Cal Poly Pomona, Dr. Laurie S. Starkey, Organic Chemistry CHM 201

Brown & Poon Chapter 6 (Stereochemistry) Outline

I. Chirality (6.1-6.2)
II. Nomenclature (R/S) (6.3)
III. Fischer Projections (17.2)
IV. Molecules with Multiple Chiral Carbons (6.4-6.6)
V. Optical Activity (6.7-6.8) and other Physical Properties (6.9)
VI. Racemic mixtures, racemates (6.8, 6.10)

Ch. 6 Suggested Textbook Problems:
See CHM 201 homepage

Isomers have the same molecular formula but are different compounds.

Constitutional Isomers (3.2)

different connectivity

Examples:

Stereoisomers (6.1)

- same connectivity (same IUPAC name!)
- differ by arrangement in space only

Examples:

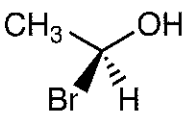
R/*S* Nomenclature of Chiral Centers

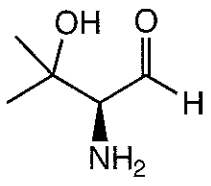
The stereochemistry of each chiral carbon (chirality center) is designated as either *R* or *S* configuration.

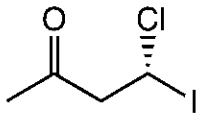
1. Assign priorities to the four groups: #1 has highest atomic number, #4 has lowest atomic number
   - if there is a tie, move away one atom at a time until you find a difference
   - a double bond can be treated as two single bonds

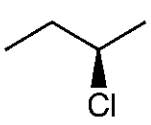
2. With the lowest priority group (#4) pointing **away** from you, go from #1 → #2 → #3

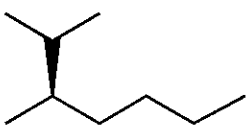
3. if rotation is **clockwise**, then (*R*) (Latin rectus/right-handed)
   if rotation is **counterclockwise**, then (*S*) (Latin sinister/left)

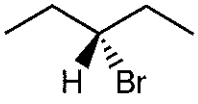












Chirality

Stereoisomers are possible for carbons with 4 different groups attached (*). These are called chirality centers or asymmetric centers.

Chiral objects have no mirror planes of symmetry
Achiral objects have a plane of symmetry

Achiral

Chiral

* All chiral objects have non-superimposable mirror images

* All achiral objects are exactly the same as mirror image

Draw (S)-2-bromopentane.

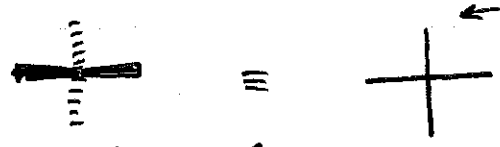
Draw the enantiomer of (S)-2-bromopentane.

Two methods ① Draw mirror image or ② Invert all chiral centers

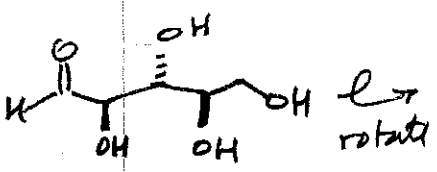
*Enantiomers have opposite configurations at

Fischer Projections (17.2)

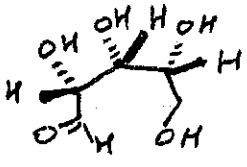
A short-hand way to draw chiral centers

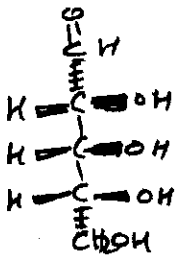
definition:  ← vertical groups = dash; ← horizontal lines = wedges

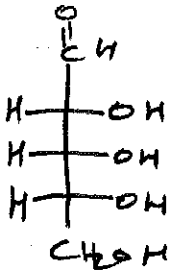
tetrahedral carbon



ribose (a sugar-carbohydrate)



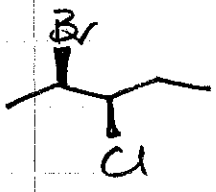




view so groups on L/R are pointing toward you

Fischer Proj.

Molecules with 2 chiral centers (6.4-6.6)

Ⓐ 

enantiomer of Ⓐ

Other stereoisomers?

How many stereoisomers are possible?

