



**Al-Mustaqbal University**  
**College of Science**



# **Drug Stereochemistry**

**Third Year Students / 2<sup>nd</sup> Semester**

**2025-2026**

## **Nomenclature of Enantiomers**

*By*

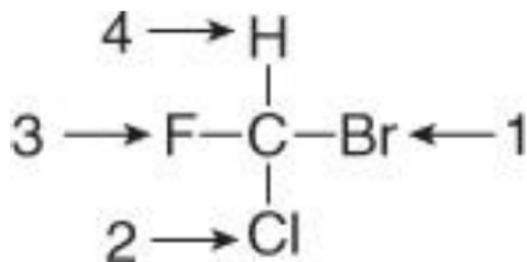
**Prof. Dr. Naser Abdulhasan Naser**

# Chirality and Symmetry

- A stereogenic center is a sufficient but not necessary condition for chirality.
- With one stereogenic center, a molecule will always be chiral.
- With two or more stereogenic centers, a molecule may or may not be chiral.
- Achiral molecules usually contain a **plane of symmetry** but chiral molecules do not.
- A plane of symmetry is a **mirror plane** that cuts the molecule in half, so that one half of the molecule is a reflection of the other half.

# Cahn-Ingold-Prelog System

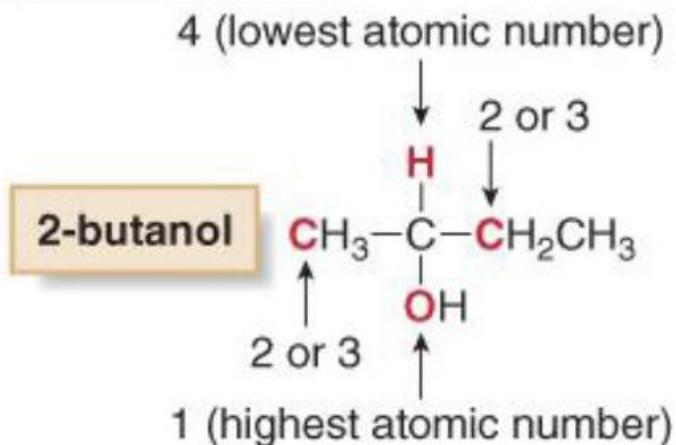
- Naming enantiomers with the prefixes *R* or *S* is called the Cahn-Ingold-Prelog system.
- **Priority rule 1.** The atom of highest atomic number gets the highest priority (1).



