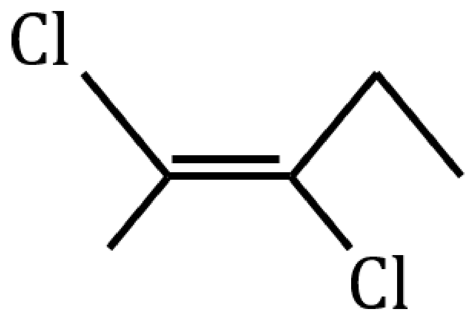


Photo 29: Optional: trans-2,3-dichloro-2-pentene – Molecular Model
(SAMPLE ANSWER BELOW)

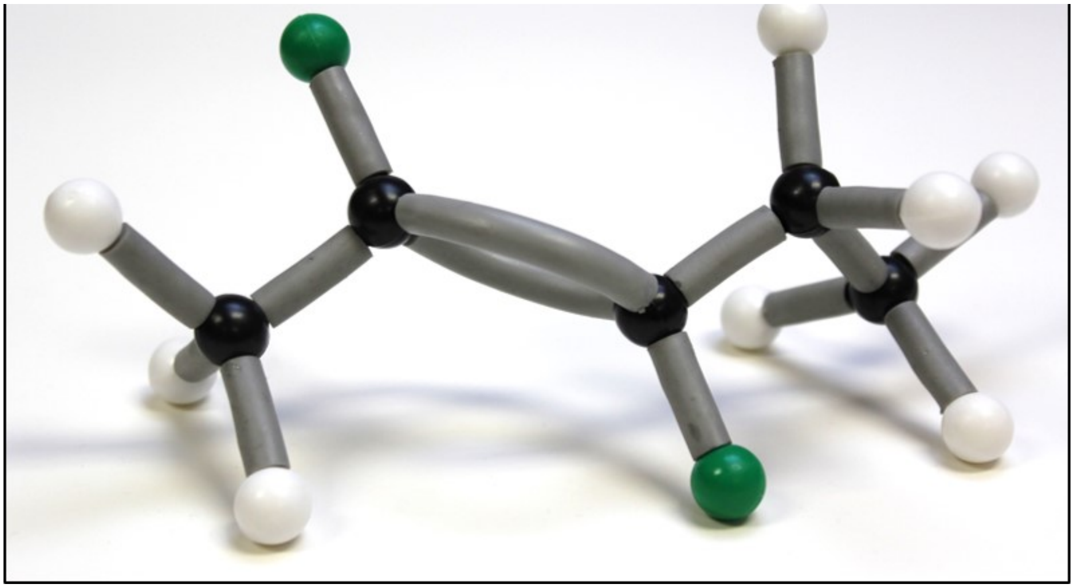


Photo 30: cis-1,3-dimethylcyclohexane – Dash-wedge Formula
(SAMPLE ANSWER BELOW)

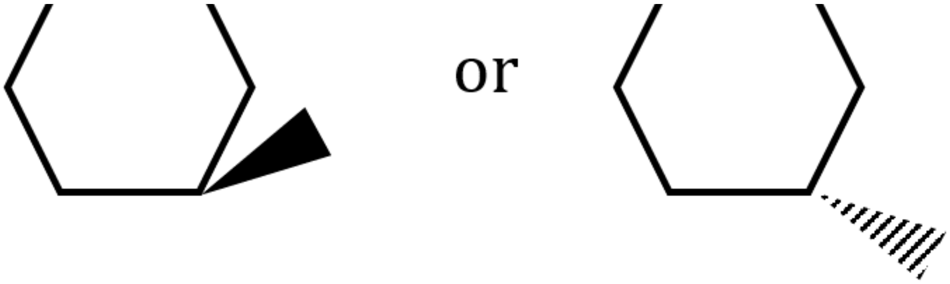
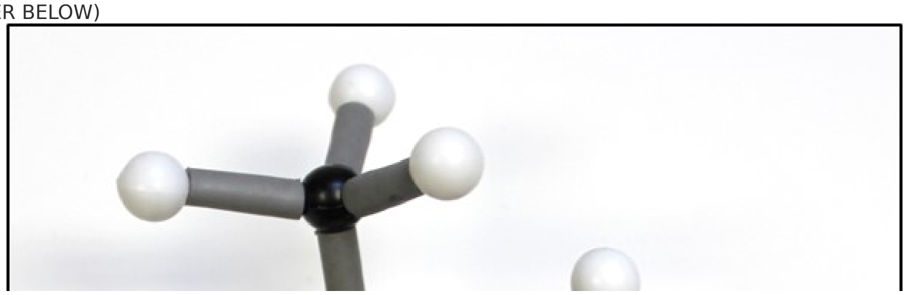


