Your Name: Cristian Villatoro

Isomer Relationships, Conformational Stability, and Reaction Selectivity

Instructions:

Read the instructions carefully and answer the following questions in the space provided. Then attach the PDF file on Discussion Board for peer discussion and peer review.

1. In a few sentences define each of the three main classes of isomers below. Configurational Isomers can be further classified as either enantiomers or diastereomers and should also be discussed. Your descriptions should enable your peers to quickly and easily compare and contrast the differences between the different classes of isomers.
   A. Constitutional Isomers (or Structural Isomers)
   B. Conformational Isomers
   C. Configurational Isomers (or Stereoisomers)
      I. Enantiomers
      II. Diastereomers

A. Constitutional Isomers - Molecules that have the same molecular formula, but share different connectivity. An example can be in how the carbon atoms are connected.

B. Conformational Isomers- These molecules share the same number of atoms but can be different depending on what view or rotation the structure is being evaluated from. An example of this can be newman projections and comparing staggered vs. eclipsed conformation.

C. Steroisomers - Components of the structure are the same and the bonds are also the same but the 3-Dimensional shape is not the same. An example of this can be when atoms (substituents) are coming out of the page or going back into the page.

C. part ①

Enantiomers - Are stereoisomers, made up of the same atoms and are connected the same and are mirror images of each other.

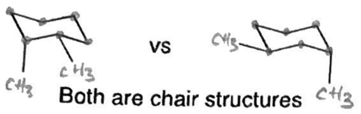
C. part 2

Diastereomers in summary are stereoisomers that are not mirror images of each other.

2. Analyze each pair of compounds below. Identify which class of isomers each pair of structures represent. Your choices are: ***(i) constitutional, (ii) conformational, (iii) enantiomers, or (iv) diastereomers or (v) identical (non-isomers).*** Only one label for each pair should be used. For each case show work (drawings, (R)/(S), rotation of bonds, chair-flips, etc) which led you to each answer for the pairs below. [During your peer review, any differences of answers between you and your peers can be discussed and corrected as needed.]

Note: Various projections may be used when drawing chemical structures including bond-line structures (using proper dash/wedge bonds), Newman projections, chair structures (for cyclohexane derivatives), Haworth projections, and Fischer projections. These projections just represent different vantage points of visualizing a chemical structure and can be interconverted from one projection to another. Each different projection has been labeled for you below. These are all utilized throughout the text book.

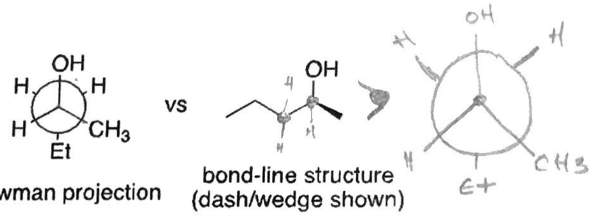
(a)



Both are chair structures

constitutional isomers

(b)



Newman projection

bond-line structure (dash/wedge shown)

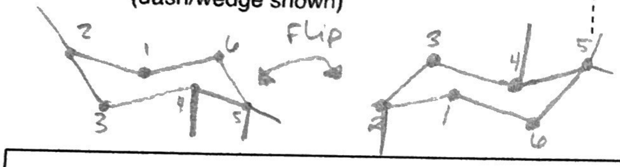
conformational isomers

(c)

Stereoisomers

bond-line structure (dash/wedge shown)

chair structure



2 - 6 carbon chain

(d)

bond-line structure (dash/wedge shown)

bond-line structure (dash/wedge shown)

Stereoisomers

A) In this case when comparing both chair structures, we have 2 cyclohexanes with 2 methyl groups as substituents. This means that all components are the same, except in how the methyl groups are connected.

B) I compared these structures by converting the bond-line structure into a newman projection, but am also aware that depending on where the eye is positioned the projection can vary.

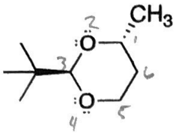
C) I compared these two structures by converting the bond line structure into a chair structure and although very similar, with the substituents having different projections with dashes and wedges I determined these as stereoisomers.

