SI Chemistry - Full Discipline Demo

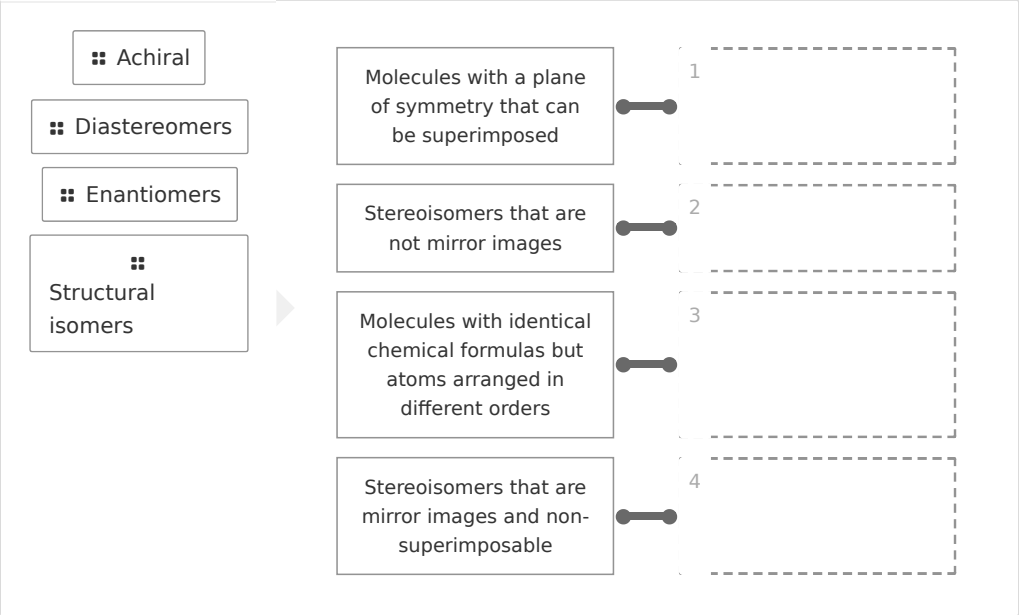
Stereochemistry 2 - Stereoisomers

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

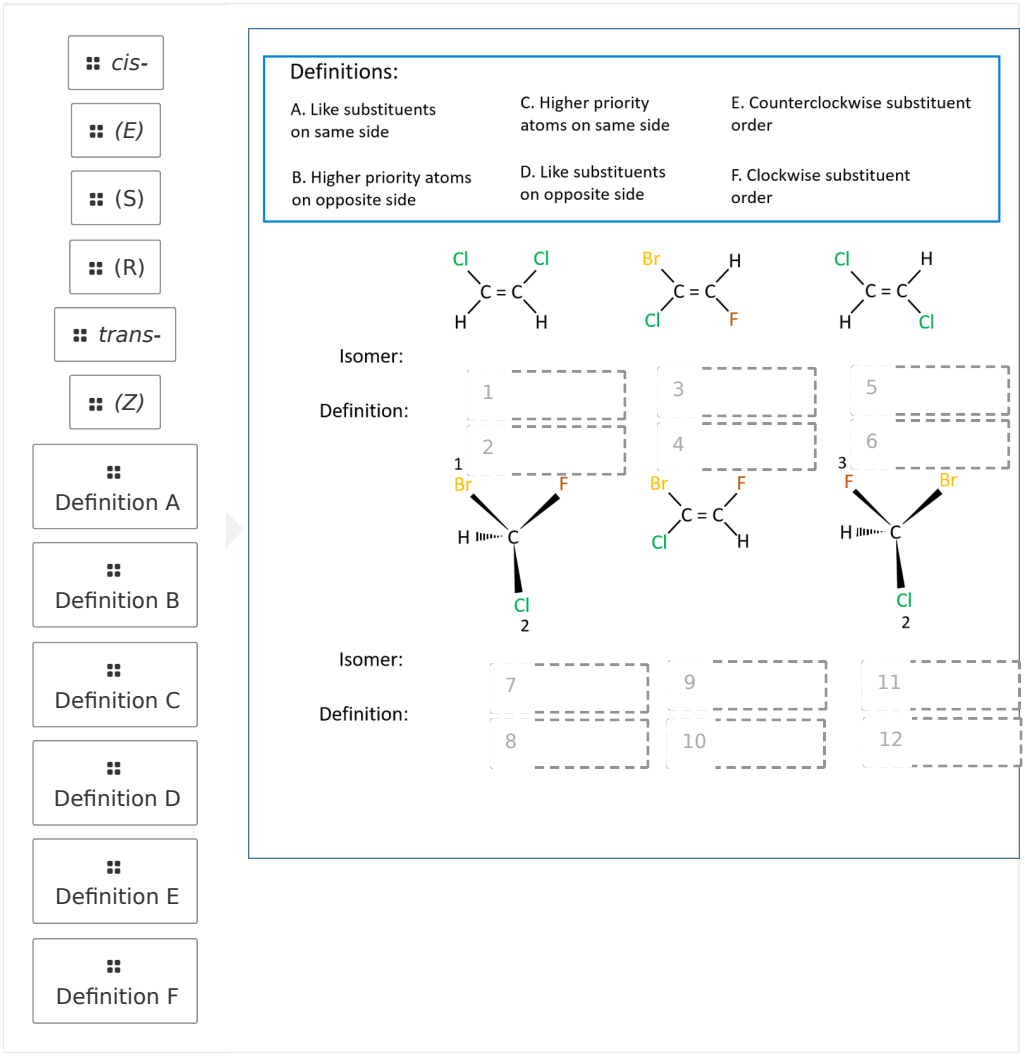
Match each term with the best description.



Correct answers:

1 Achiral 2 Diastereomers 3 Structural isomers 4 Enantiomers

Match the naming prefix and definition to the appropriate structural formula.



