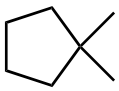
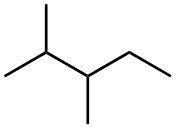
Learning Guide for Chapter 6 - Stereochemistry

I. Stereoisomers containing C=C

What do two compounds which are constitutional isomers have in common? How are they different?

Give the molecular formula and one constitutional isomer for each of the following compounds.





Are these compounds constitutional isomers of each other?

What do two compounds which are stereoisomers have in common? How are the different?

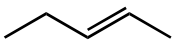
Draw line structures for two different molecules with the condensed structure shown.

$CH_3CH{=}CHCH_3$

What keeps these two compounds from being the same?

Why aren't these two structures the same as the ones above? What relationship do they have?

Draw a constitutional isomer, a stereoisomer, and a conformation of the following compound.



constitutional isomer

stereoisomer

conformation

same formula?

same bonding sequence?

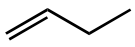
same shape?

same compound?

How many stereoisomers are possible for a compound containing a C=C?

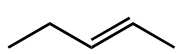
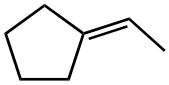
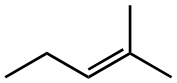
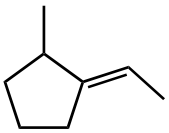
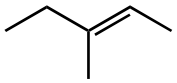
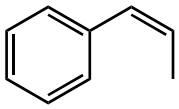
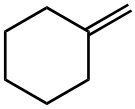
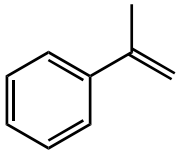
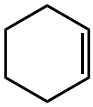
Do all compounds containing a C=C have stereoisomers?

How many stereoisomers does the following compound have? Why?



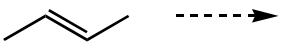
How can you tell if a compound with a C=C will have a stereoisomer?

Determine whether or not the compounds below will have a stereoisomer, and for those that will, draw it.

What is a stereocenter?

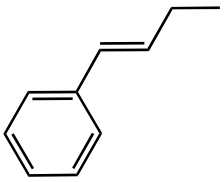
carbon - switch two substituents, get a new compound

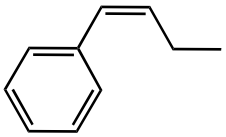


Can a compound containing a C=C have only one stereocenter?

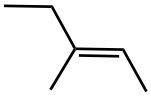
When can we use cis and trans to label the two stereoisomers?

Which of these is cis, and which is trans?

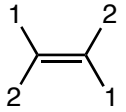


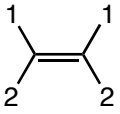


Why can't cis and trans be used on the following compound?

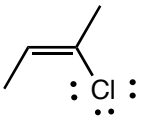


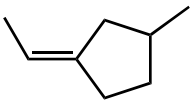
In the following examples, the #1 substituent has priority over the #2 substituent. Which is E and which is Z?

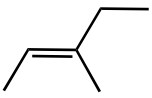


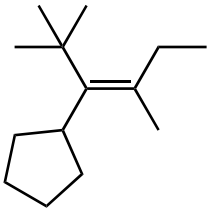


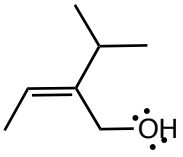
Label the following as E or Z and explain why.

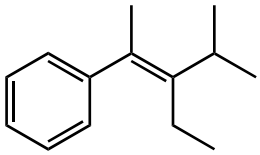










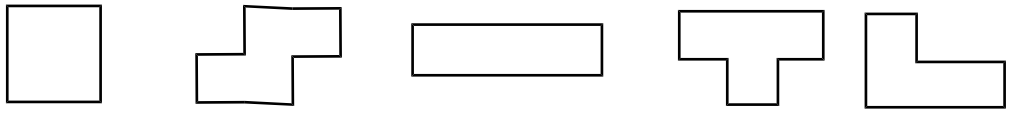


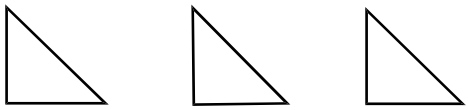
II. Introduction to Chirality

What does it mean to say that an object is chiral? What about achiral?