D) In this case, both these structures share a ⑥ carbon chain and even the bonds are the same except in how the substituents would be viewed in a 3-Dimensional figure.

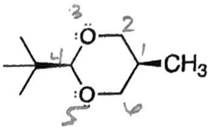
3. Analyze the structures for **Compound A** and **Compound B** shown below. Answer and discuss each question (a) and (b), respectively.

   a. What type of isomers do these represent?
   b. Which compound is more stable? (Hint: You will need to draw the chair structures for each compound (4 total chairs, two for each compound) and compare/contrast/analyze the various 1,3-diaxial interactions in order to justify this answer. Show your work clearly.

Compound A



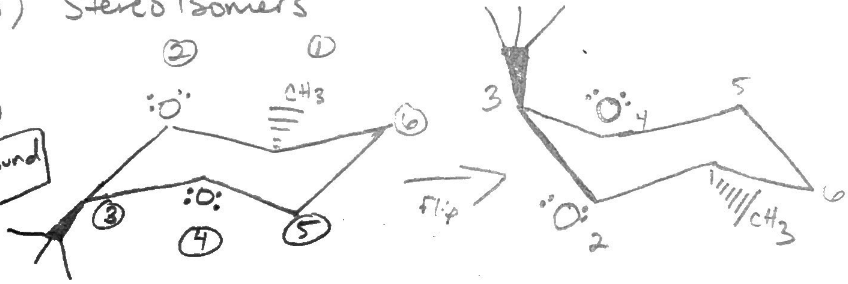
Compound B



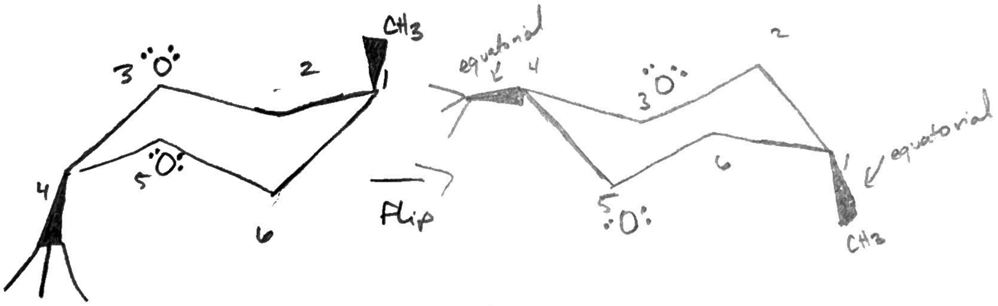
A) Stereoisomers

B)

Compound A

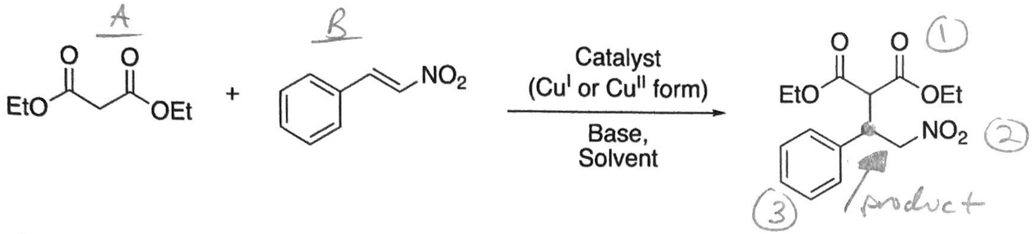


Compound B



I determined that compound B is more stable because after the chair flip, the large substituents are in the equatorial position causing less repulsion with hydrogen substituents.

