4.9: CIS-TRANS ISOMERISM IN CYCLOALKANES

Learning Objective

- identify & draw the geometric (cis/trans) isomers of cycloalkanes

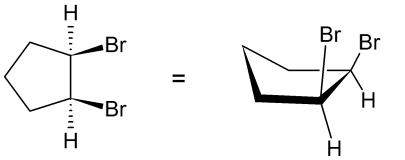
GEOMETRIC ISOMERISM OF CYCLOALKANES

The carbon ring of cycloalkanes forms a pseudo-plane that can be used to assign the relative orientation of atoms or substituents bonded to the ring (stereochemistry). One side of the ring is called "up" while the other side is called "down". By agreement, chemists use heavy, wedge-shaped bonds to indicate a substituent located above the average plane of the ring (up), and a hatched line for bonds to atoms or groups located below the ring (down).

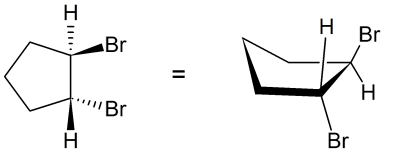
Disubstituted cycloalkane stereoisomers may be designated by nomenclature prefixes such as *cis* and *trans*. Cis and trans isomers are also called "geometric isomers".

For the cis isomer, both substituents are aobe or below the carbon ring. For the trans isomer, one substituent is above the ring while the other substituent is below the ring.

The cis and trans isomers for 1,2-dibromocyclopentane are shown as an example below.



cis-1,2-dibromocyclopentane

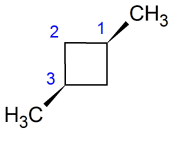


trans-1,2-dibromocyclopentane

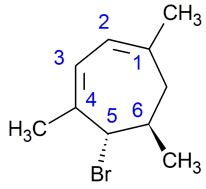
While the carbon-carbon single bonds of the rings can rotate partially, there is NO way to inter-convert between the cis and trans isomers. Cis and trans isomers are unique compounds with their own unique melting points, boiling points, densities, etc.

Further explanation:

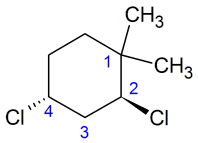
In general, if any two sp^3 carbons in a ring have two different substituent groups (not counting other ring atoms) stereoisomerism is possible. This is similar to the substitution pattern that gives rise to stereoisomers in alkenes; indeed, one might view a double bond as a two-membered ring. Four other examples of this kind of stereoisomerism in cyclic compounds are shown below.



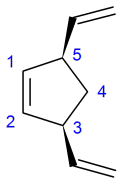
cis-1,3-dimethylcyclobutane



trans-5-bromo-1,4,6-trimethyl-1,3-cycloheptadiene



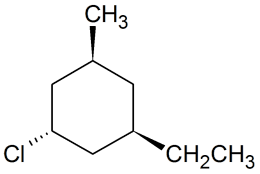
trans-2,4-dichloro-1,1-dimethylcyclohexane



cis-3,5-divinylcyclopentene

If more than two ring carbons have different substituents (not counting other ring atoms) the stereochemical notation distinguishing the various isomers becomes more complex. However, we can always state the relationship of any two substituents using cis or trans. For

example, in the trisubstitutued cyclohexane below, we can say that the methyl group is *cis* to the ethyl group, and *trans* to the chlorine. We can also say that the ethyl group is *trans* to the chlorine. We cannot, however, designate the entire molecule as a *cis* or trans *isomer*.



Exercise

1. Draw the following molecules:

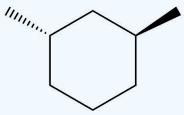
trans-1,3-dimethylcyclohexane

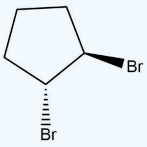
trans-1,2-dibromocyclopentane

cis-1,3-dichlorocyclobutane

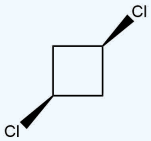
Answer

1.


1



2



3

CONTRIBUTORS AND ATTRIBUTIONS

- Dr. Dietmar Kennepohl FCIC (Professor of Chemistry, Athabasca University)
- Prof. Steven Farmer (Sonoma State University)
- Organic Chemistry With a Biological Emphasis by Tim Soderberg (University of Minnesota, Morris)