Many everyday objects are chiral. Consider the following. Are they chiral or achiral? Is the mirror image of the object the same, or different?

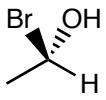
hand	scissors
spoon	gloves
fork	nail
knife	screw
socks	DNA helix
shoes	folding student desk

Tetris shapes 

striped quilt triangles 

How can a molecule be chiral?

Using models, make the compound below. Then construct its mirror image

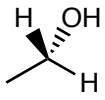


Are they the same (are they superimposable)?

What is the relationship between these two compounds?

Are the central carbon atoms stereocenters?

Construct the compound below, and its mirror image.



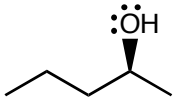
Are these compounds superimposable?

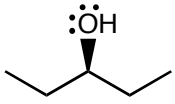
Is the original compound chiral?

Does the original compound have an enantiomer?

How can you determine if a molecule is chiral?

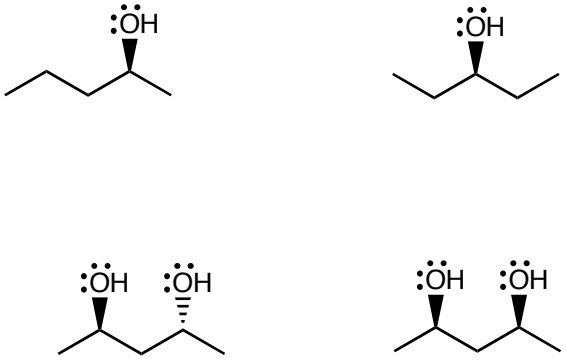
1) Is the mirror image superimposable?



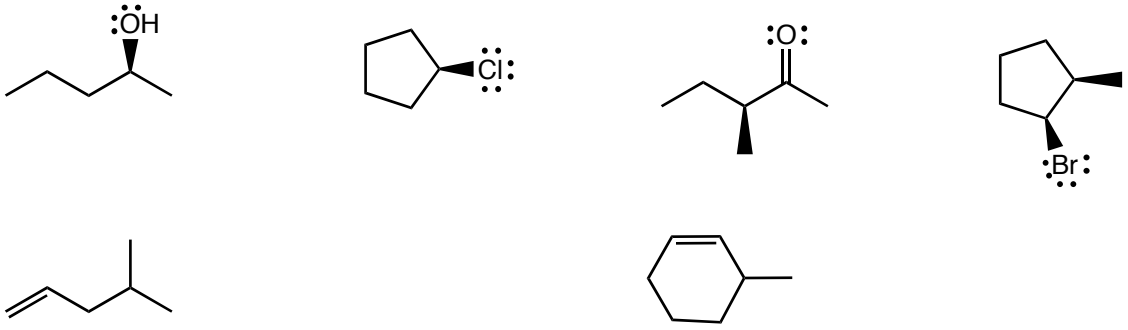


2) Is there a plane of symmetry in the molecule?

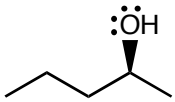
3) How many asymmetric carbons are in the molecule?

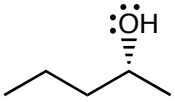


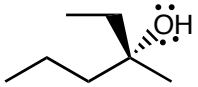
Which of the following molecules are chiral? Which have planes of symmetry? Where are the asymmetric carbons? Where are the stereocenters?



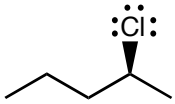
How are enantiomers labeled?

