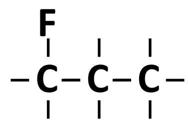
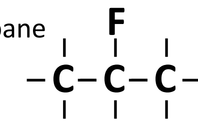
ISOMERS

As we discussed in class, there are three types of isomers.

Structural isomers: These are the main type of isomer we have been discussing and drawing this unit. Structural isomers are two compounds that have the same formula but different arrangements of how the atoms are bonded together. For example, 1-fluoropropane

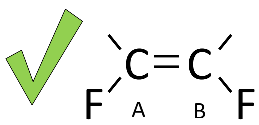


and 2-fluoropropane



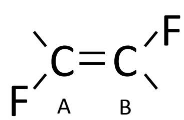
would be structural isomers: one is a 3-carbon chain with a fluorine atom on the first (end) carbon. The second is a 3-carbon chain with a fluorine atom on the second (middle) carbon. The first several questions refer to just structural isomers.

Geometric isomers: These have the same structure but different geometric configurations. What makes them different is that double bonds (and cyclo-structures) do not allow rotation. Thus consider two atoms (call them A and B) on opposite sides of a double bond (or *any* two atoms in a cyclo-structure); if atom A has two different things attached to it and atom B does as well, then there **will be geometric isomerism**. Examples:

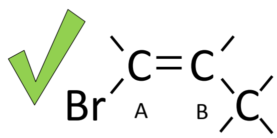


C-atom A has two different things: one H and one F.	C-atom B has two different things: one H and one F.

So this molecule will have a geometric isomer that looks like this:

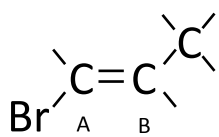


Note: the top one is called **cis-1,2-difluoroethene** and the bottom one is called **trans-1,2-difluoroethene**

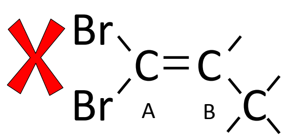


C-atom A has two different things: one H and one Br.	C-atom B has two different things: one H and one CH_3.

So this molecule will have a geometric isomer that looks like this:

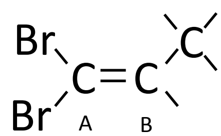


Note: the top one is called **cis-1-bromo-1-propene** and the bottom one is called **trans-1-bromo-1-propene**

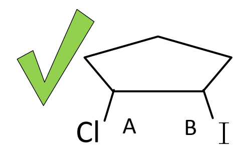


C-atom A does **NOT** have two different things: they're both Br's	C-atom B has two different things: one H and one CH_3.

Because atom A did NOT have two different things attached, this

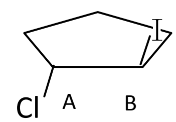


Note that this is just a repeat of the top molecule – just flipped over



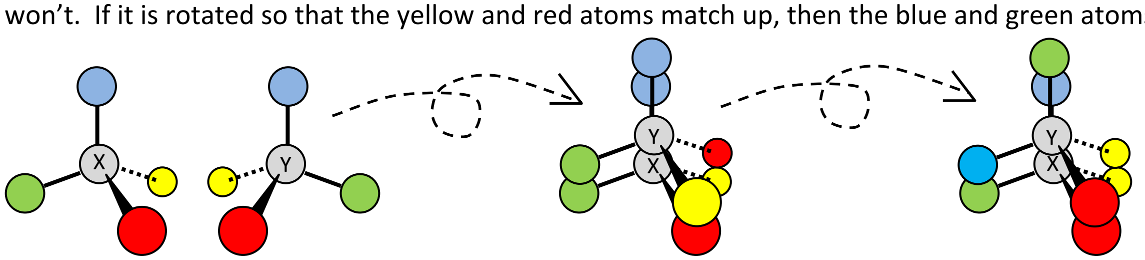
C-atom A has two different things: one H and one Cl.	C-atom B has two different things: one H and one I.

