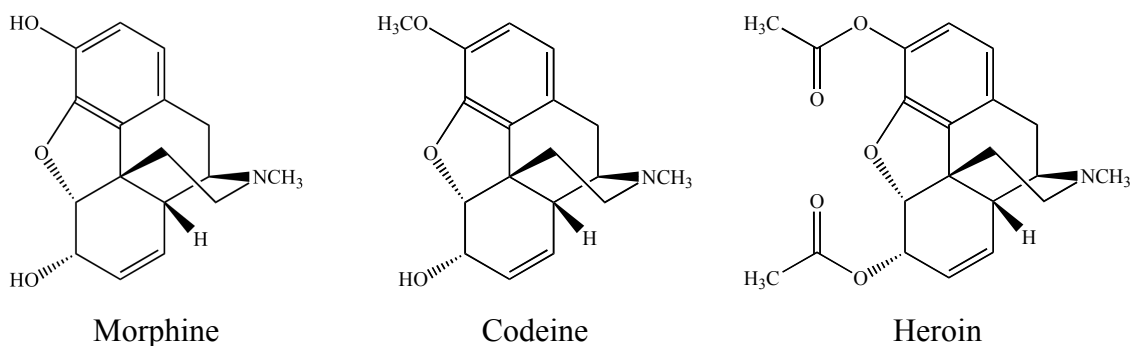


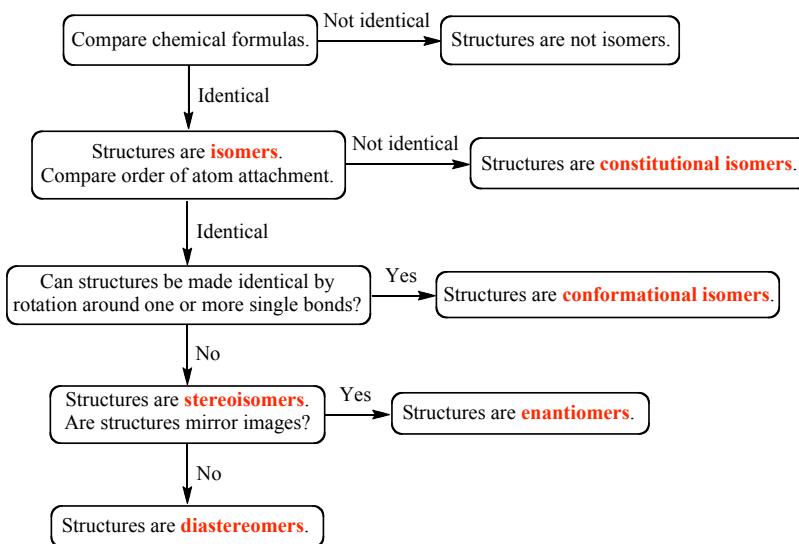
Stereochemistry Tutorials: Classification of Isomers

Definitions for vocabulary words can be found in the *Illustrated Glossary of Organic Chemistry*, available on the course web site.

The structures of organic molecules vary widely. Within this variety there are similarities in structure that result in similarities in chemical, physical, and/or biological properties. If one can understand the properties of a compound based on its structure, then we might be able to predict properties of a compound with similar structure. For example, we know that the opiate alkaloid morphine is an analgesic, and so we expect (correctly, as it turns out) that compounds with similar chemical structure might also have analgesic properties. This is true for codeine and heroin; note their structural similarities to morphine.



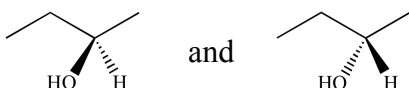
The power to predict the properties of a substance based on its similarity to other substances of known structure is a powerful tool for organic chemists, especially so for the discovery of new pharmaceuticals. It is useful, therefore, for you to learn to recognize various categories of structural relationships, namely isomers, constitutional isomers, conformational isomers, stereoisomers, enantiomers, and diastereomers. (This is a good time to review definitions of these structural types.) A flowchart that shows the relationship of these isomer types can be useful tool for their categorization.



Stereoisomers are also called configurational isomers. This makes the process of classifying isomers into a 'con game': The isomers may be *constitutional*, *conformational*, or *configurational*.

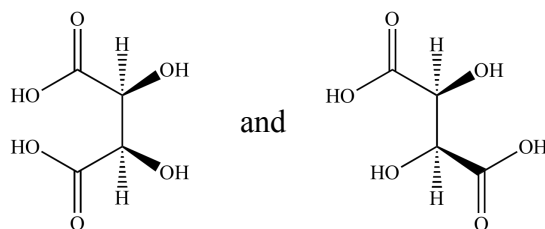
Now let's work a few examples to see how this 'con game' goes.