Photo 31: Optional: cis-1,3-dimethylcyclohexane – Molecular Model
(SAMPLE ANSWER BELOW)



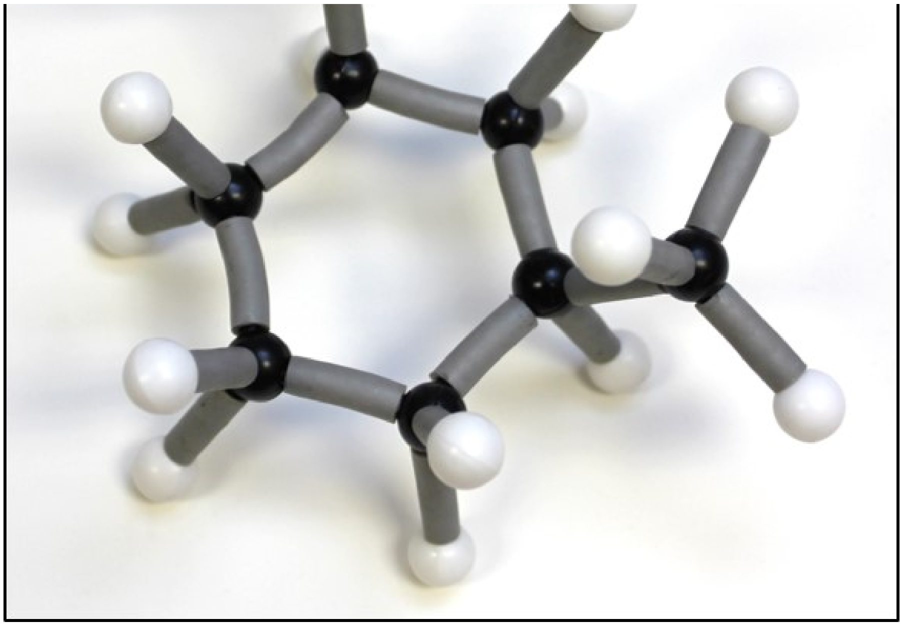


Photo 32: trans-1,3-dimethylcyclohexane – Dash-wedge Formula
(SAMPLE ANSWER BELOW)