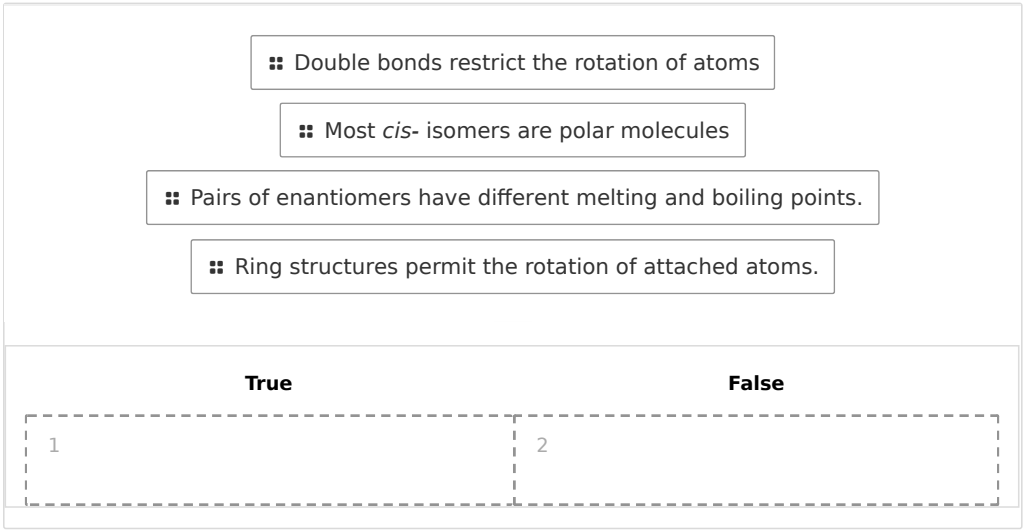
Correct answers:

1 *cis-* 2 Definition A 3 *(E)* 4 Definition B 5 *trans-*

6 Definition D 7 (S) 8 Definition E 9 *(Z)* 10 Definition C

11 (R) 12 Definition F

Categorize each statement as true or false.



Correct answers:

1 Double bonds restrict the rotation of atoms

Most *cis*- isomers are polar molecules

2 Pairs of enantiomers have different melting and boiling points.

Ring structures permit the rotation of attached atoms.

Exploration

____ are molecules with identical chemical formulas but different three-dimensional arrangements of atoms.

- Chain isomers
- Stereoisomers ✔
- Structural isomers

Geometric isomers form when atoms are locked into their spatial positions due to a _____.

- chiral carbon atom
- double bond or ring structure ✔
- stereocenter

Trans- isomers consist of like substituents on _____ of double-bonded carbons.

- opposite sides ✔
- the same side
- all four corners

Generally, more energy is required to break intermolecular forces of _____ isomers.

- _cis_- ✔
- chiral
- _(E)_-
- _trans_-

_(Z)_- isomers have higher priority atoms on _____ of the double-bonded carbons.

- opposite sides
- the same side ✔
- all four corners

A ____ in the structural formula of cyclic compounds represents substituents oriented toward the viewer

- dashed wedge
- diagonal line
- horizontal line
- solid wedge ✔

An asymmetric carbon atom contains ____ unique substituents.

- two
- three
- four ✔
- five

Enantiomers are pairs of chiral molecules that are non-superimposable mirror images.

- True ✔
- False

Enantiomers are named using the ____.

- CIP convention ✔
- *cis-trans* system
- *E-Z* system

A molecule with multiple chiral centers can form both enantiomers and diastereomers.

- True ✔
- False

Exercise 1

What are geometric isomers?

Geometric isomers are molecules that are locked into their spatial positions, with respect to one another, due to a double bond or a ring structure.

How does the *E-Z* notation system differ from the *cis-trans* naming system?

The *cis-trans* naming system assigns names to geometric isomers based on the relative positions of substituents on
each side of the double bond or ring structure. The system assigns names to geometric isomers by giving priorities to substituents based on atomic or molecular mass, and is used for isomers possessing different substituents on each end of double bonds.

How are wedge-dash notations used to indicate the position of atoms in an isomer?

Solid wedges indicate atoms oriented toward the viewer, whereas dashed wedges indicate atoms orientated away from the viewer.

If the bromine atom was replaced with a fluorine atom in Part 2 of this exercise, would the *E-Z* notations differ for the resulting molecule? Explain your answer.

Replacing bromine with fluorine would not change the notations of the resulting molecule because fluorine has a higher atomic mass than hydrogen, just as bromine does.

Photo 1: cis-2-butene

(SAMPLE ANSWER BELOW)

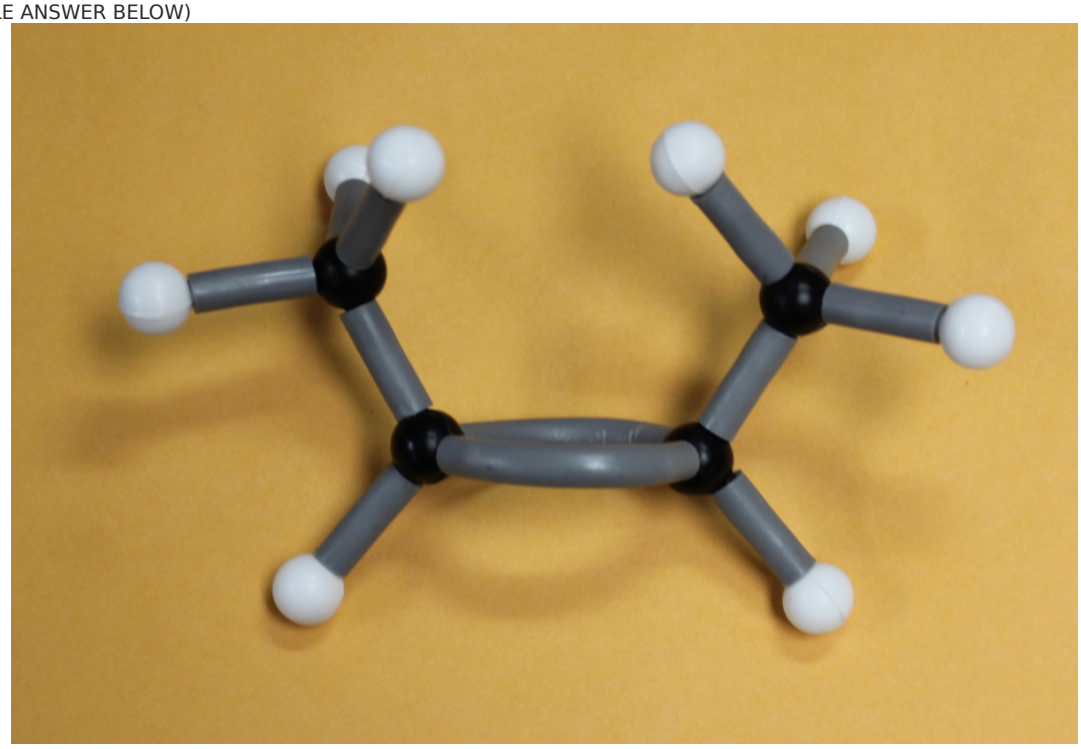


Photo 2: trans-2-butene

(SAMPLE ANSWER BELOW)