Example 1: Using the isomers classification flowchart above, categorize the following molecules using all the terms that apply: Isomers, constitutional isomers, conformational isomers, stereoisomers, enantiomers, and diastereomers. *Molecular models can be very useful for this task.*



Solution: The molecules have the same chemical formula ($C_4H_{10}O$) but are not identical so they are isomers. Examining the order of atom attachment we see they have the same sequence of connectivity (a four-carbon chain with a hydroxyl group on the second carbon), so they are not constitutional isomers. Experimenting with models reveals the molecules cannot be made identical by rotation around bonds, so they are not conformational isomers. By process of elimination, these molecules are stereoisomers. When working with the models you may have noticed that the molecules are mirror images, so they are enantiomers.

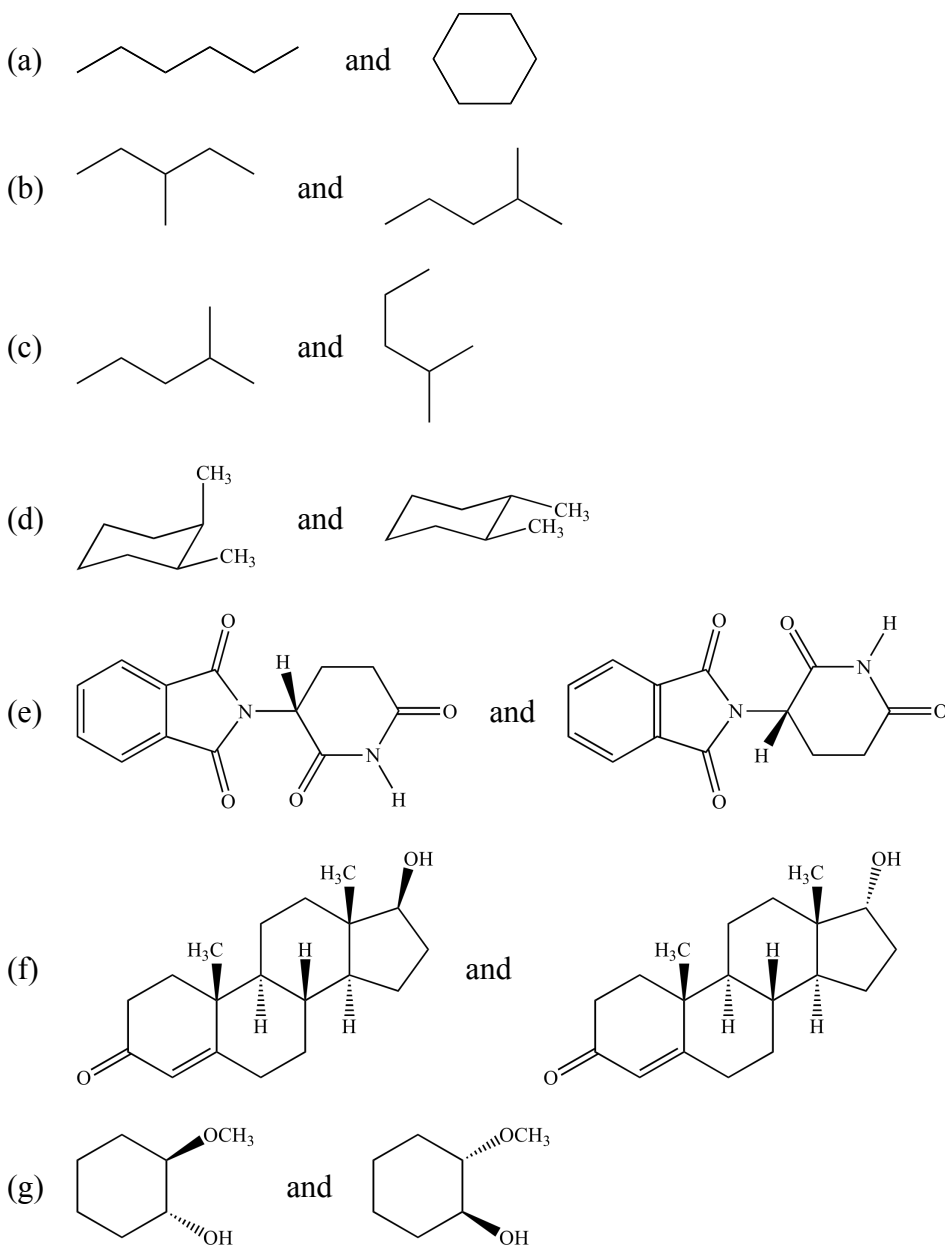
Example 2: Using the isomers classification flowchart above, categorize the following molecules using all the terms that apply: Isomers, constitutional isomers, conformational isomers, stereoisomers, enantiomers, and diastereomers. *Molecular models can be very useful for this task.*



Solution: The molecules have the same chemical formula ($C_4H_6O_6$) but are not identical so they are isomers. Examining the order of atom attachment we see they have the same sequence of connectivity (carbon with H, COOH, and OH attached to another carbon with H, COOH, and OH), so they are not constitutional isomers. Experimenting with models reveals the molecules cannot be made identical by rotation around bonds, so they are not conformational isomers. By process of elimination, these molecules are stereoisomers. When working with the models you may have noticed that the molecules are not mirror images, so they are diastereomers. (When examining models to detect mirror image relationships, it is often necessary to consider different conformations. Try to rotate the molecule and its bonds so that obvious groups can be moved into a mirror image if possible. In this case you might use the carboxylic acid groups for this purpose.)