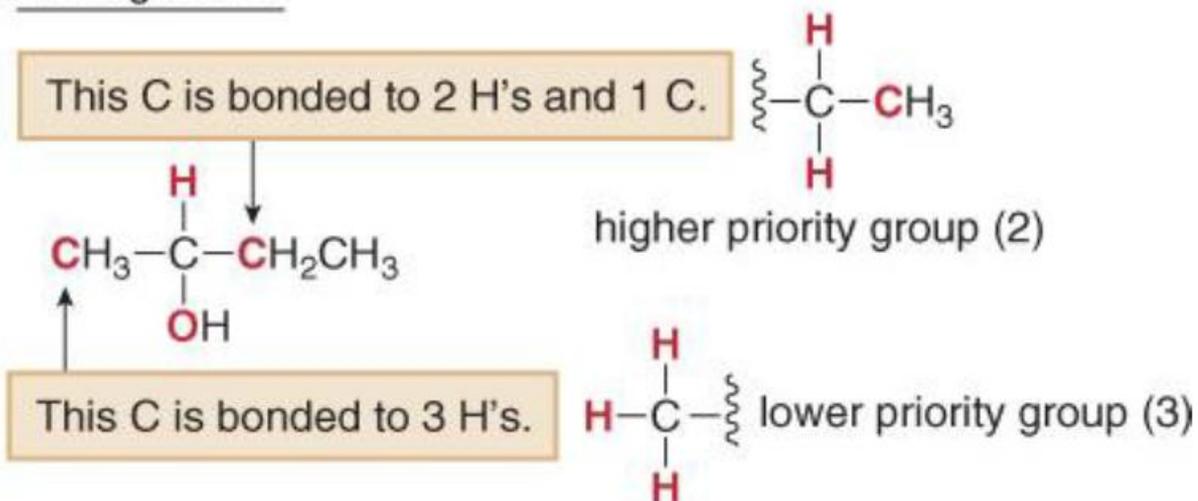
# Cahn-Ingold-Prelog System

- Priority rule 2.** If two atoms on a stereogenic center are the same, assign priority based on the atomic number of the atoms bonded to these atoms. *One* atom of higher atomic number determines the higher priority.

Following rule 1:



Adding rule 2:



# Cahn-Ingold-Prelog System

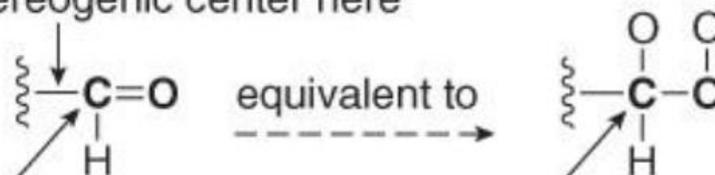
- **Priority rule 3.** If two isotopes are bonded to the stereogenic center, assign priorities in order of decreasing mass number. Thus, in comparing the three isotopes of hydrogen, the order of priorities is:

	<b>Mass number</b>	<b>Priority</b>
T (tritium)	3 (1 proton + 2 neutrons)	1
D (deuterium)	2 (1 proton + 1 neutron)	2
H (hydrogen)	1 (1 proton)	3

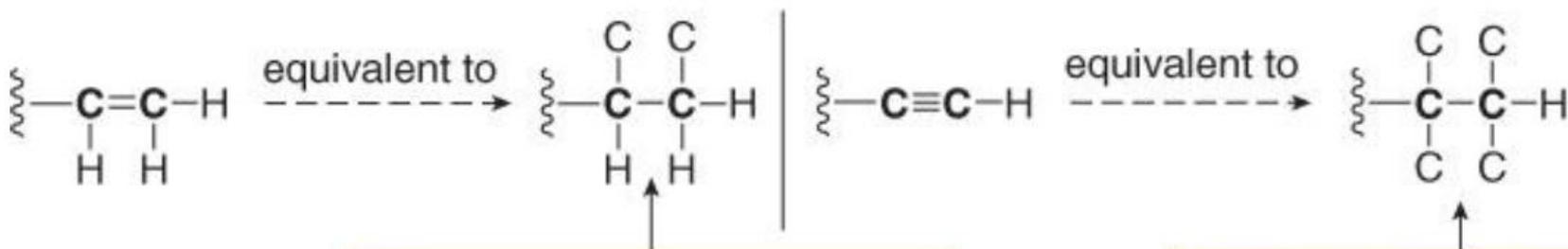
# Cahn-Ingold-Prelog System

- Priority rule 4.** To assign a priority to an atom that is part of a multiple bond, treat a multiply bonded atom as an equivalent number of singly bonded atoms. For example, the C of a C=O is considered to be bonded to two O atoms.

bonded to a stereogenic center here



Consider this C bonded to 2 O's.



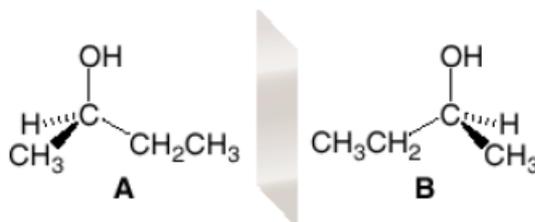
Each atom in the **double** bond is drawn **twice**.

Each atom in the **triple** bond is drawn **three** times.

