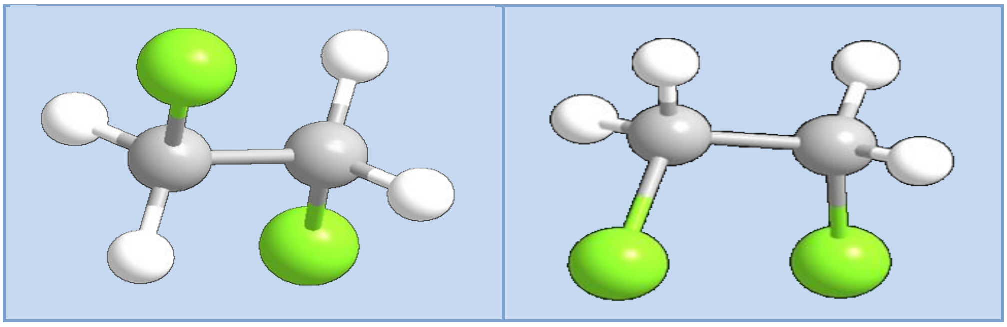
E1-Geometric Isomers

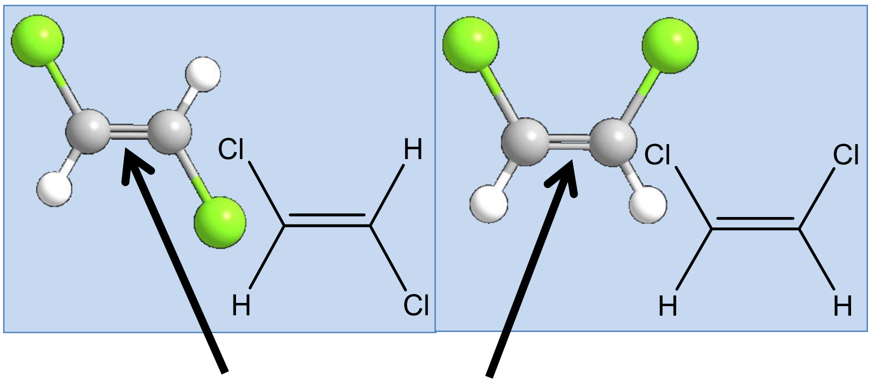
Stereoisomers are two molecules that have the same structural formula but whose three-dimensional arrangement of atoms in space are different; this excludes any different arrangement of the atoms which is due from rotation of the atoms or any bonds.

Geometric isomerism is one example of stereoisomers, also known as *cis-trans* or *E/Z* isomerism.

This happens in carbon-carbon *double* bonds, and *not in single* bonds!
For example 1,2-dichloroethane can be drawn in two ways:

These two structures are due entirely to free rotation around the C-C single bond.
So these are NOT isomers.

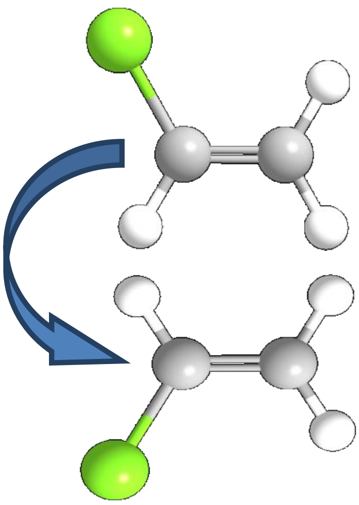




NO ROTATION ABOUT DOUBLE BOND!

If we replace the single bond with a double bond and make it an alkene then there is no free rotation around the carbon-carbon double bond and therefore the groups are fixed to the carbons. If you have models of these molecules then you will have to take the model apart in order to change the arrangement.
So therefore these ARE isomers.

However, the groups on each carbon have to be different. So on the left carbon there has to be two different groups, and the same on the right carbon for stereoisomers to exist.



For example, you will not get geometric isomers from the molecules on the left. Even though the groups on the left carbon have been swapped, you can get from one structure to the other by rotating the whole molecule.

TOP TIP! Try and always draw the displayed structure showing the correct bond angles, rather than the structural formulae. Even though it is very tempting in exams because it is quicker, try and avoid it because it is very easy to miss geometric isomers!