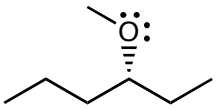


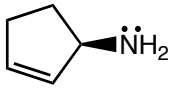


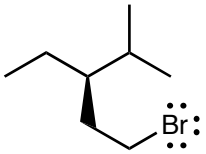


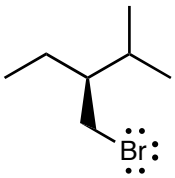
Practice:



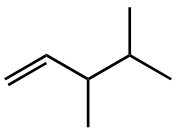


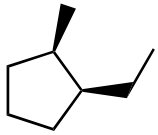


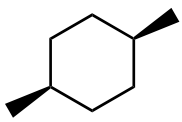




How is this label included in the name?

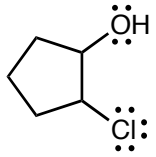






III. Compounds with two or more stereocenters

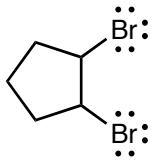
Consider the following compound. How many stereocenters does it have? How many stereoisomers could it have?



Which stereoisomers are enantiomers?

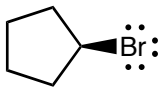
Which stereoisomers are diastereomers?

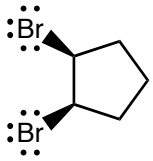
Next, consider the following compound. How many stereocenters does it have? How many stereoisomers does it have?



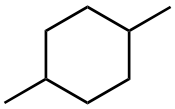
Enantiomers? Diastereomers?

What is the difference between the following compounds?





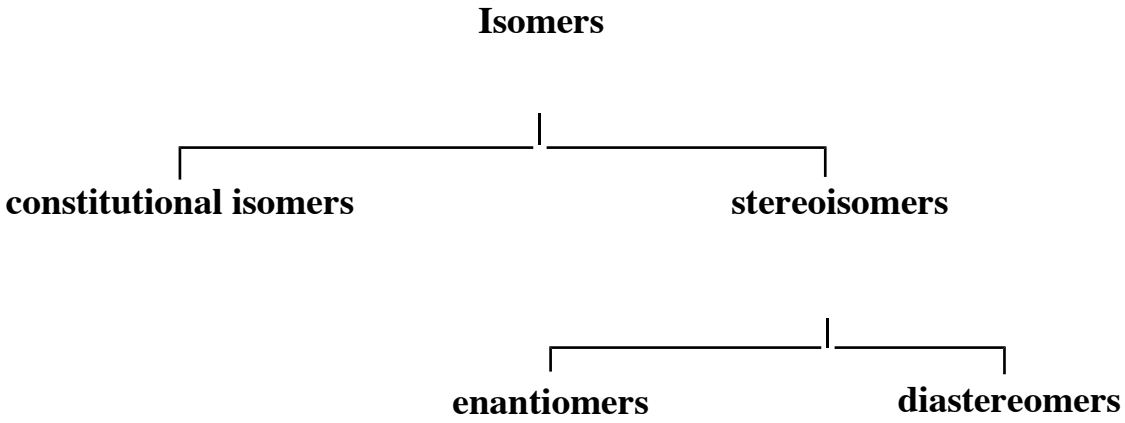
Consider the following compound. How many stereocenters does it have? How many stereoisomers does it have?