# Cahn-Ingold-Prelog System

## How To Assign *R* or *S* to a Stereogenic Center

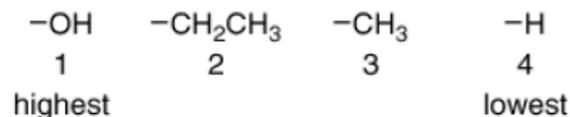
Example Label each enantiomer as *R* or *S*.



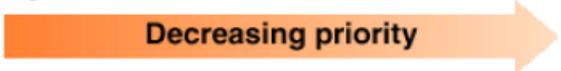
two enantiomers of 2-butanol

Step [1] Assign priorities from 1 to 4 to each group bonded to the stereogenic center.

- The priorities for the four groups around the stereogenic center in 2-butanol were given in Rule 2, on page 172.



Decreasing priority

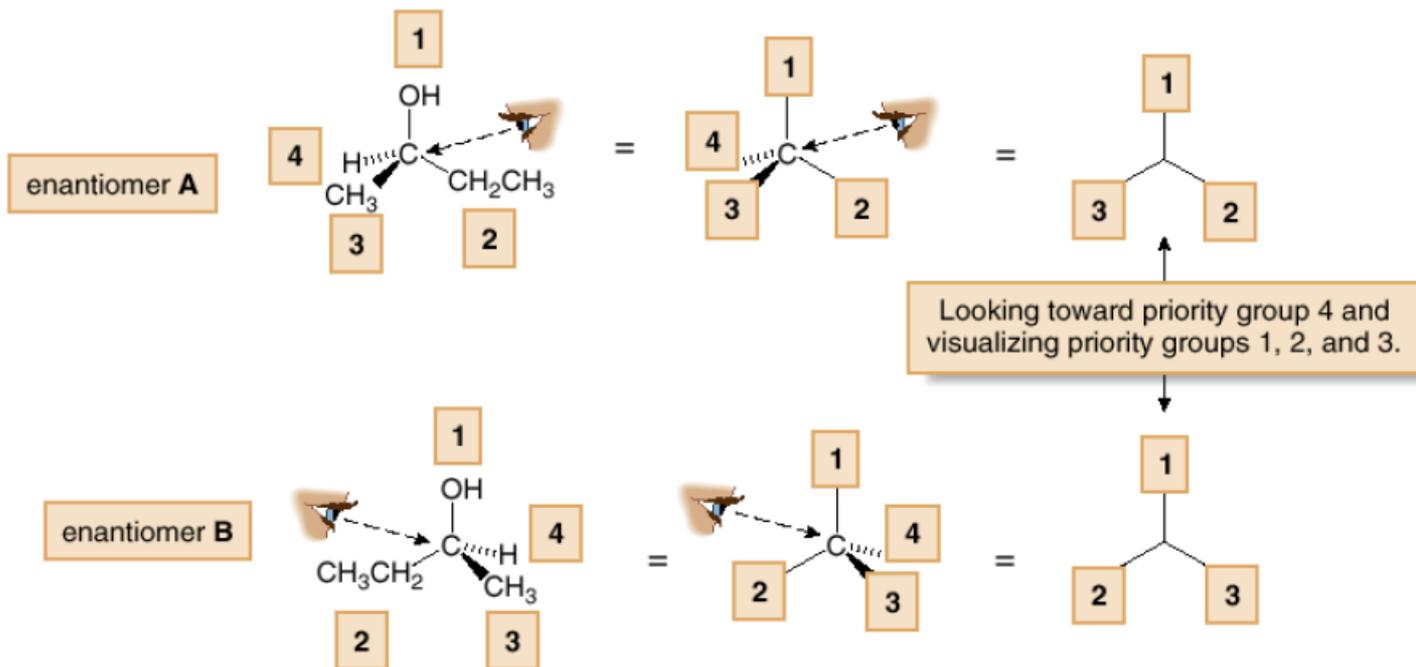


# Cahn-Ingold-Prelog System

## How To, continued . . .

Step [2] Orient the molecule with the lowest priority group (4) *back* (on a *dash*), and visualize the relative positions of the remaining three groups (priorities 1, 2, and 3).