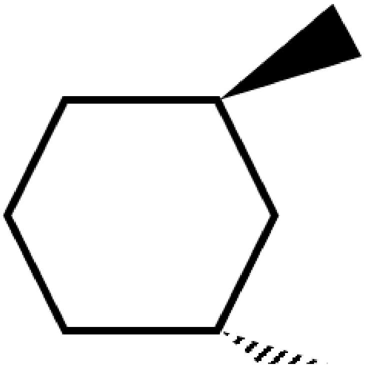
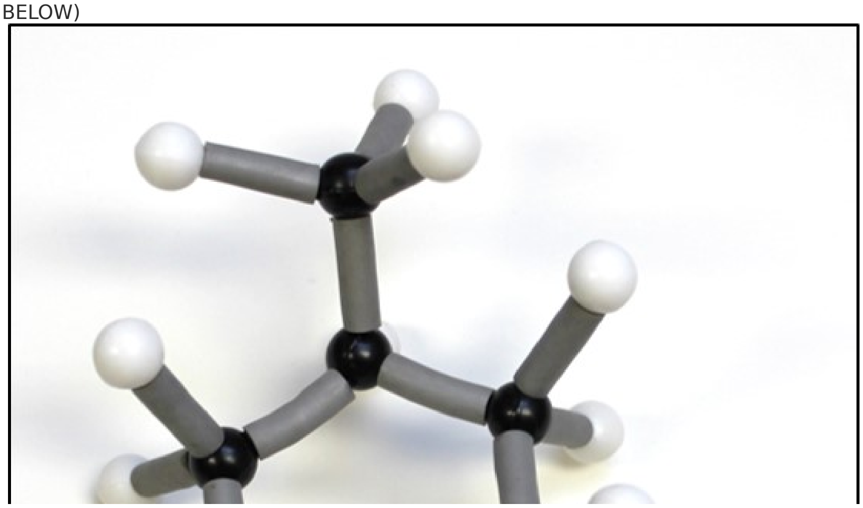
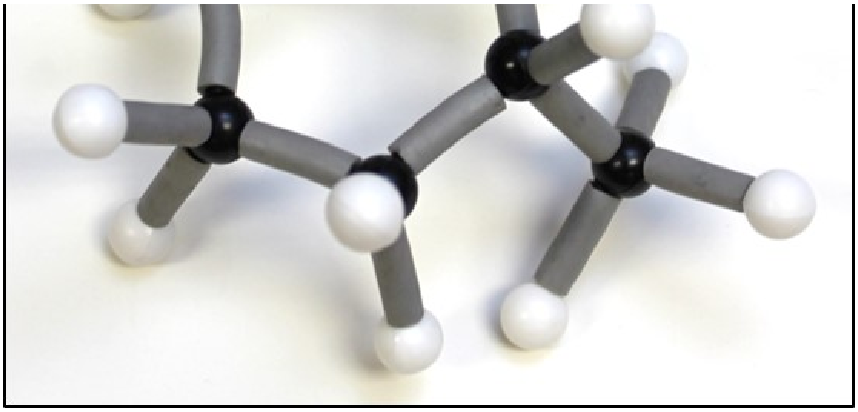


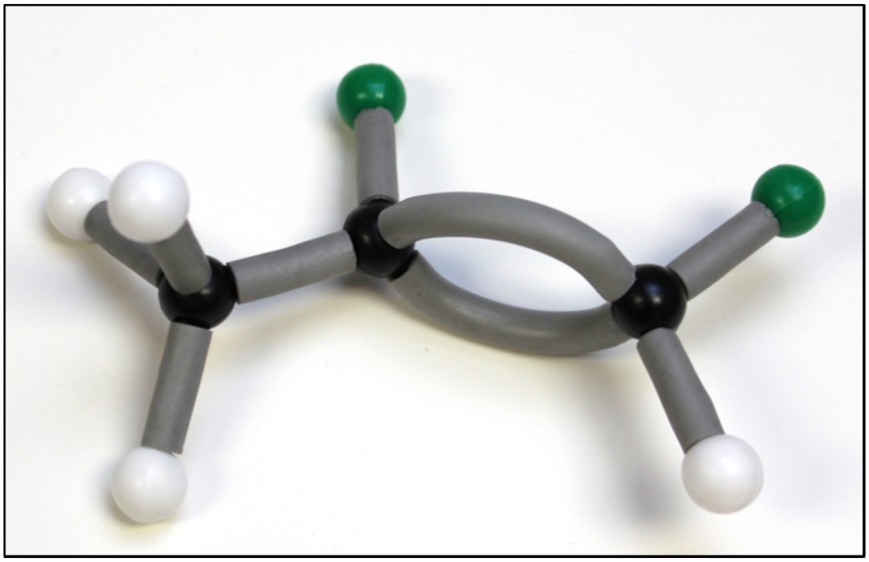
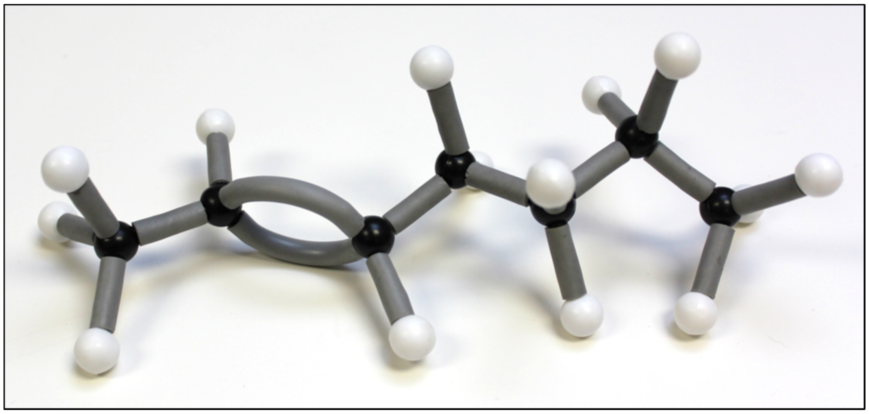
Photo 33: Optional: trans-1,3-dimethylcyclohexane – Molecular Model
(SAMPLE ANSWER BELOW)