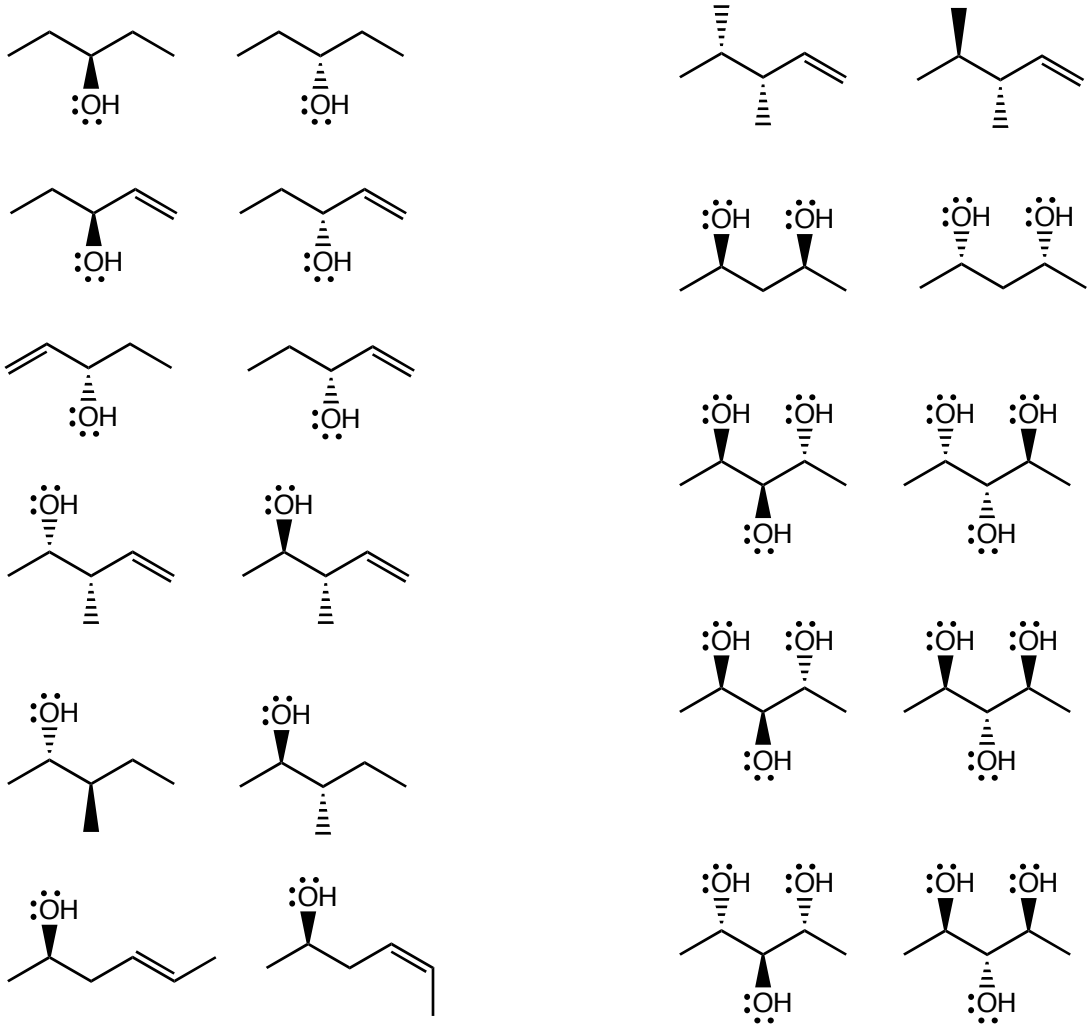
Enantiomers?

Diastereomers?

All of the isomers we have seen so far can be related as follows:



Classify the following compounds as identical, enantiomers, diastereomers, meso, or constitutional isomers.

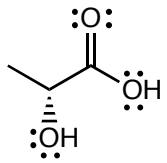


Fischer Projections

When are Fischer projections useful?

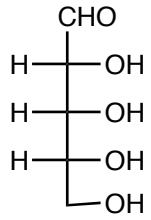
Draw a Fischer projection of the following molecule:

lactic acid



Convert the following Fischer projection to a line structure.

ribose

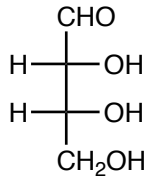


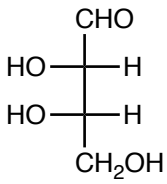
Why are the OH's all on the right in the Fischer projection, but some up and some down on the line structure?

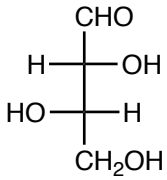
Which shows the relationship between the stereocenters better?

