Properties of Chiral Molecules: Optical Activity
A substance is optically active if it rotates the plane of polarized light.

In order for a substance to exhibit optical activity, it must be chiral and one enantiomer must be present in excess of the other.
Light

has wave properties
periodic increase and decrease in amplitude of wave
optical activity is usually measured using light having a wavelength of 589 nm, this is the wavelength of the yellow light from a sodium lamp and is called the D line of sodium.
ordinary light consists of many beams vibrating in different planes

plane-polarized light consists of only those beams that vibrate in the same plane
Polarization of light
Polarization of light

Nicol prism
Polarization of light

Nicol prism
Rotation of plane-polarized light
Rotation of plane-polarized light
Rotation of plane-polarized light
Rotation of plane-polarized light
observed rotation (\( \alpha \)) depends on the number of molecules encountered and is proportional to:

path length (\( l \)), and

concentration (\( c \))
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- path length ($l$), and
- concentration ($c$)

therefore, define specific rotation [$\alpha$] as:

$$[\alpha] = \frac{100 \alpha}{cl} = \frac{\text{concentration (g/100 mL)}}{\text{length in decimeters}}$$
A mixture containing equal quantities of enantiomers is called a *racemic mixture*.

A racemic mixture is optically inactive \((\alpha = 0)\).

A sample that is optically inactive can be either an achiral substance or a racemic mixture.
an optically pure substance consists exclusively of a single enantiomer

\[
\text{enantiomeric excess} = \frac{\% \text{ one enantiomer} - \% \text{ other enantiomer}}{100}
\]

\[
\% \text{ optical purity} = \text{enantiomeric excess}
\]
7.5
Absolute
and
Relative Configuration
Relative configuration compares the arrangement of atoms in space of one compound with those of another.

Absolute configuration is the precise arrangement of atoms in space.
Relative configuration compares the arrangement of atoms in space of one compound with those of another. Until the 1950s, all configurations were relative.

Absolute configuration is the precise arrangement of atoms in space. We can now determine the absolute configuration of almost any compound.
No bonds are made or broken at the stereogenic center in this experiment. Therefore, when (+)-3-buten-2-ol and (+)-2-butanol have the same sign of rotation, the arrangement of atoms in space is analogous. The two have the same relative configuration.
Two possibilities

But in the absence of additional information, we can't tell which structure corresponds to (+)-3-buten-2-ol, and which one to (−)-3-buten-2-ol.
Two possibilities

Nor can we tell which structure corresponds to (+)-2-butanol, and which one to (−)-2-butanol.
Absolute configurations

\[ \alpha = +33.2° \]
\[ \alpha = +13.5° \]
\[ \alpha = -13.5° \]
\[ \alpha = -33.2° \]
Not all compounds that have the same relative configuration have the same sign of rotation. No bonds are made or broken at the stereogenic center in the reaction shown, so the relative positions of the atoms are the same. Yet the sign of rotation changes.