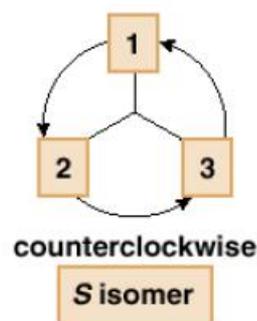
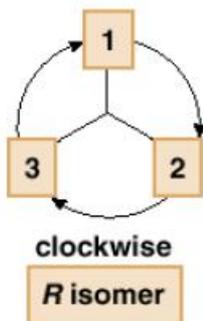
- For each enantiomer of 2-butanol, look toward the lowest priority group, drawn behind the plane, down the C–H bond.



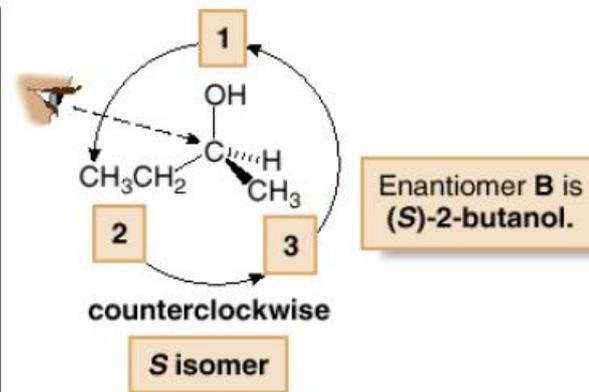
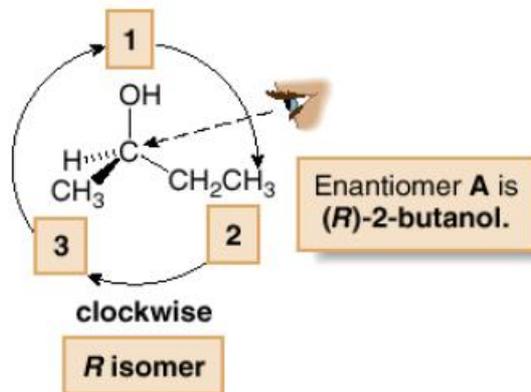
# Cahn-Ingold-Prelog System

Step [3] Trace a circle from priority group 1 → 2 → 3.

- If tracing the circle goes in the **clockwise** direction—to the right from the noon position—the isomer is named **R**.
- If tracing the circle goes in the **counterclockwise** direction—to the left from the noon position—the isomer is named **S**.



- The letters *R* or *S* precede the IUPAC name of the molecule. For the enantiomers of 2-butanol:



## 1.7 NOMENCLATURE OF OPTICAL ISOMERS

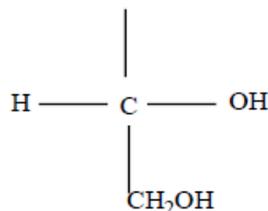
---

Following three nomenclatures are used for optically active compounds:

### 1.7.1 D, L SYSTEM OF NOMENCLATURE

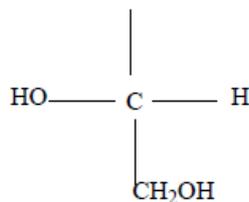
This nomenclature is mainly used in sugar chemistry or optically active polyhydric carbonyl compounds. This is a relative nomenclature because all the configurations described with respect to glyceraldehydes.

All sugars whose Fischer projection formula shows the OH group on the right hand side of the chiral atom belong to the D-series.



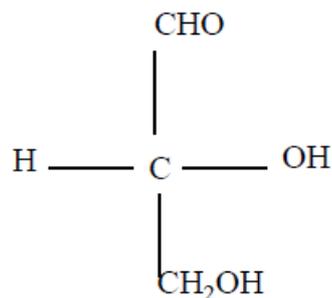
D-series.