Relationship between
A + B?
C + D?
A + C?
(also:)

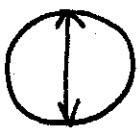
*All stereoisomers are either:
enantiomers (chiral and all chiral centers inverted) OR
diastereomers cis/trans alkenes OR some but not all chiral centers inverted

Draw all the stereoisomers of 2,3-dichlorobutane

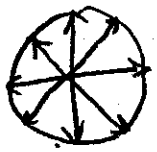
V Optical Activity + Other Physical Properties (6.7 - 6.9)

Chiral molecules rotate a plane of polarized light

Angle of rotation (α) is measured by a polarimeter.



polarized light
(oscillations of electromagnetic field occur in a single plane)



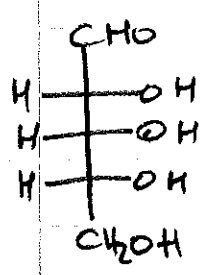
ordinary light

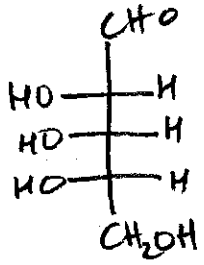
achiral species are not optically active.

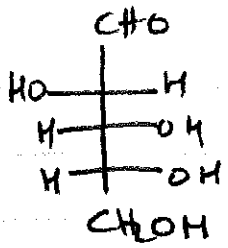
* Enantiomers have identical physical properties (bp, solubility, IR, mp, etc) except they have equal + opposite optical rotations [α] ("specific rotation")

* Diastereomers have different everything! (bp, solubility, IR, mp, [α], etc.)

Ex.







Question: how many stereoisomers are there? (3 are shown here)

(2R, 3R, 4R) (2, 3, 4) (2, 3, 4)

(-)-ribose

$[\alpha]_D^{20}$ -19°

mp 88°C

* There is no relationship between R/s and +/- ! Have to measure (α), it can't be predicted.

When do enantiomers behave differently? When interacting with another chiral molecule or a chiral environment.

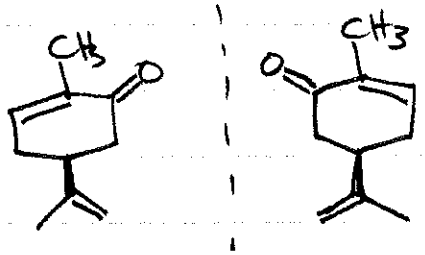
R/L hand + coffee mug →

R/L hand + R-handed glove →

+/- molecule + chiral receptor →

↑ a protein

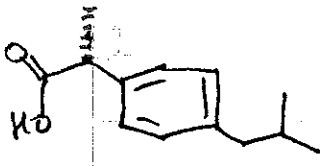
ex. a drug an enzyme



(S)-carvone (R)-carvone

VI Racemic Mixture (Racemate) (6.10)

→ a 1:1 mixture of enantiomers
→ optically inactive
→ can be separated, but it's a difficult process
→ nature makes single enantiomers of chiral compounds, but lab synthesis gives racemates
→ most chiral drugs are sold as racemates but it is likely that a single enantiomer is more effective



ibuprofen

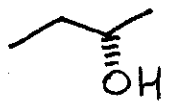
← is this the R or S enanantiomer?

Draw the other enantiomer: (the active form)

Is it (+) or (−)?

Chapter 6 Skill: Identify Relationship between structures

A) Constitutional (Structural) Isomers
B) Enantiomers
C) Diastereomers
D) Same Compound
E) Unrelated



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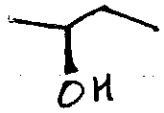

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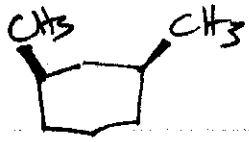

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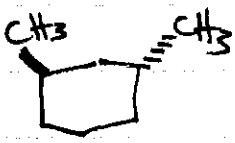

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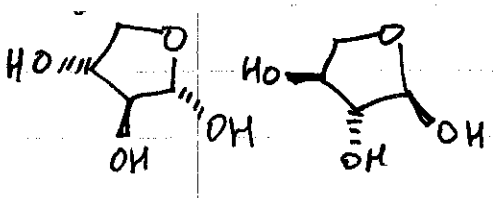

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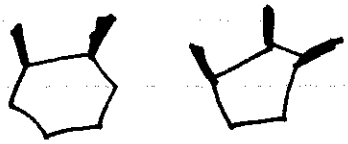

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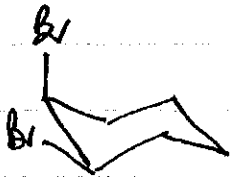

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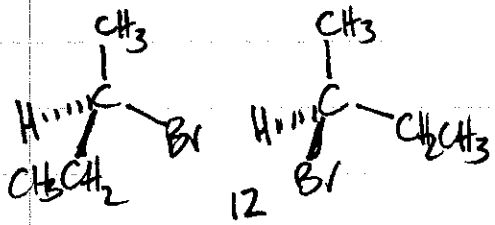

11 12

Next: Chapter 7 (7.1 - 7.6)