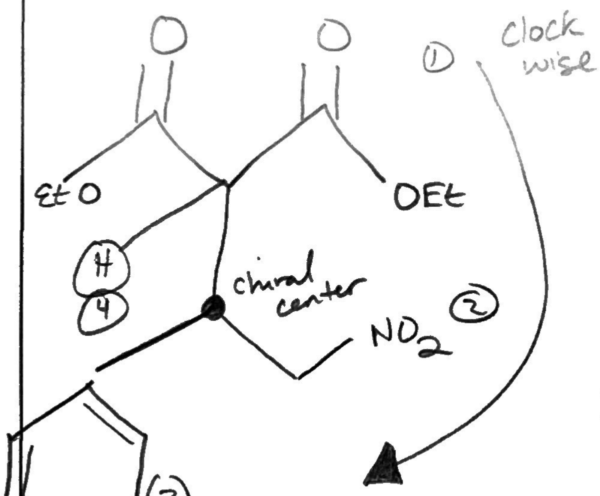
4. Chiral catalysts can be designed to favor the formation of one enantiomer over another in reactions where a new chiral center is formed. The example shown below was recently reported in the chemical literature (*J. Am. Chem. Soc.* **2012**, *134*, 8054–8057) where a new type of chiral copper (Cu) catalyst was developed. When the Cu^{I} catalyst was used, the (S)-enantiomer of the product predominated, and the (R)-enantiomer of the product was selectively formed when Cu^{II} catalyst was used instead.



Answer part (a) and (b) below. You aren't required to understand the chemistry to answer correctly and discuss the experimental results.

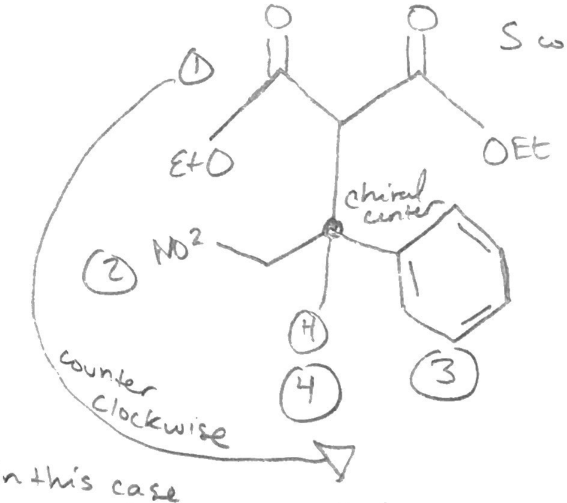
a. The product has been shown on the right of the reaction scheme above but the absolute stereochemistry of the product has been excluded. Draw the **major enantiomer** formed when each form of the catalyst is used. You need to be sure to show the stereochemistry clearly using appropriate dash/wedge bonds at the stereocenter and indicate which catalyst (Cu^{I} or Cu^{II}) was used for each of the two individual enantiomers you draw.

R confirmation



Cu'' catalyst

S configuration



in this case I found the chiral center and found the S + R confirmation.

Cu' catalyst

b. The chart below reports the data when the (S)-selective catalyst was used in various solvents. The enantiomeric excess (reported as % ee) is shown for each case.

Solvent	% ee of (S)-product	% Yield of total product	% S	% R	
Toluene	24	55	62	38	②
THF	48	33	74	26	⑤
Acetonitrile	72	55	86	14	①
Chloroform	30	40	65	35	④
Dichloromethane	46	44	73	27	③
Hexane	51	30	75.5	24.5	⑥

$S - R = 24$ $S + R = 100$

Complete the table above by calculating the % (S) and % (R) formed when the (S)-selective reaction was repeated in the various solvents. How are these values calculated? Illustrate this by showing a complete calculation for the toluene case. For the others, you can simply just write in the values. If your values do not match your peers', you will need to discuss this and correct as needed. Also, discuss which solvent gives the optimal results in terms of both enantioselectivity and overall total product yield. What experimental data led you to make this conclusion? Where any other solvents comparable? What solvent gave the worst results?

Toluene

$S - R = 24$

$S + R = 100$
$-S$
$R = 100 - S$
$R = 100 - 24$
$\frac{\cancel{2}R}{\cancel{2}} = \frac{76}{2}$
$R = 38$

THF

$S - R = 48$

$S + R = 100$
S
$R = 100 - S$
$\frac{2R}{2} = \frac{52}{2}$
$R = 26$

- I was able to calculate the % S + % R using the equations above.
- The solvent that gave the optimal results was Acetonitrile because of highest percentages in % S and % yield of total product. I labeled the reactions from 1-6, ① being the best results, some solvents were very close such as THF and Hexane.
- I determined that Hexane had the worst results from the percentages on the data.