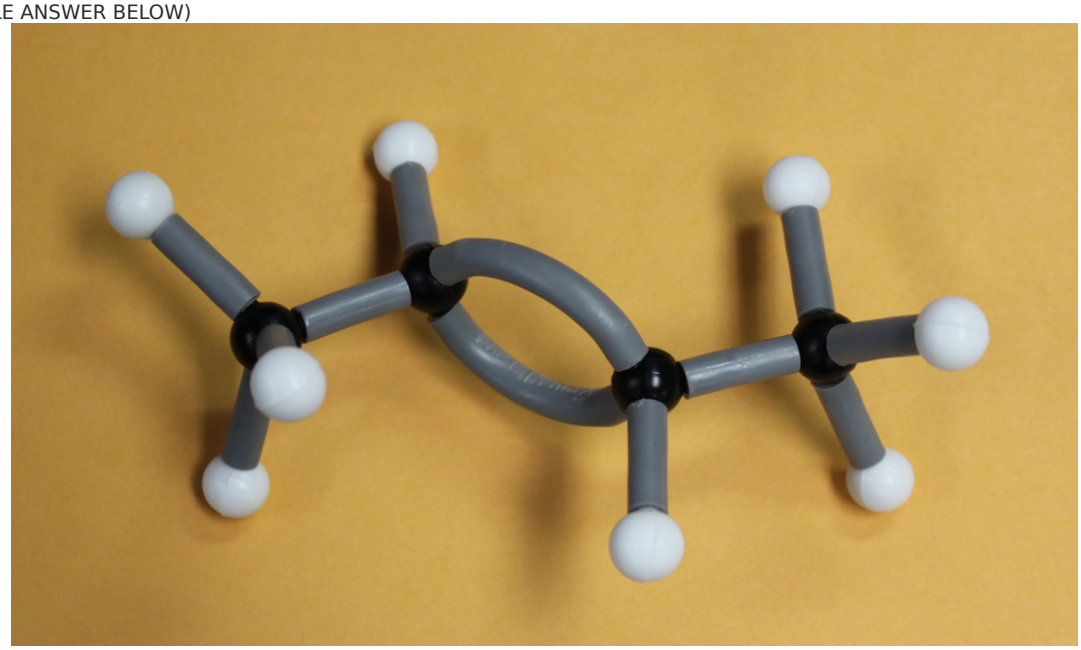
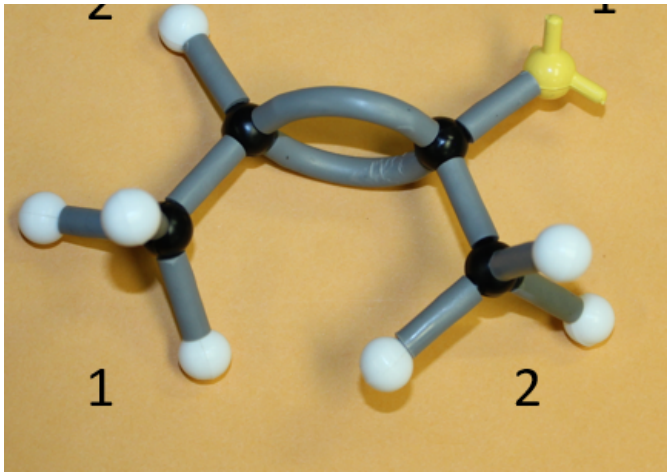


Photo 3: 2-bromo-2-butene Isomer #1

(SAMPLE ANSWER BELOW)



Data Table 1: 2-bromo-2-butene Isomers

(SAMPLE ANSWER BELOW)

Isomer Number	Isomer Name
Isomer #1	(E)-2-bromo-2-butene
Isomer #2	(Z)-2-bromo-2-butene

Photo 4: 2-bromo-2-butene Isomer #2
(SAMPLE ANSWER BELOW)

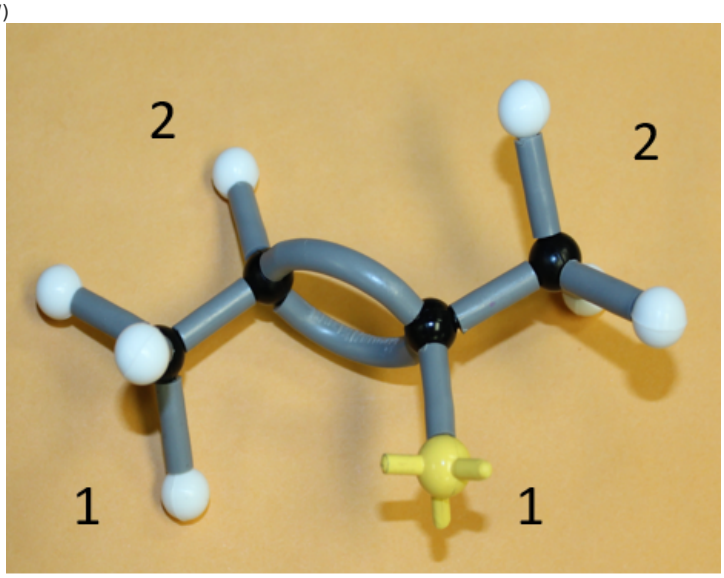


Photo 5: cis-2-bromocyclohexanol
(SAMPLE ANSWER BELOW)