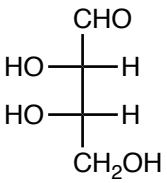
Which is the more stable conformation?

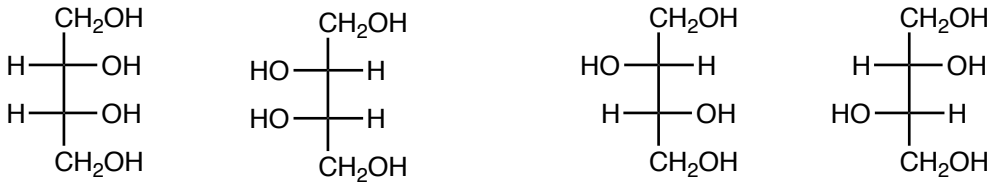
What is the relationship between the following molecules?





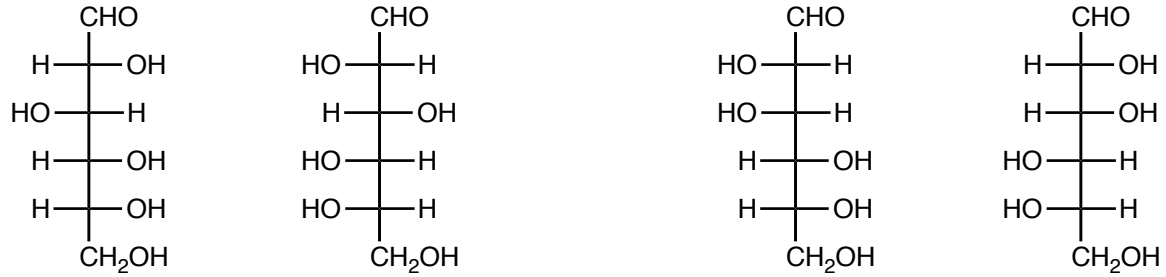






Label each stereocenter as R or S:

Label each of the following molecules as D or L:



What is the relationship between the first two molecules? What about the second two? What about the middle two?

Since D and L only give the stereochemistry of one stereocenter, how can you tell what the rest are?

IV. Physical Properties of Chiral Compounds

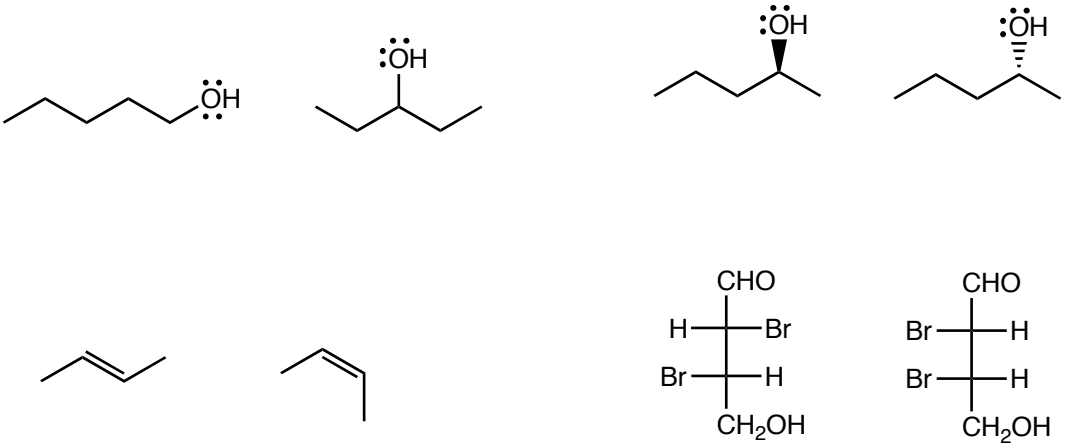
Regular physical properties

What are some of the physical properties that we regularly talk about with organic compounds?

How are the properties of enantiomers related?

How are these properties of diastereomers related?

What is the relationship of the pairs of compounds below? What would you predict about their physical properties?