Similarly, if OH is on the left hand side, then the sugar belongs to the L-series.

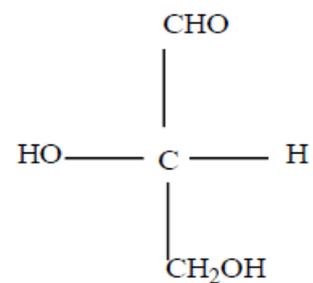


L-series

Examples:



D(+) glyceraldehyde

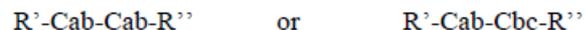


L(-) glyceraldehydes

- 
- It must be noted that there is no relation between sign of rotation and (+, - or *d,l*) and configuration (D and L) of enantiomer.
  - Any compound that can be prepared from, or converted in to D(+) glyceraldehydes will belong to D-series and similarly any compound that can be prepared from, or converted in to L(-) glyceraldehydes will belongs to the L-series.

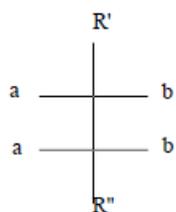
### 1.7.2 ERYTHRO AND THREO SYSTEM OF NOMENCLATURE

This nomenclature is mainly used only in those compounds which have only two chiral carbons and the following structures:

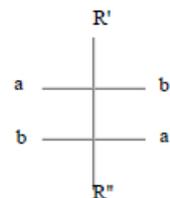


*i.e.* out of six substituent on two asymmetric carbons, at least one should be same in both the carbons.

When two like groups in fisher projection formula are drawn on the same side of vertical line, the isomer is called *erythro* form; if these are placed on the opposite sides the isomer is said to be *threo* form.

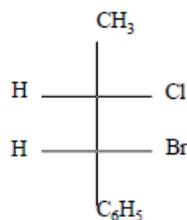


*erythro* form

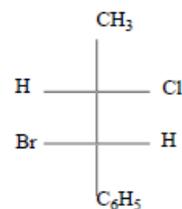


*threo* form

Following are some examples of *threo* and *erythro* form.



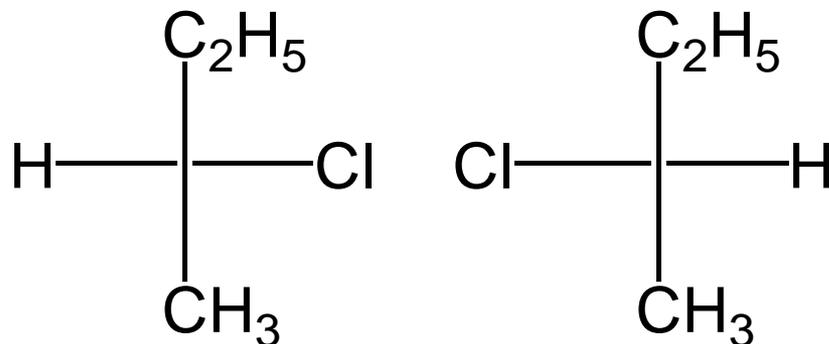
*erythro* form



*threo* form

# How do we “name” an enantiomer?

A problem.....How can we look at two Lewis structures and decide if they represent two identical compounds or a pair of enantiomers? How can we name them?



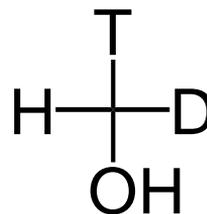
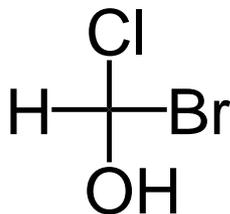
Let's take a drive through the Alps with....