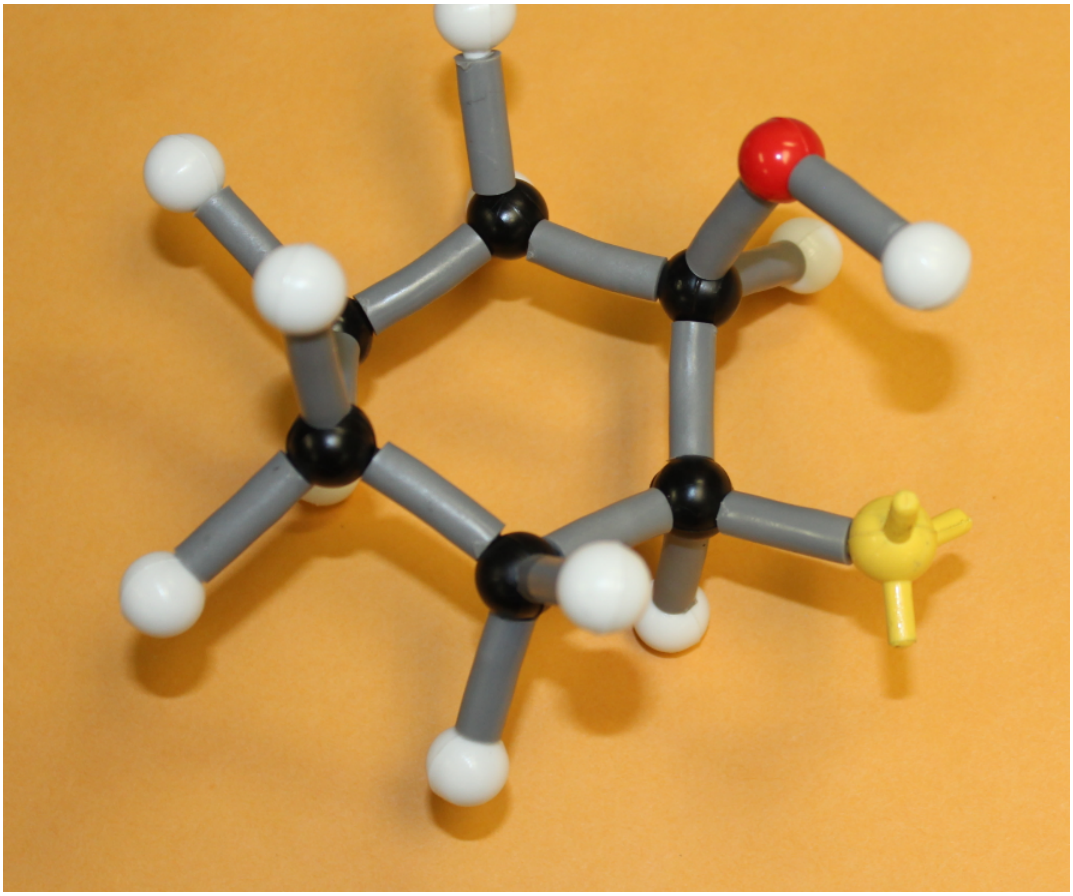
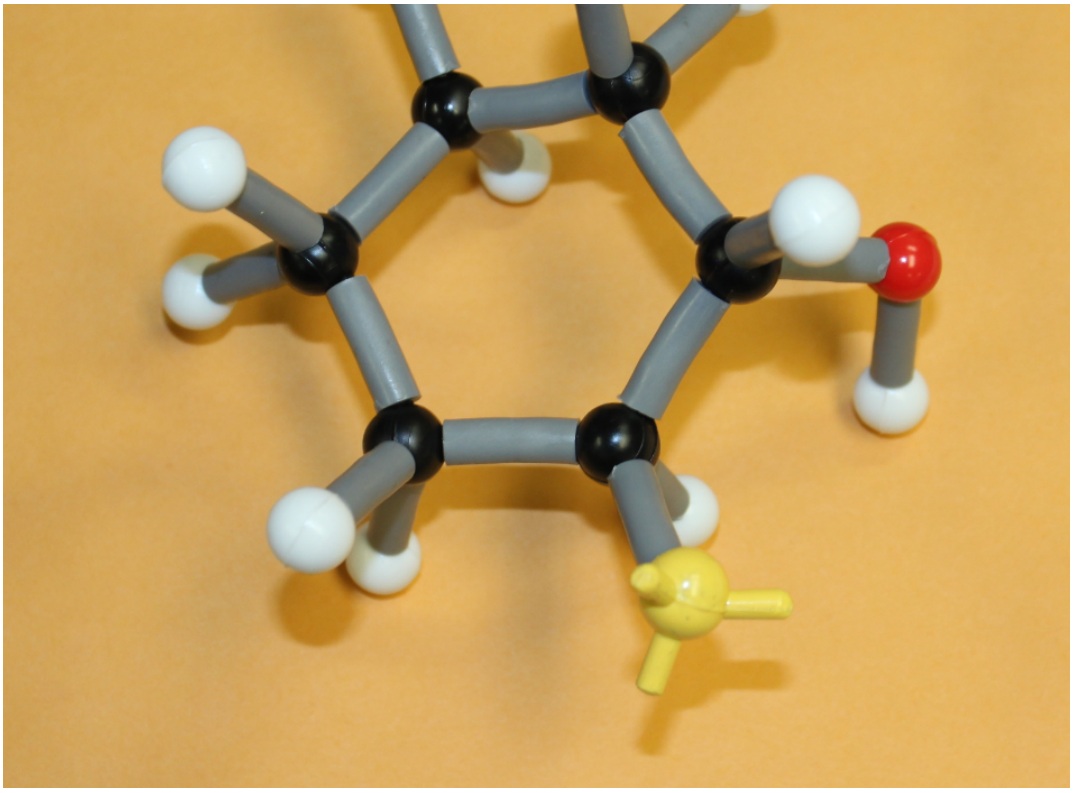


Photo 6: trans-2-bromocyclohexanol

(SAMPLE ANSWER BELOW)



Exercise 2

What are optical isomers?

Optical isomers are molecules that differ three-dimensionally by the placement of substituents around one or more
atoms in a molecule.

Which of the molecules in Data Table 2 are enantiomers? Explain your answer.

(S)-bromochlorofluoromethane and (R)-bromochlorofluoromethane are a pair of enantiomers because they are mirror images that cannot be superimposed on each other. The bromochloromethane mirrored molecules are not enantiomers because they can be superimposed on each other.

What are diastereomers?

Diastereomers are optical isomers that are not mirror images.