Data Table 2: IUPAC Name of Geometric Isomers
(SAMPLE ANSWER BELOW)

Model	Model Image	IUPAC Name
A		cis-1,2-dichloro-1-propene

		
B		2-heptene
C		trans-1,3-dichlorocyclopentane

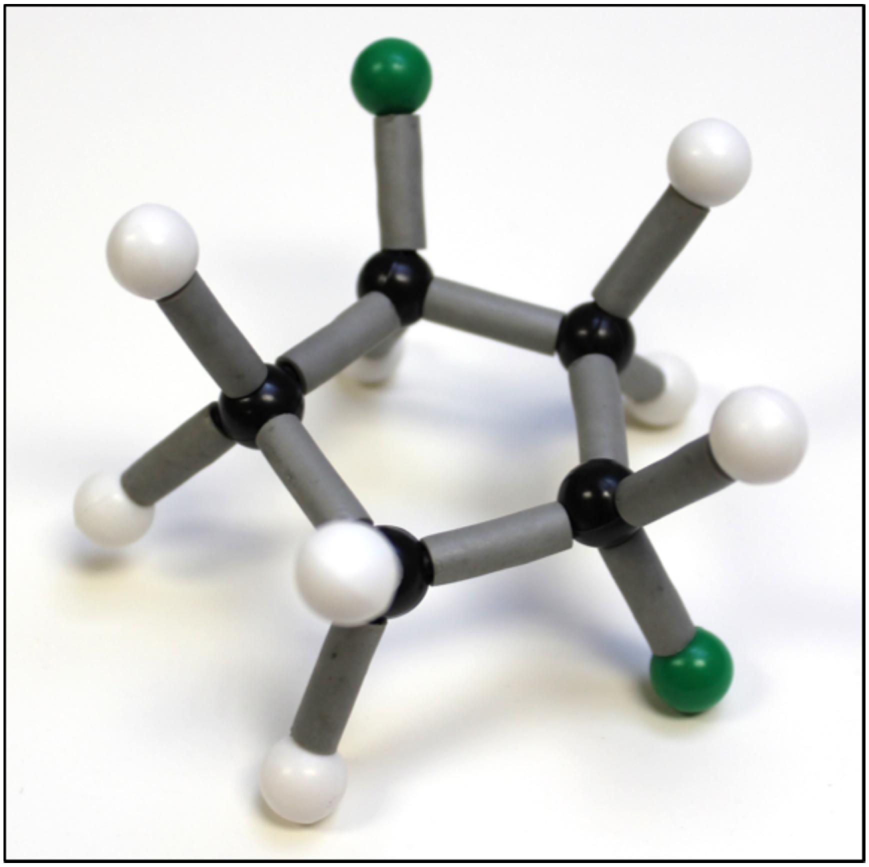


Photo 34: Model A – Line-angle Formula
(SAMPLE ANSWER BELOW)

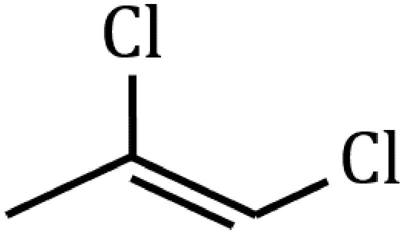
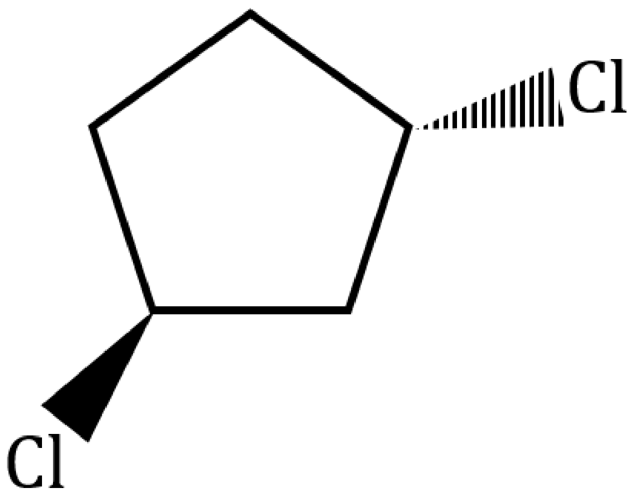