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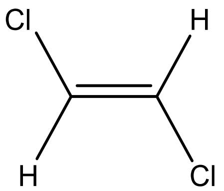
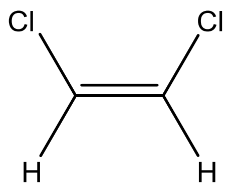
Edited by Steven Carman as part of an MChem project.

Naming geometric isomers

For this example the priority group is Cl because it has a higher atomic number than H. Also since the two groups attached to each carbon are the same (H, Cl) then we can use *cis/trans*.



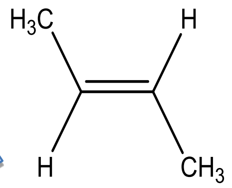
Since the Cl groups are on **opposite** sides of the double bond, it is the ***trans*** isomer.
<u>*trans*-1,2-dichloroethene</u>



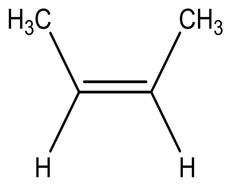
Since the Cl groups are on the **same** side of the double bond; it is the ***cis*** isomer.
<u>*cis*-1,2-dichloroethene</u>

Another example is but-2-ene. The priority group is the carbon in CH_3 as this has a higher atomic number than H.

TOP TIP! You can remember ***trans*** is opposite by thinking of transatlantic or transcontinental or transvestite!



trans-but-2-ene
OR
E-but-2-ene



cis-but-2-ene
OR
Z-but-2-ene

TOP TIP! An easy way to remember which isomer is which is that you would think Z as it visually looks like this, but it's the opposite! Or you can think E for 'Enemies'! Or when looking at Z isomers the higher priority groups are on 'zee zame zide'! Another way to remember it is that Z is a consonant and '**s**ame' starts with a consonant, and E is a vowel and '**o**pposite' starts with a vowel!

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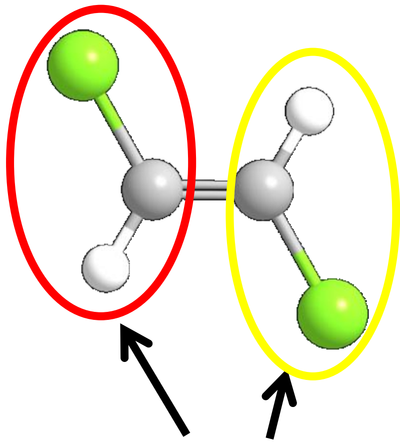
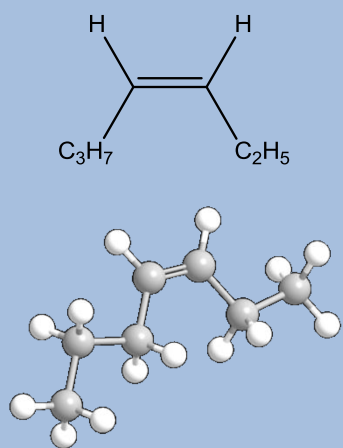
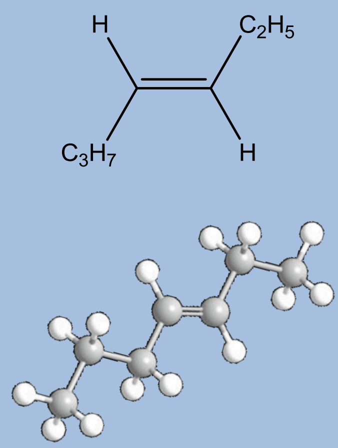


same groups!

The more widely applicable system is *E/Z* isomerism, in fact *cis/trans* is just a special case of *E/Z* isomerism. Look at the picture to the left. You can see that both carbons have the same groups attached; they both have a Cl and a H. This is also the case in the previous example, but-2-ene. Both carbons are attached to a CH_3 group and an H. Since they are the same you name the geometric isomer either *cis* or *trans*. But some molecules don't have the same groups on both carbons, what happens then? Well, we still use the same rules but we change *trans* to *E* and *cis* to *Z*.

For geometric isomers in general, each carbon on the double bond must be attached to two different groups, which may or may not be identical to those on the other carbon. If the two groups on each carbon are the same, you can use cis/trans, as explained above, **or** E/Z. If they are not both the same, you can **only** use E/Z. In the example on the right; the left group C_3H_7 is the priority because it has a higher atomic number, and on the right group C_2H_5 is the priority.

(Z) Hept-3-ene	(E) Hept-3-ene
	

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