Which pairs of molecules in Data Table 3 would be expected to have identical chemical properties? Explain your answer.

The isomer pair (2S,3R) and (2R,3S) would have identical chemical properties because they are enantiomers. Similarly, the enantiomer pair (2S,3S) and (2R,3R) would share chemical properties. All other pair combinations would exhibit different chemical properties because they are diastereomers.

Data Table 2: Bromochlorofluoromethane and Bromochloromethane Isomers
(SAMPLE ANSWER BELOW)

Isomer #	Isomer Name
Isomer #1	(S)-bromochlorofluoromethane
Isomer #2	(R)-bromochlorofluoromethane
Isomer #3	Bromochloromethane mirrored molecules (See Photo 9)

Photo 7: Bromochlorofluoromethane Isomer #1

(SAMPLE ANSWER BELOW)

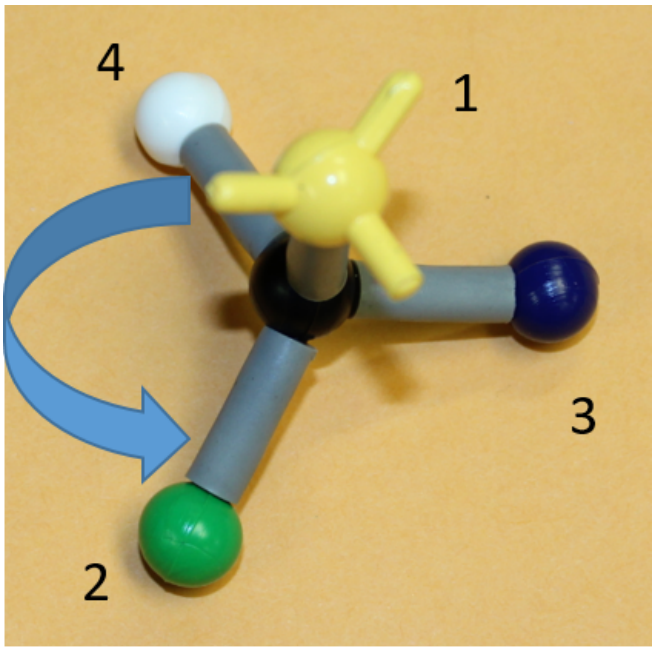


Photo 8: Bromochlorofluoromethane Isomer #2

(SAMPLE ANSWER BELOW)

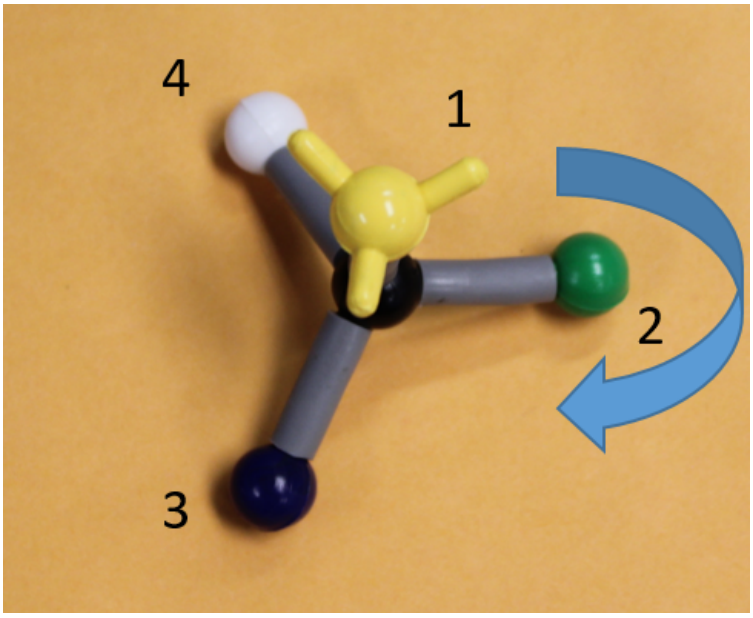
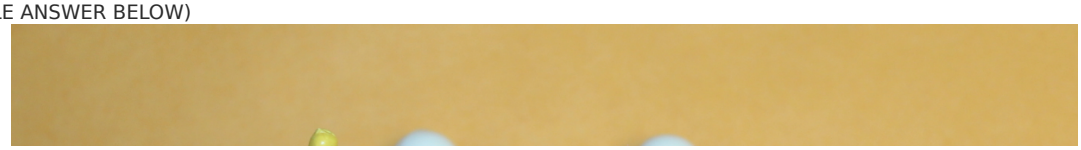
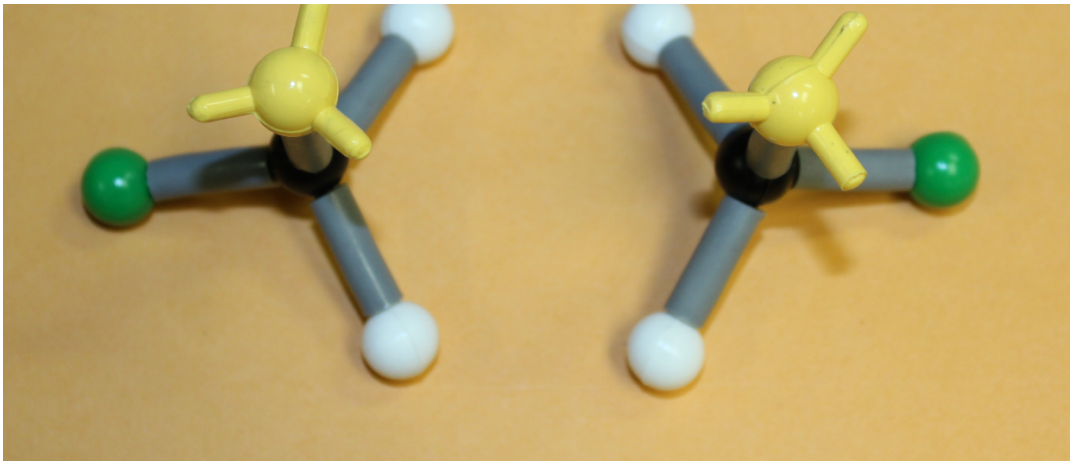


Photo 9: Bromochloromethane Mirror-Image

(SAMPLE ANSWER BELOW)