Exercises

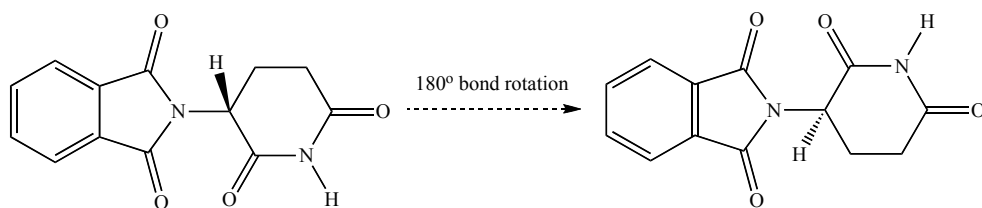
Using the isomers classification flowchart given above, categorize each pair of structures using all the terms that apply: Identical, isomers, constitutional isomers, conformational isomers, stereoisomers, enantiomers, and diastereomers. *Molecular models can be very useful for this task.*



Solutions to Exercises

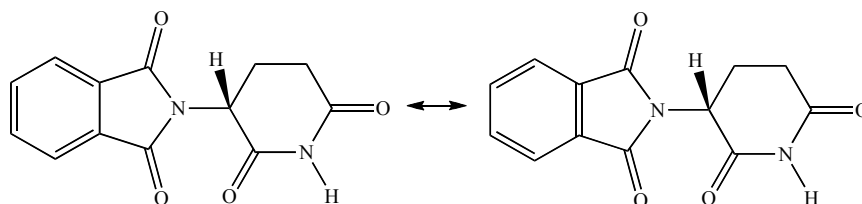
(a) These molecules do not have the same chemical formula (C_6H_{14} and C_6H_{12}) so they are not isomers.

- (b) These structures have the same chemical formula (C_6H_{14}) so they **might be isomers** (we have to verify that they are not identical before we can conclude they are isomers). They do not have the same sequence of atom connections (the methyl group on the third carbon versus the second carbon) so they are **constitutional isomers**.
- (c) These structures have the same chemical formula (C_6H_{14}) so they **might be isomers**. They have the same sequence of atom connections (a five-carbon chain with a methyl group attached to the second carbon) so they are **not constitutional isomers**. They can be interconverted (i.e., made identical) by rotation around a single bond, followed by rotation of the entire structure, so they are **conformational isomers**. (Verify this with a model). *Some textbooks do not treat conformational isomers as a type of isomers, and will therefore label these molecules as identical.*
- (d) These structures have the same chemical formula (C_8H_{16}), so they are **might be isomers**. They have the same sequence of atom connections (a cyclohexane ring with methyl groups on adjacent carbons) so they are **not constitutional isomers**. The structures cannot be interconverted by rotation around one or more single bonds (verify this with a molecular model) so they are **stereoisomers (configurational isomers)**. They are not mirror images in any conformations (verify with molecular models) so they are **diastereomers**.
- (e) At first inspection, we see the molecules are very similar. Rotation around one bond makes them even more similar:



The molecules have the same chemical formula ($C_{13}H_{10}N_2O_4$) so they **might be isomers**. The sequence of atom attachments is identical so they are **not constitutional isomers**. They cannot be interconverted by rotation around one or more single bonds, so they are **stereoisomers**. The molecules are nonsuperposable mirror images, so they are **enantiomers**.

Don't be fooled by the positions of the double bonds (i.e., resonance contributors).



Remember that resonance contributors are alternate ways of representing the same structure. It does not matter which resonance structure you use when analyzing isomer types.

- (f) These molecules have the same chemical formula ($C_{19}H_{28}O_2$) so they **might be isomers**. The sequence of atom attachment is identical so they are **not constitutional isomers**. The molecules cannot be interconverted by rotation around one or more single bonds, so they are **not conformational isomers**. The molecules are not mirror images or identical so they are **diastereomers**.
- (g) These molecules have the same chemical formula ($C_7H_{14}O_2$) so they **might be isomers**. They have the same sequence of atom attachment (a cyclohexane ring with OH and OCH_3 on adjacent carbons) so they are **not constitutional isomers**. They cannot be interconverted by rotation around one or more single bonds (carefully verify this with molecular models) so they are **not conformational isomers**. The same molecular models will reveal that these structures are nonsuperposable mirror images, and therefore they are **enantiomers**.