Why is the odor of a compound an exception to this?

What areas of chemistry are strongly influenced by stereochemistry? Why?

Optical Activity

How is plane polarized light different from ordinary light?

How do you obtain plane polarized light?

What would happen if you put two polarizing filters together and then turned them at right angles?

Why do polarizing sunglasses work?

What happens when polarized light passes through a solution containing chiral molecules?

What is this called?

How is it measured?

What factors affect the optical rotation? Which is the most useful? How do we eliminate the effect of other factors?

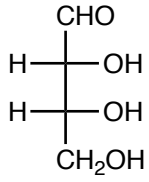
The optical rotation of a compound measured under these conditions is called:

We can use a different concentration or path length and correct for them using what equation? Why does this work?

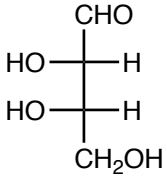
The specific rotation of (S)-2-butanol is -13.5°. If a sample is made by dissolving 6 g of the compound in 40 ml of solvent, and a 2 cm cell was used to measure the optical activity, what angle of rotation will be observed?

If given an observed rotation, how could you figure out the specific rotation?

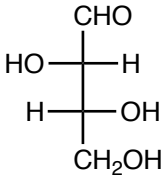
What is the relationship between the following molecules? How would their melting points and specific rotations be related?



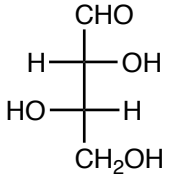
D-erythrose



L-erythrose



D-threose

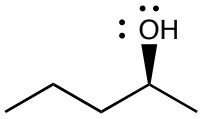


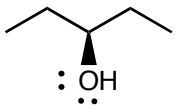
L-threose

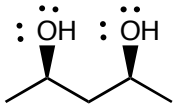
What can you tell about R and S vs. + and - rotations? What can't you tell?

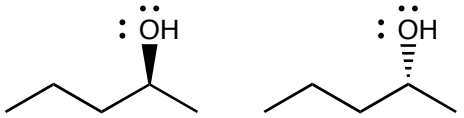
What does it mean to say a solution is optically active?

Would a solution of the following compound(s) be optically active?

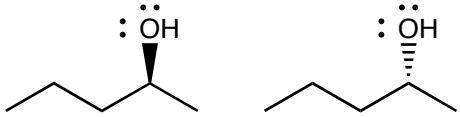
a) 

b) 

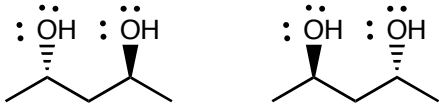
c) 

d) 

5 mol 5 mol

e) 

5 mol 3 mol

f) 

5 mol 5 mol

Why are racemic mixtures common?

If a solution has 40% optical purity, what does this mean?

If a pure enantiomer has an optical rotation of 20º, what rotation will a solution have which has a 40% optical purity?

What equation describes this?

What proportion of enantiomers will give you a 40% optical purity?

If the specific rotation of (S)-2-butanol is 13.75°, and a mixture of (R)- and (S)-2-butanol has a rotation of -6.75, what is the optical purity of the solution? What is the % e.e.? What percentage of the two isomers is present?