Data Table 3: 2-bromo-3-chlorobutane Isomers

(SAMPLE ANSWER BELOW)

Isomer #	Isomer Name
Isomer #1	(2S,3R)-2-bromo-3-chlorobutane
Isomer #2	(2R,3R)-2-bromo-3-chlorobutane
Isomer #3	(2R,3S)-2-bromo-3-chlorobutane
Isomer #4	(2S,3S)-2-bromo-3-chlorobutane

Photo 10: 2-bromo-3-chlorobutane Isomer #1

(SAMPLE ANSWER BELOW)

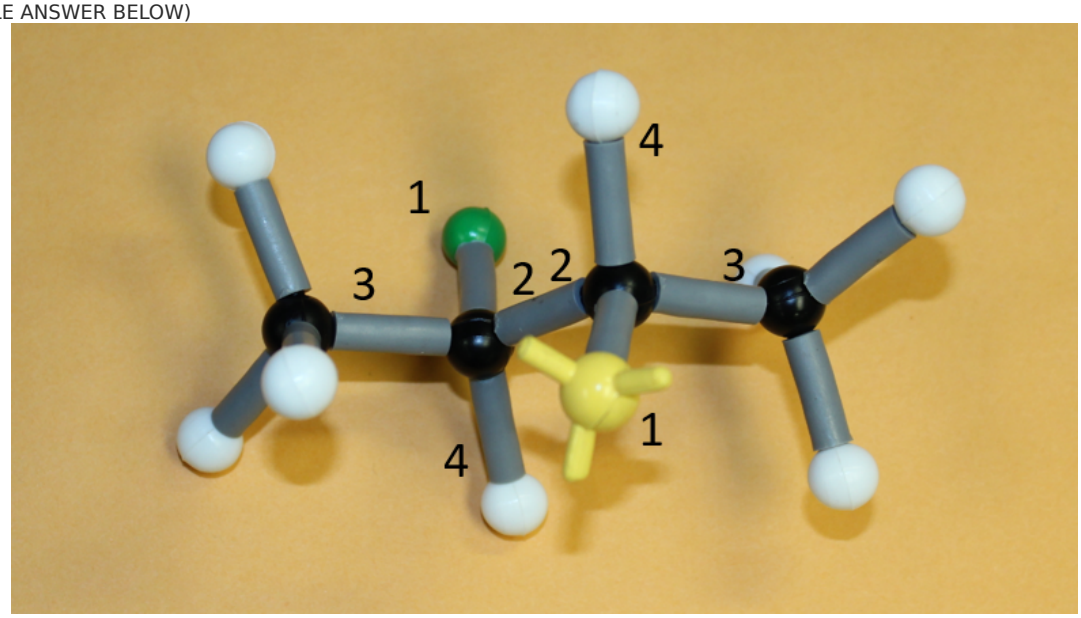


Photo 11: 2-bromo-3-chlorobutane Isomer #2

(SAMPLE ANSWER BELOW)

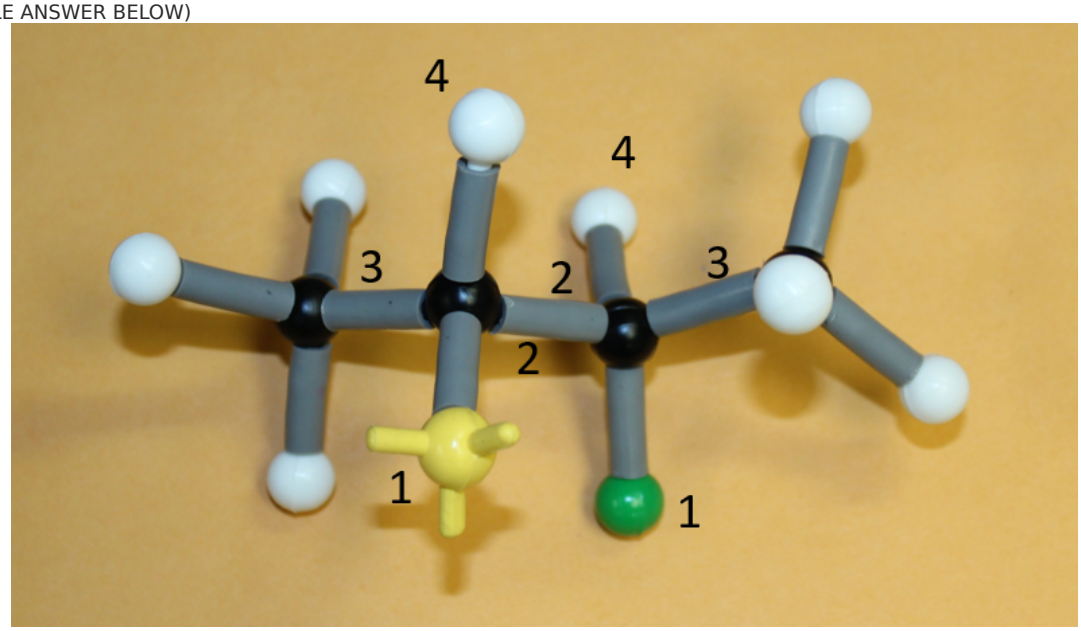
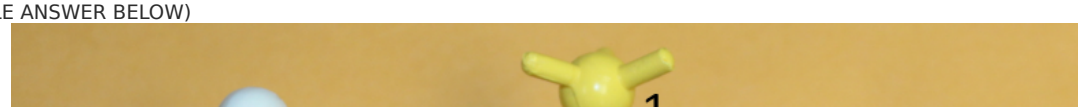


Photo 12: 2-bromo-3-chlorobutane Isomer #3

(SAMPLE ANSWER BELOW)



