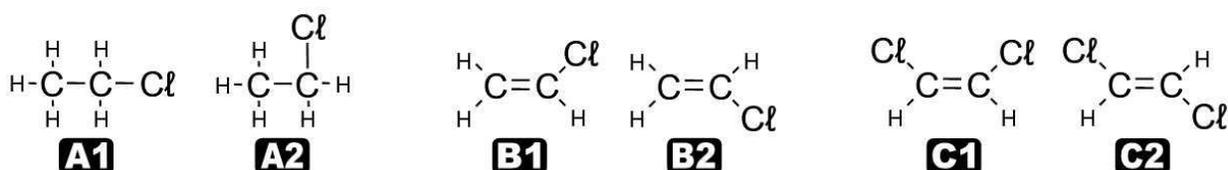


Organic Isomers 1: *cis- and trans-*

If you've ever played with a chemical model kit, you may have noticed that when there is a single bond between two atoms, it's possible to twist the atoms to rotate about the bond. This mimics what actually happens in molecules with single bonds: the atoms are free to spin while remaining bonded. If you've created a molecule with a double or triple bond, however, you can only twist the atoms so far before a bond pops out. Double and triple bonds are more rigid in reality. This creates an additional requirement in naming organic compounds. Look at the following pairs of molecules.



Consider A1 and A2: the drawing represents two carbon atoms, each with three other atoms bonded to it in a tetrahedral configuration. Because of the free rotation at a single bond, the chlorine atom on the right can be rotated into any position. A1 and A2 are actually the same molecule; there's no need to differentiate between them with a name.

B1 and B2 have a double bond, so no significant turning at that bond is possible. On the other hand we can take molecule B1 and flip it over. That takes the chlorine atom from the upper position in B1 to the lower position in B2. B1 and B2 are also two different drawings of the same molecule and do not need separate names.

We don't have that option for C1 and C2. C1 has the chlorine atoms on the top half and hydrogen atoms on the bottom half; flipping this molecule over won't give us one chlorine on the top and one chlorine on the bottom. The atoms in C2 are put together in a fundamentally different arrangement and no amount of physical manipulation can turn C1 into C2. These molecules are different. They are a special type of **isomer** called **diastereomers** or **geometric isomers**. This means that the molecules have the same connections among atoms, but a different spatial arrangement of those atoms. We use the prefixes **cis-** or **trans-** to describe the different arrangement of substituents. These kinds of isomers are also known as **cis-trans isomers**. Cis-trans isomers can only occur in alkenes with different substituents on either end of the double bond, or in cycloalkanes. (It cannot occur in triple bonds: with only one bond available for a substituent at each carbon; there's no ambiguity in the configuration.)

If we draw a perpendicular line through the double bond and fold the molecule over the



cis-1,2-dichloroethene

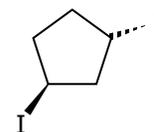
trans-1,2-dichloroethene

line, **trans** substituents will never be on top of each other. **Cis** substituents will line up with each other. These prefixes come at the very start of the molecule name. Molecules C1 and C2 are correctly labelled as shown.



In cycloalkanes, we need to indicate whether the substituents project out of the page towards us, or into the page away from us — they're not flat like the atoms around a double bond are.

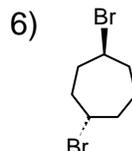
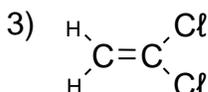
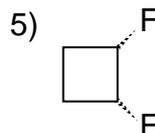
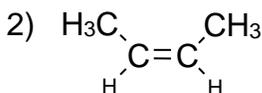
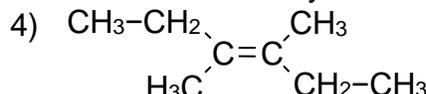
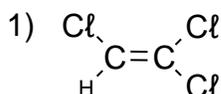
In this molecule, the iodo substituent at the bottom of the diagram has a bond drawn as a black triangle with the wide end at the substituent. That means it projects out towards us — it's exaggerated perspective, so that the end of the bond that's close to us looks bigger. The other iodo's bond is a dashed triangle, and tapers down to the substituent. This bond points away from us. The two bonds are on different sides of the ring, so this is a *trans* isomer. This molecule is ***trans*-1,3-diiodocyclopentane**. It's understood that at each carbon there is also a hydrogen atom, one projecting into the page at the bottom iodo and one projecting out of the page at the carbon bonded to the top iodo. If the two iodine substituents were projected in the same direction (both into the page or both out of the page), it would be a *cis* isomer.



***trans*-1,3-diiodocyclopentane**

EXERCISES

A. Name these compounds, indicating isomerism when necessary.



B. Draw the following.

1) *trans*-2,3-diiodo-2-butene

3) *cis*-1,3-dimethylcyclohexane

2) *cis*-2-pentene

4) *trans*-1,2-dihydroxycyclopentane

SOLUTIONS

A: (1) 1,1,2-trichloroethene (2) *cis*-2-butene (3) 1,1-dichloroethene
 (4) *trans*-3,4-dimethyl-3-hexene (5) *cis*-1,2-difluorocyclobutane
 (6) *trans*-1,4-dibromocycloheptane