So this molecule will have a geometric isomer that looks like this:



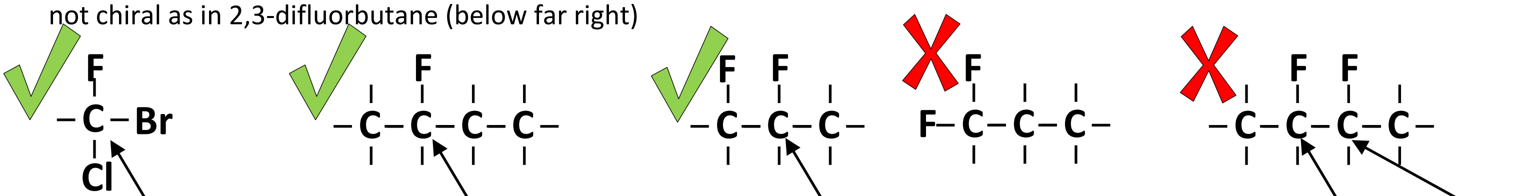
Note: the top one is called **cis-1-chloro-2-iodocyclopentane** and the bottom one is called **trans-1-chloro-2-iodocyclopentane**
NOTE ALSO: The C atoms do not have to be adjacent (directly next to each other) on the ring. This would have worked just as well with 1-chloro-3-iodocyclopentane

Optical isomers: These have the same structure and the same geometric configurations: only one is the mirror image of the other, and they are not superimposable. That is if you tried to lay one molecule directly on top of the other, the atoms would not all be in the same place. Notice the two molecules below labeled X and Y. See how Y is a mirror image of X. But if Y is rotated 180° and placed on top of X, the blue and green atoms will match up, but the red and yellow ones won't. If it is rotated so that the yellow and red atoms match up, then the blue and green atoms won't.



Molecules like this are called optical isomers, or sometimes "enantiomers." And this effect is known as "chirality." Take a brief look at http://en.wikipedia.org/wiki/Chirality_(chemistry). The naming of these compounds is a little more complicated, and there are different conventions. Some refer to them as right-handed and left-handed (Think of it: your two hands are identical, and yet they're not: they are non-superimposable mirror images of one another!) One interesting thing these molecules do is that if they are in solution and a beam of light is shined through that solution, that light beam gets rotated. One enantiomer rotates it to the right (clockwise) and the other rotates it to the left (counter-clockwise). A lot of biomolecules and enzymes are enantiomers. One will work in a certain reaction and the other one will not. Think of it as a lock and key. If you replaced you key with its mirror image, that key may or may not still work in that lock: it depends on how complex the shape of the key is. (Most keys used today will not work.) It's also fun to apply this ideal of chirality to everyday objects. A T-shirt for example (with no writing on it) would not be chiral. If someone replaced one of your t-shirts with its mirror image, you wouldn't notice. But if there were a pocket on one side, then the t-shirt would be chiral, and you would be able to distinguish the original shirt from its mirror image. How about a dress shirt (no pocket)? That would be chiral because you would notice the buttons are on the wrong side. By the way, that is one major difference between men's dress shirts and woman's dress shirts/blouses. Men's have their buttons on the right, and woman's have theirs on the left. (Many people don't know that!)

Back to chemistry! One easy way to determine if a molecule is chiral or not is to see if it has a carbon atom with four different "things" attached. If it does, then it will be chiral – that is, it will have a non-superimposable mirror image – in other words: an optical isomer. This is sometimes easy to spot like in bromochlorofluoromethane (below left). Other times it is more subtle as in 2-fluorobutane or 1,2-difluoro propane (below second and third). Also note: this rule is not hard and fast: if a molecule has two such C atoms and they are symmetrical, then they cancel out and the molecule is not chiral as in 2,3-difluorbutane (below far right)



Notice how this C atom has four different things attached: a bromine, a fluorine, a chlorine and a hydrogen. Thus it **will** have an optical isomer.

Notice how this C atom has four different things attached: a CH_3 (methyl) to the left, a fluorine on top, a CH_2CH_3 (ethyl) to the right and a hydrogen on the bottom. Thus it **will** have an optical isomer.

Notice how this C atom has four different things attached: a CH_2F to the left, a fluorine on top, a CH_3 to the right and a hydrogen on the bottom. Thus it **will** have an optical isomer.

Notice how none of the C atoms in this molecule have four different things attached, so it will **not** have an optical isomer.

Notice how this C atom has four different things attached: a CH_3 to the left, a fluorine on top, a $CHFCH_3$ to the right and a hydrogen on the bottom. BUT, since the C atom right next to it has the exact same thing, these two C's essentially cancel each other out and if you were to build a model for this molecule, you would quickly see that its mirror image would be superimposable, so this molecule will not have an optical isomer.