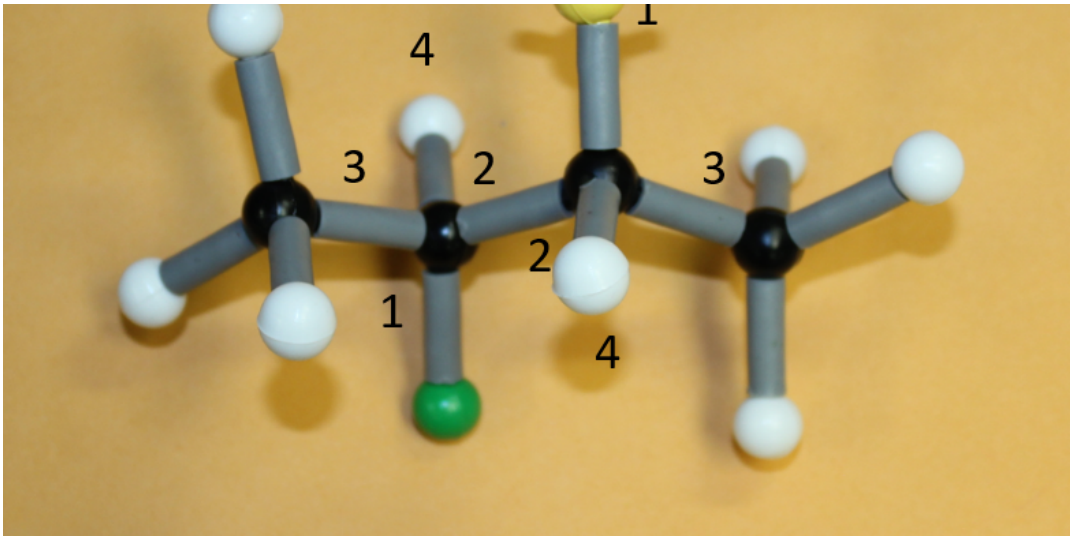
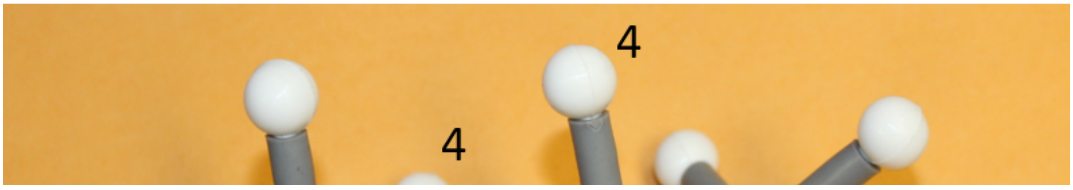
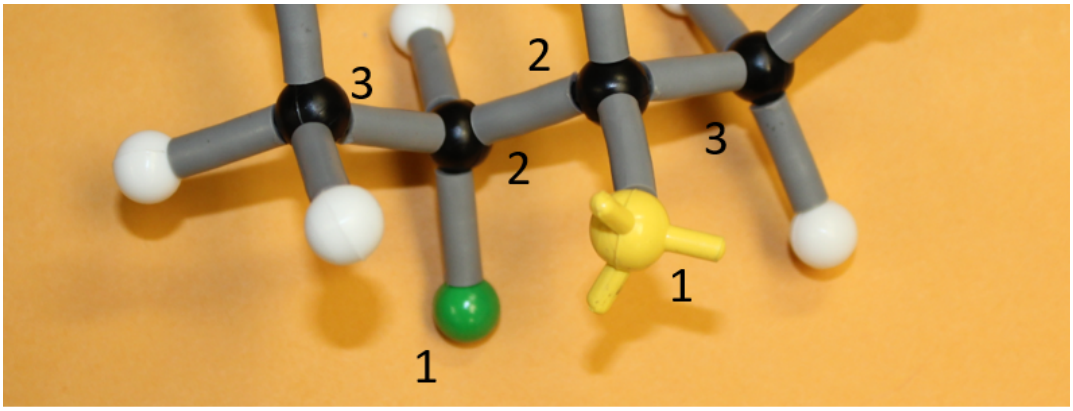


Photo 13: 2-bromo-3-chlorobutane Isomer #4

(SAMPLE ANSWER BELOW)





Competency Review

____ are examples of stereoisomers.

- Geometric isomers and optical isomers ✔
- Chain isomers and positional isomers
- Structural isomers and functional isomers
- Conformers and rotomers

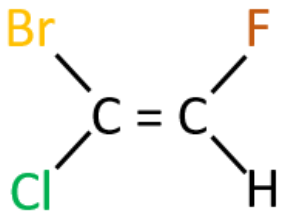
Double bonds and ring compounds inhibit the formation of geometric isomers.

- True
- False ✔

Generally, *cis*- isomers are ____ molecules.

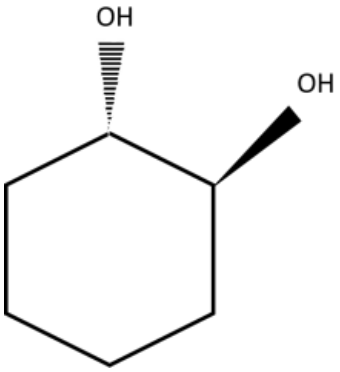
- nonpolar
- polar ✔
- chiral
- achiral

The structural formula pictured represents ____ .



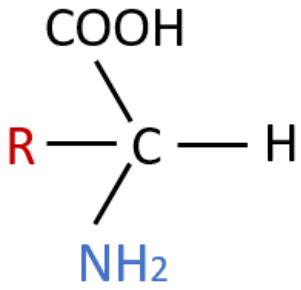
- *trans*-1 bromo-1-chloro-2-fluoro-ethene
- (S)-1 bromo-1-chloro-2-fluoro-ethene
- *(E)*-1 bromo-1-chloro-2-fluoro-ethene
- *(Z)*-1 bromo-1-chloro-2-fluoro-ethene ✔

The wedge-dash notations in the formula represent a *trans*- isomer.



- [x] True ✔
- [ ] False

The structural formula pictured represents a(n) ____.

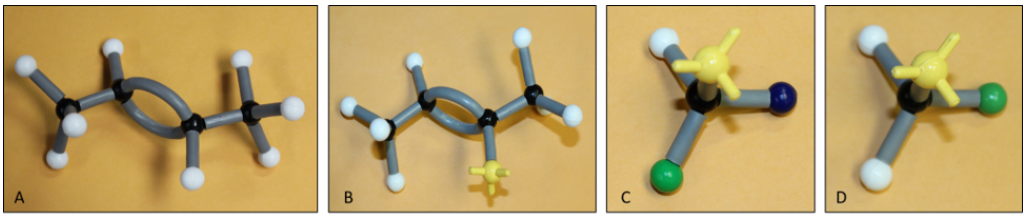


- [ ] asymmetric carbon atom
- [ ] chiral molecule
- [ ] stereogenic center
- [x] All of the above ✔

Pairs of diastereomers have identical chemical properties.