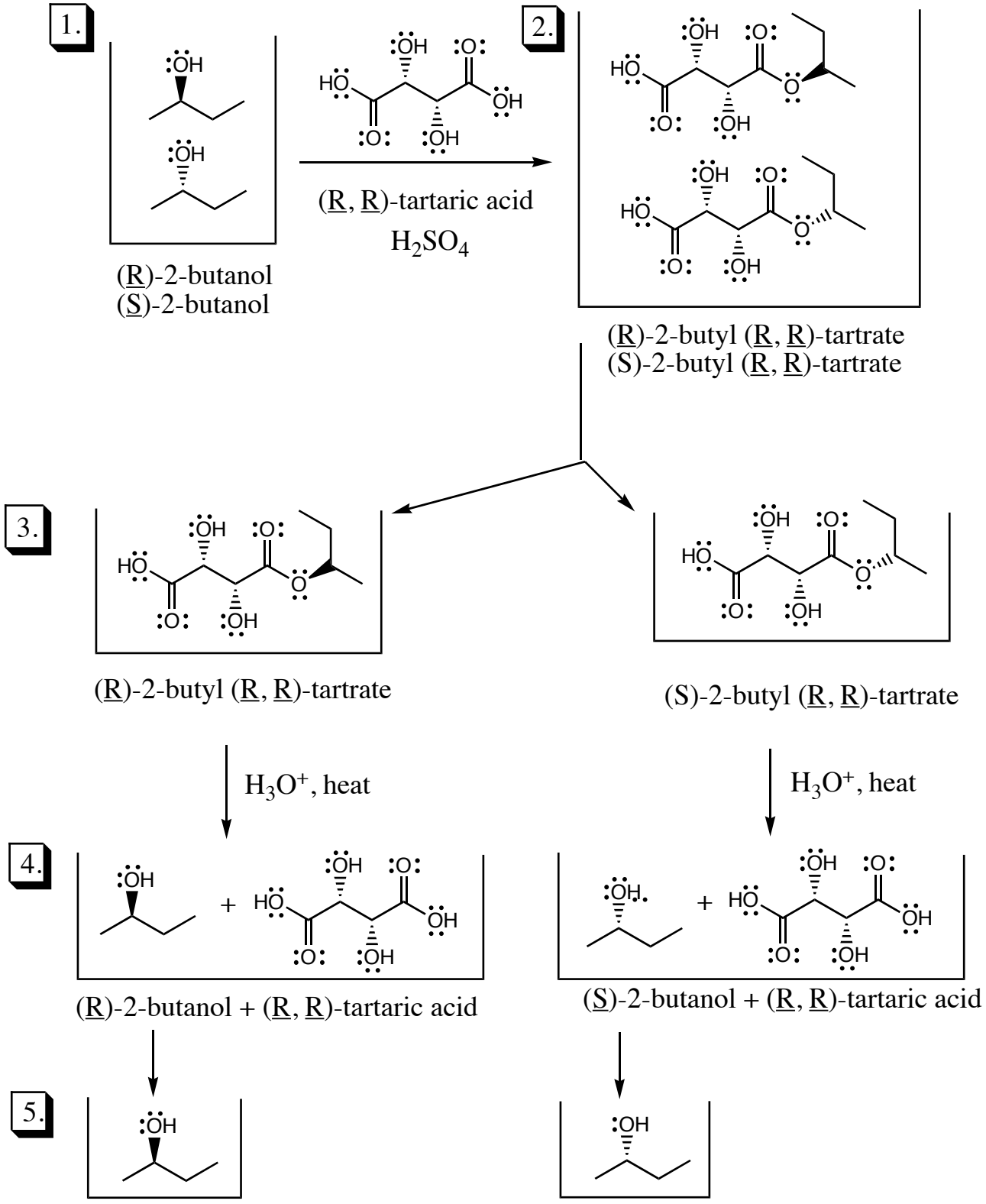
Separation of Enantiomers

Where do enantiomerically pure compounds come from?

Why can't enantiomers be separated by operations like chromatography, distillation, etc?

What must be done to separate them?

Consider the following example:

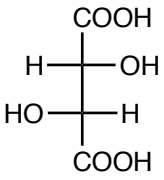


Determining the stereochemical correlation

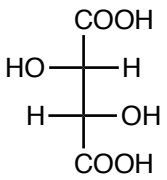
What does it mean to determine the stereochemical correlation for a pair of enantiomers?

Why is this difficult?

+ tartaric acid	- tartaric acid



2R, 3R



2S, 3S

What method has been developed?

Once the stereochemical correlation of one compound has been discovered, how can it be used to determine another without x-ray crystallography?