Objectives

After completing this section, you should be able to

1. recognize that a formula of the type \((C_nH_{2n})\) may represent a cycloalkane.
2. draw structural formulas that distinguish between cis and trans disubstituted cycloalkanes.
3. construct models of cis and trans disubstituted cycloalkanes using ball-and-stick molecular models.

Key Terms

Make certain that you can define, and use in context, each of the key terms listed below.

- cis-trans isomers
- cycloalkane (see the “Study Notes,” below)
- stereoisomer

Study Notes

Compounds in which the carbon atoms are joined in a ring, and in which no multiple bonds or other functional groups are present, are called cycloalkanes. A cycloalkane containing only one ring will correspond to the general formula \(C_nH_{2n}\), but alkenes containing only one double bond also correspond to this formula. Cycloalkanes containing more than one ring are not considered in this section. It is difficult to make models of cyclopropane and cyclobutane using the model kit provided with this course: this difficulty is a reflection of the concept of ring strain, which will be introduced in Section 4.3. However, you can make an approximate model of cyclopropane if you use the curved rods to represent the carbon-carbon bonds. The result is not perfect, but it should help you to visualize cis and trans isomers. Similarly, you can make an imperfect model of cyclobutane by using two straight rods and two curved rods to represent the carbon-carbon bonds. Remember, however, that in practice, all of the C-C bonds in cyclobutane are identical. You can construct models of cyclopentane and cyclohexane using the normal rods to represent carbon-carbon bonds.

Stereoisomers are also observed in certain disubstituted (and higher substituted) cyclic compounds. Unlike the relatively flat molecules of alkenes, substituted cycloalkanes must be viewed as three-dimensional configurations in order to appreciate the spatial orientations of the substituents. By agreement, chemists use heavy, wedge-shaped bonds to indicate a substituent located above the average plane of the ring, and a hatched line for bonds to atoms or groups located below the ring. As in the case of the 2-butene stereoisomers, disubstituted cycloalkane stereoisomers may be designated by nomenclature prefixes such as cis and trans. The stereoisomeric 1,2-dibromocyclopentanes below are an example.

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.
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 trisubstituted 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.

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