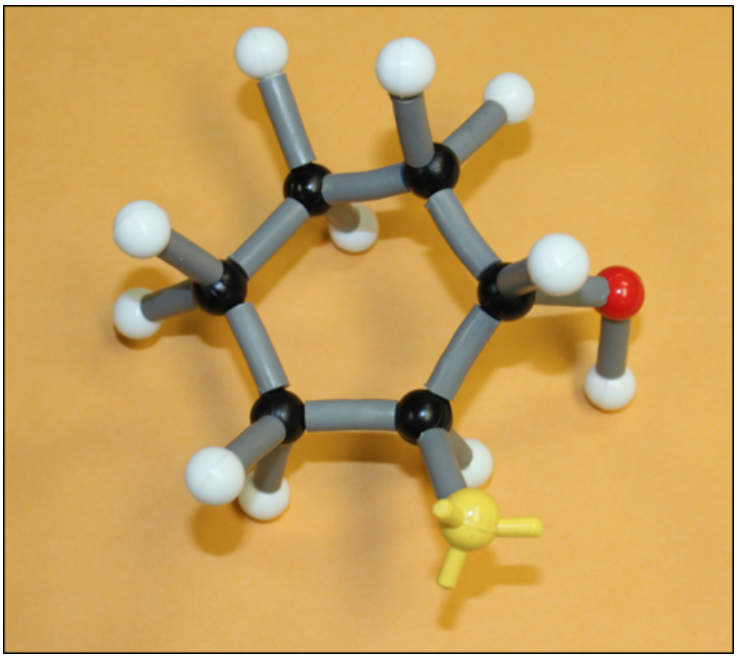
- [ ] True
- [x] False ✔

Which model pictured represents a chiral molecule?



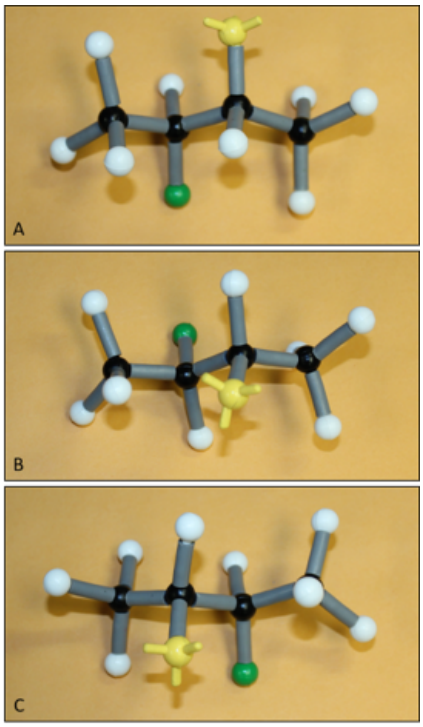
- A
- B
- C ✔
- D

What is the name of the compound represented by the molecular model pictured?



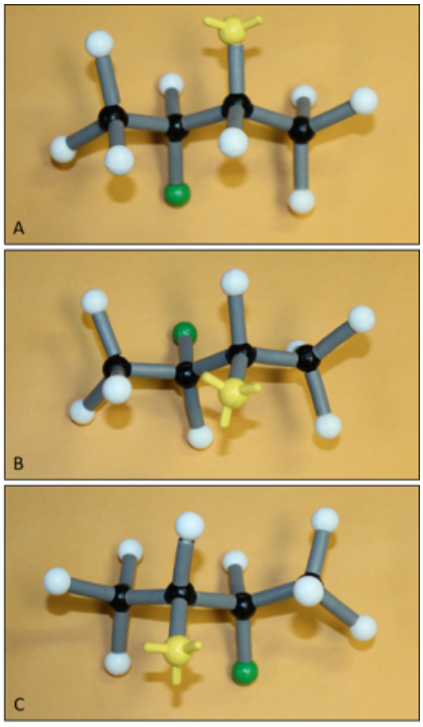
- *Cis*-2-bromocyclohexanol
- (S)-2-bromocyclohexanol
- *Trans*-2-bromocyclohexanol ✔
- (Z)-2-bromocyclohexanol

Which of the models pictured are enantiomers?



- A and B ✔
- B and C
- A and C

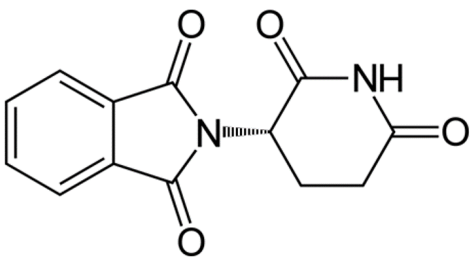
Which of the models pictured represents a molecule that would be expected to exhibit chemical properties that are unique among the three substances?



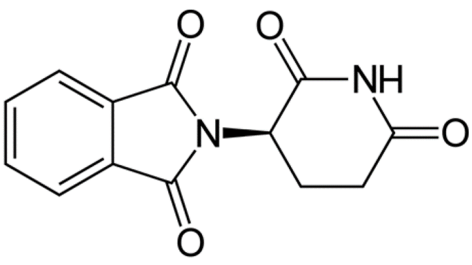
- A
- B
- C ✔

Extension Questions

Thalidomide is a drug that exists as a pair of enantiomers (shown below). While the physical properties of melting and boiling points of (R)- and (S)- thalidomide are identical, each enantiomer produces different biological reactions in a chiral environment.



(S)-thalidomide



(R)-thalidomide

Research and discuss the history of thalidomide. Explain how the stereochemisty of the molecule results in the contrasting biological reactions of each enantiomer.

(SAMPLE ANSWER BELOW)

Thalidomide was prescribed as both a sedative and cure for morning sickness in pregnant women in the late 1950's and early 1960's. The drug was later found to have catastrophic side effects resulting in fetal deaths and birth defects. The (S)- enantiomer of thalidomide fits the active site of an enzyme that produces the desired effect of sedation. The (R)- enantiomer of the drug fites the active site of a different enzyme leading to the toxic effects of fetal death and deformation.