R.S. Cahn, C.K. Ingold et V. Prelog, *Experientia*, 12, 81 (1956)

# Cahn - Prelog - Ingold rules

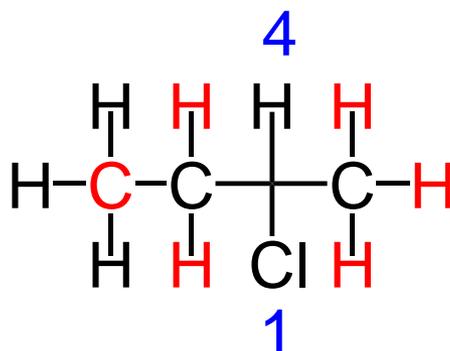
**Step 1:** assign a priority to the 4 atoms or groups of atoms bonded to the tetrahedral stereogenic centre:

1. If the 4 atoms are all different, priority is determined by atomic number. The atom of higher atomic number has the higher priority.



# Determination of priority

2. If priority cannot be determined by (1), it is determined by a similar comparison of atoms working out from the stereocentre.

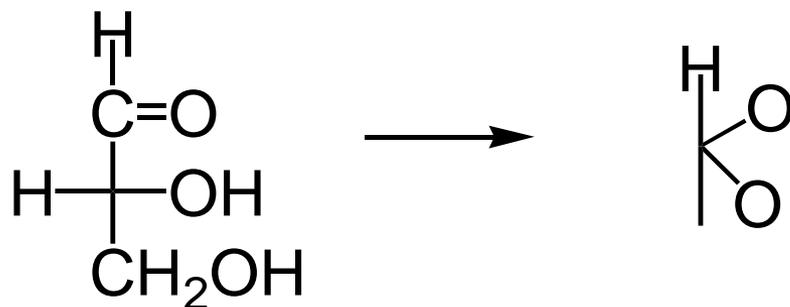


In the methyl group, the second atoms are H, H, H whereas in the ethyl group, they are C, H, H.

The priority sequence is therefore Cl,  $\text{C}_2\text{H}_5$ ,  $\text{CH}_3$ , H.

# Cahn - Prelog - Ingold rules

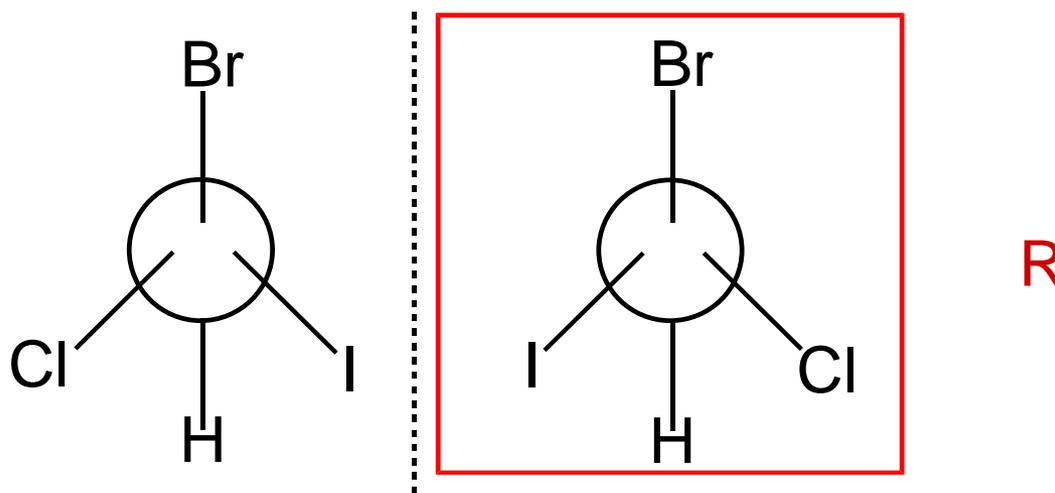
3. A double or triple bond to an atom, **A**, is considered as equivalent to two or three single bonds to **A**:



The sequence is therefore -OH, -CHO, -CH<sub>2</sub>OH, -H.