Photo 35: Model B – Line-angle Formula
(SAMPLE ANSWER BELOW)

Photo 36: Model C – Line-angle Formula
(SAMPLE ANSWER BELOW)



Competency Review

_____ shows only the number and type of atoms of each element in the compound.

- Structural formula
- Lewis structure
- Line-angle formula
- Molecular formula ✔

Structures that show the bonding of atoms in three-dimensions are known as _____.

- dash-wedge structures ✔
- molecular formulas
- line-angle formulas
- Lewis structures

_____ structures are characterized by zig-zag lines and eliminates C and H.

- Lewis
- Line-angle ✔
- Dash-wedge
- Condensed molecular

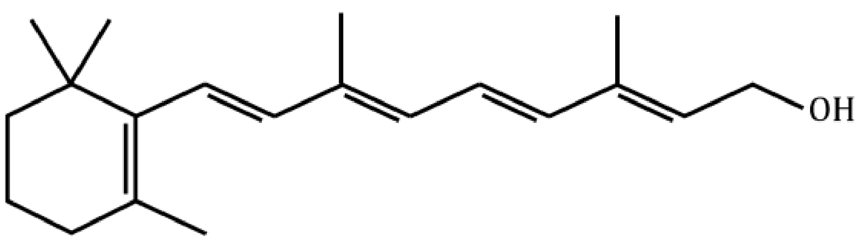
Structural formulas show bonds between all atoms and lone pair electrons.

- True
- False ✔

_____ show all the atoms in the molecule, but does not include lines for the bonds between C's and H's.

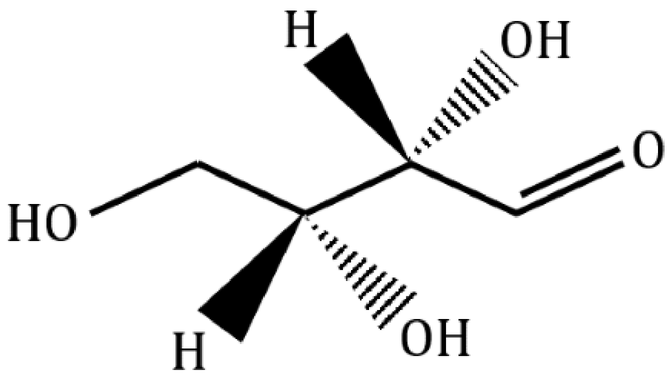
- Structural formulas
- Lewis structures
- Condensed structural formulas ✔
- Molecular formulas

The drawing below represents a _____.



- line-angle formula ✔
- Lewis structure
- molecular formula
- dash-wedge structure

The diagram below represents a _____.



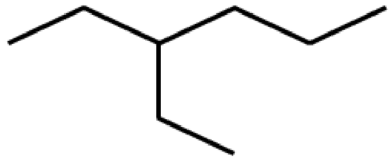
- molecular formula
- line-angle formula
- Lewis structure
- dash-wedge structure ✔

The image below represents a _____.

$$CH_3CH_2CH_2CH_3$$

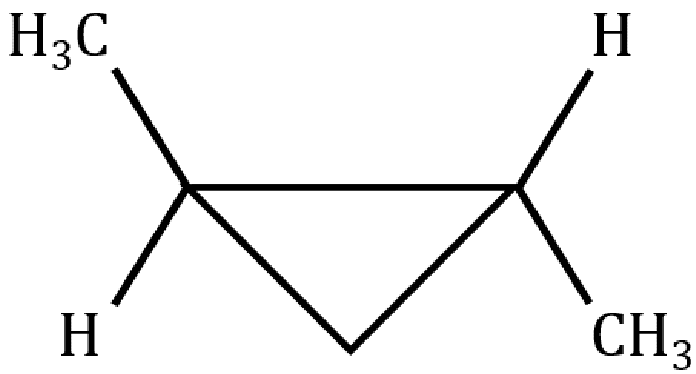
- Lewis structure
- dash-wedge structure
- line-angle formula
- condensed molecular formula ✔

The IUPAC name for the compound below is _____.



