GEOMETRIC ISOMERS

In geometric isomers the atoms are connected in the same manner – i.e. if we look at each C atom, the groups attached to the C are the same. The only difference is the location of groups with the respect to a ring or C=C bond. The groups can be on the same side (cis-) or the groups can be on opposite side (trans-) of the plane of the ring or the C=C bond.

Geometric isomers in cyclic compounds (cycloalkanes)

Examples:

In A, the two methyl groups are on the same side of the ring - the groups are said to be cis groups. In B, the two alkyl groups (a methyl and an ethyl group) are on opposite sides of the ring- the groups are said to be trans groups.

Geometric isomers in alkenes

If we evaluate alkenes we look at the groups attached to each C of the C=C.

Consider the compounds below:

In our discussions below we only look at the groups attached to each C of the C=C bond.

If we look at compound D, then we have to compare two H’s on the left C with the H and a CH₃ group on the right C. We see that the CH₃ group is on the same side of the one H but it is also on the opposite side of the other H - that means the structure is neither cis or trans.

N.B. If an alkene molecule has a structure where a C atom of the C=C bond has two of the same groups or atoms, then there are no trans or cis isomers for that compound.
Is we consider compounds, E and H, we see that the two C=C bonds have the same groups attached to it. The difference is that the groups are oriented differently around the C=C bonds. The compounds, E and H, are thus geometric isomers. In compound E, the two CH₃ groups are on the same side of the C=C and therefore the structure is the cis isomer. In compound H the two CH₃ groups are on opposite sides of the C=C and therefore the structure is the trans isomer.

Below are examples where the double bond is classified. The same groups on C=C bonds are compared (which are H’s) for those C=C bonds that can be classified as either cis- or trans.

Neither cis- or trans

Neither cis- or trans

Neither cis- or trans

Trans

Trans

Neither cis- or trans

Cis

E/- Z-Nomenclature:

If we consider the molecule below we see that the left C (of the C=C bond) has a CH₃ group and a CH₂CH₃ group attached to it and the other C (of the C=C bond) has a Br and a CH₂CH₂CH₃ group attached to it.

CH₃
CH₂CH₂CH₃
CH₃CH₂
Br

The Z/E nomenclature is used when the groups attached to the C=C bond are different. This notation assigns priority order to the groups attached to the each carbon of the C=C bond. The priority is assigned in terms of atomic number of atom attached to C=C bond – the higher atomic number is assigned the higher priority. If the atoms are the same then you look at the next point of difference.
Numbering the longest C chain from the side to give the C=C the lowest possible number:

To assign the E- / Z- notation, we look at the groups attached to the two C’s of the C=C bond.

**On C-3:** -CH₃ and -CH₂CH₃

Comparing the two C’s that are attached to C-3, we see that the first C of the -CH₂CH₃ group is bonded to 2 H’s and a CH₃ group whereas for the -CH₃ group the C is only bonded to 3 H’s. Therefore, the **-CH₂CH₃ has higher priority**

**On C-4:** -Br and -CH₂CH₂CH₃;

We compare the Br with a C and hence the **Br has higher priority**

The two priority groups are **on the SAME side of the C=C double bond → Z-isomer.**

To obtain the IUPAC name of the compound:

According to the IUPAC convention, the longest continuous carbon chain has 7 C’s → heptane but there is a C=C bond in the chain → change the ending from ‘ane’ to ‘ene’. Begin numbering at the end of the C-chain to give the C=C the lowest number → 3-ene. The substituents are: at C-3 a CH₃ group → 3-methyl; at C-4 a Br atom → 4-bromo; name the substituents in alphabetical order. Combining these with the Z- classification, gives:

**(Z)-4-bromo-3-methylhept-3-ene**

If we consider the geometric isomer of the above compound:

The two priority groups, **Br and CH₂CH₃ are on opposite sides of the C=C bond.** This is the **E isomer** and the IUPAC name is: **(Z)-4-bromo-3-methylhept-3-ene**

**If you have to draw the E-/ Z- isomers of an alkene and give the IUPAC name, then you CANNOT name it as cis- or trans-.**