# Step 2

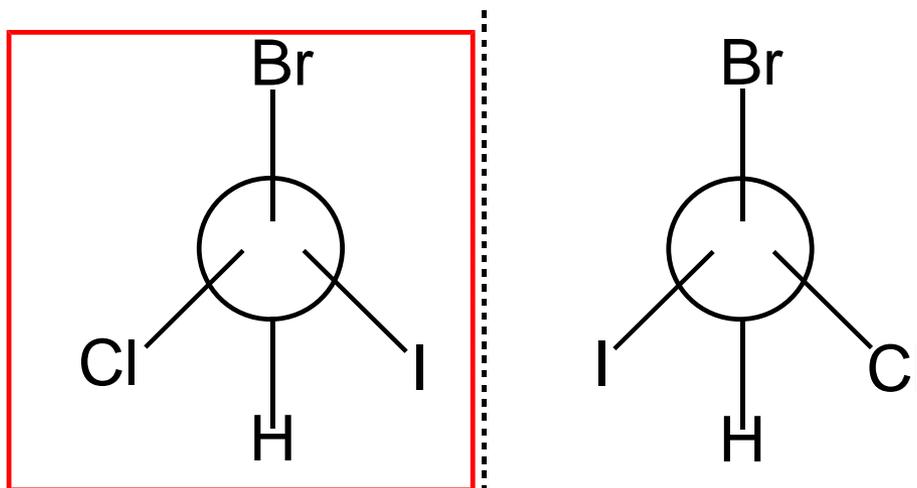
Arrange the molecule so that the group of lowest priority is pointing away from you and observe the arrangement of the remaining groups:



If, on going from the group of highest priority to that of second priority and then to the group of third priority, we go in a clockwise direction, the enantiomer is designated (R).

# Step 2

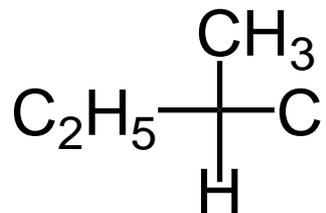
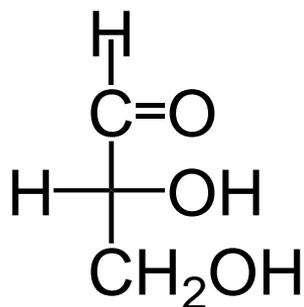
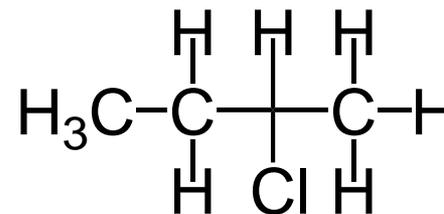
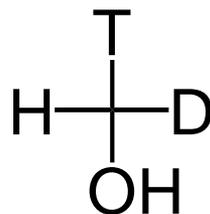
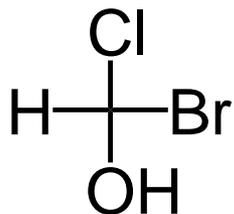
(S)



If the direction is counterclockwise, the enantiomer is designated (S).

Thus the complete name for one of the enantiomers of 2-chlorobutane is (R)-2-chlorobutane.

# R or S?



# Problems

Try problems 5.11 and 5.12, page 206, and 5.13 on page 208 of Solomons and Fryhle.

# Properties of enantiomers

a) Physical: Enantiomers have identical physical properties with the exception that they rotate the plane of polarized light in opposite directions although  $|\alpha|$  is identical.

b) Chemical: They have identical chemical properties except for their reaction with reagents which are, themselves, optically active. In this case, reaction rates differ and depend on which enantiomer of the reagent is used.

(+)-Glucose is central to the fermentation process whereas (-)-glucose doesn't react!