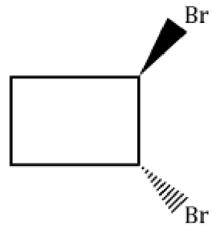
- 3-propylbutane
- 3-ethylhexane ✔
- octane
- ethylhexane
- 1,1-dimethylbutane

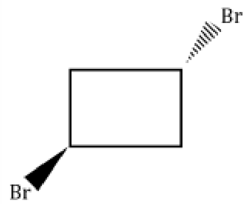
The IUPAC name for the compound below is _____.

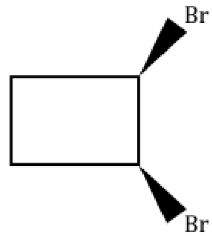


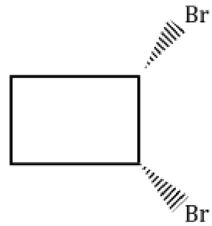
- pentane
- *cis*-1,2-cyclopropane
- *trans*-pentane
- *trans*-1,2-dimethylcyclopropane ✔
- cyclopentane

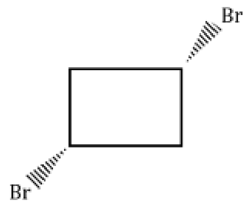
The correct structure for *cis*-1,3-dibromocyclobutane is _____.









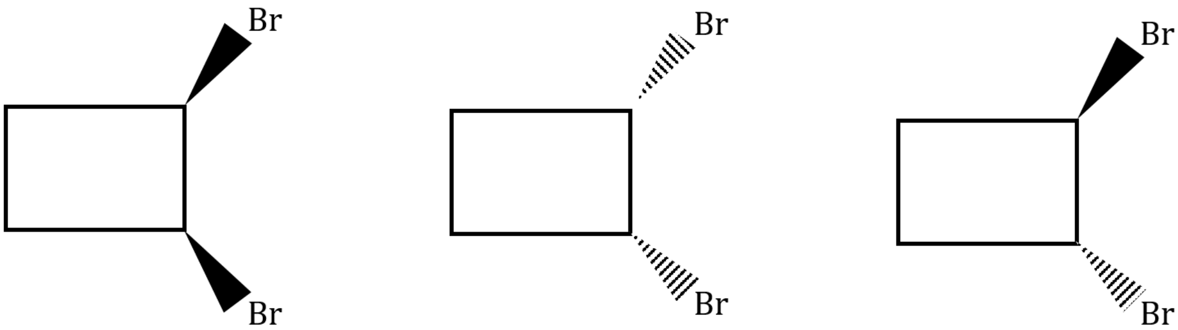


✔

Extension Questions

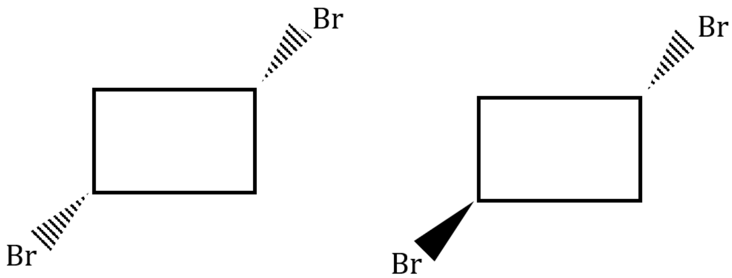
One of the more challenging aspects of organic chemistry is recognizing when different structures represent different compounds, different compounds that are isomers, different conformations of the same compound, or are simply the same structure rotated

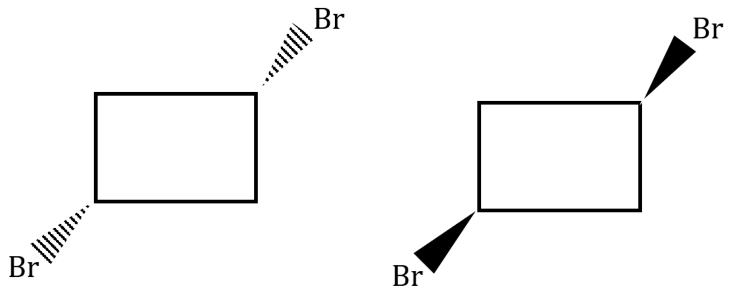
90 or 180 degrees. For example, structures (a) and (b) below look different, but are identical. Simply flip the second one over (top to bottom) and the bonds to Br will point toward you instead of away, matching the first structure. However, no amount of flipping will make structure (c) identical to the first two structures. Structure (c) represents a compound that is a geometric (*cis*/*trans*) isomer of the compound represented by structures (a) and (b).

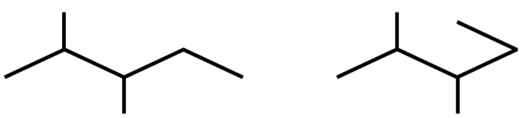


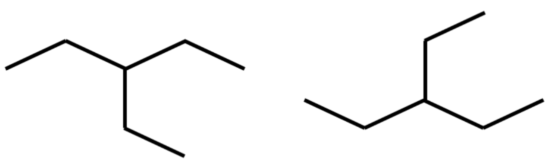
a) b) c)

Look at the following pairs of structures carefully to identify them as representing a) completely different compounds, b) compounds that are structural isomers of each other, c) compounds that are geometric isomers of each other, d) conformers of the same compound (part of structure rotated around a single bond) or e) the same structure.

a) 

b) 

c) 

d) 

e) $CH_3-CH{=}CH-CH_2-CH_2-CH_3$ $\qquad$ $CH_3-CH_2-CH{=}CH-CH_2-CH_3$

f) $CH_3-\overset{\overset{H}{|}}{C}{=}\overset{\overset{H}{|}}{C}-CH_2-CH_2-CH_3$ $\qquad$ $CH_3-\overset{\overset{H}{|}}{C}{=}\underset{\underset{H}{|}}{C}-CH_2-CH_2-CH_3$

g) $CH_3-CH{=}CH-CH_2-CH_2-CH_3$ $\qquad$ $CH_3-CH_2-CH_2-CH{=}CH-CH_3$

(SAMPLE ANSWER BELOW)

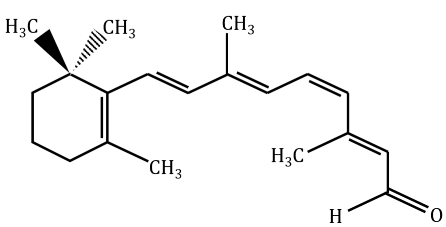
a. c, geometric isomers
b. e, same structure
c. d, conformers of same compound
d. e, same structure
e. b, structural isomers
f. f, geometric isomers
g. e, same structure

Research the compound, retinal. Describe the role of *cis-trans* isomerism in vision. Include the structures of both *cis* and *trans* retinal in your answer. Upload images of the *cis*-retinal and *trans*-retinal in the Question 3 Photo panel after answering the question. (SAMPLE ANSWER BELOW)

Retinal has a critical role in vision. It has two isomers that are responsible for converting energy in light photons into electrical impulses in the retina. Retinal is derived when Vitamin A (trans-retinol) in the diet is converted to *cis*-retinol (an alcohol) and oxidized to form *cis*-retinal (an aldehyde). Molecules of *cis*-retinal (structure A) are found attached to the vision pigments, the opsins, such as rhodopsin. When light hits the *cis*-retinal components of the vision pigments, the *cis*- double bond is isomerized to a *trans*- double bond (structure B), changing the shape of the retinal and the shape of the opsin protein. This change in shape of the protein, through a series of rapidly-occurring steps, results in a neural signal being sent to the optical centers in the brain. Because the *trans* shape is rigid and elongated, it does not fit well in the protein. While it is in the protein, it develops a twisted conformation which is not stable or energetically favorable. Therefore, the *trans*-retinal molecules will be removed from the opsin proteins and replaced by *cis*-retinal molecules.

Upload a labeled image of *cis*-retinal and *trans*-retinal. (SAMPLE ANSWER BELOW)

A.



B.