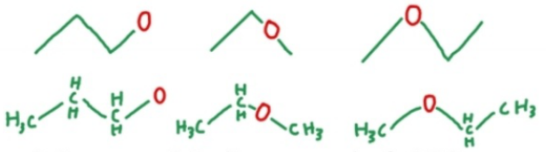
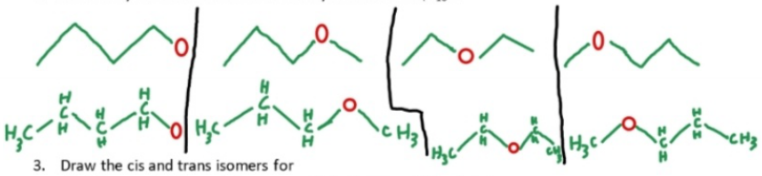
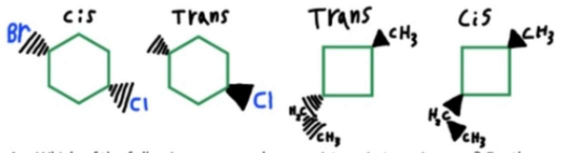
1. Draw three constitutional isomers with the molecular formula C_3H_8O.



2. How many constitutional isomers can you draw for $C_4H_{10}O$.



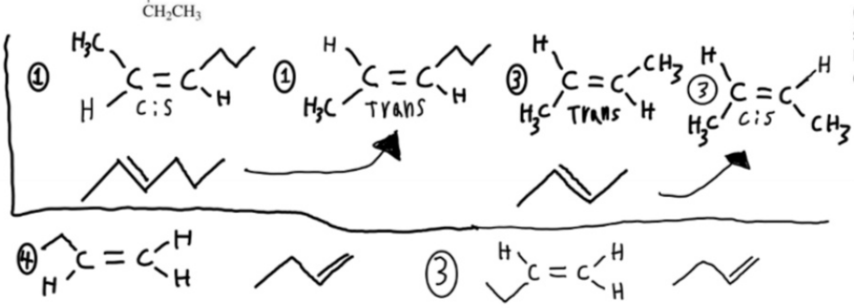
3. Draw the cis and trans isomers for
   a) 1-bromo-4-chlorcyclohexane b) 1-ethyl-3-methylcyclobutane.



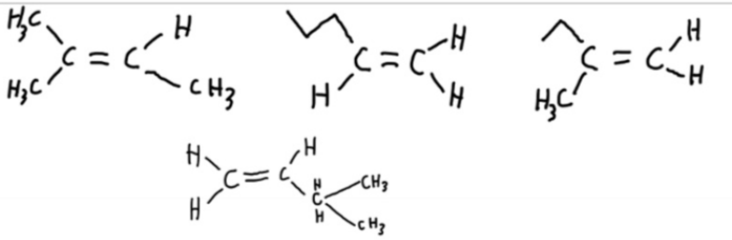
4. Which of the following compounds can exist as cis-trans isomers? For those compounds that can exist as cis and trans isomers, draw and label the isomers. Also, draw the skeletal structures.

1. $CH_3CH{=}CHCH_2CH_2CH_3$ 3. $CH_3CH{=}CHCH_3$

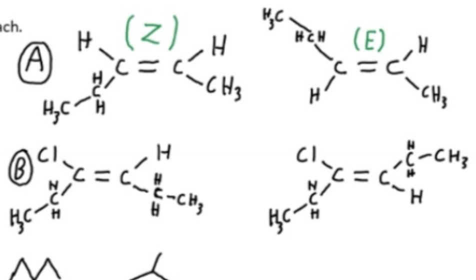
2. $CH_3CH_2C(CH_2CH_3){=}CHCH_3$ 4. $CH_3CH_2CH{=}CH_2$



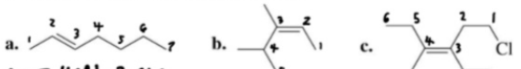
5. Draw four compounds with the formula C_5H_{10} that have a carbon-carbon double bond but do not have Cis-trans isomers.



6. Draw and label the E and Z form for each.
   a. $CH_3CH_2CH{=}CHCH_3$
   b. $CH_3CH_2C(Cl){=}CHCH_2CH_3$
   c. $CH_3CH_2CH_2CH_2$–$C(CH_2CH_3){=}C(CH_2Cl)$–CH_2CHCH_3



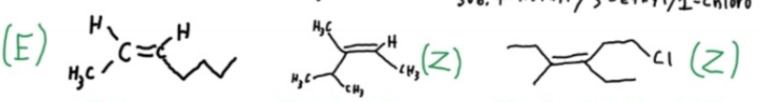
7. Use E and Z notation to name the following:



PC= Hept-2-ene

PC: Pent-2-ene
Sub: 3,4-di methyl

PC: Hex-3-ene
Sub: 4-methyl/3-ethyl/1-chloro



(E)-2-heptene
(E)-hept-2-ene

(Z)-3,4-dimethyl-2-pentene
(Z)-3,4-dimethylpent-2-ene

(Z)-1-chloro-3-ethyl-4-methyl-3-hexene
(Z)-1-chloro-3-ethyl-4-methylhex-3-ene

Problem 1 and 2

(A Constitutional Isomer is another version of a molecule with different locations of different atoms causing the name to be different but with the same molecular formula).

Tips for Drawing Constitutional Isomers:
(1) Start by drawing the structure and then move the functional group or substituent to one place away from the past location for every new structure you draw.
(2) Try to draw a Primary, Secondary, Tertiary, Quaternary, or Iso group.

SEE ATTCHED FILE ON HOW TO DRAW ISOMERS AT THE BOTTOM OF THIS DOCUMENT

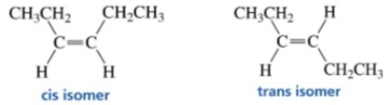
Problem 3

To draw the Cis Isomer for a compound **without double bonds**:
Put both of the groups on either a hatched wedge or both on a sold wedge.

To draw the Trans Isomer for a compound:
Put one of the groups on a hatched wedge and the other on a solid wedge.

Problem 4

Cis and Trans Isomers must have two **DIFFERENT** groups on each of the Carbon atoms.
(1) To determine if Cis, Trans, or other, draw the structure at the double bond(s) and see if the groups attached are different or the same.
(2) Look at the double bond and see if the two identical groups are on the opposite side or on the same side of the double bond.
If two groups on one of the carbons is the **SAME** then use E and Z notation. If not use Cis or Trans accordingly.



Problem 5

To find the different Isomers (different molecules) use the tips given for drawing Isomers. Keep in mind the format such as keeping a double bond for this problem. All the tips still apply.

Remember that if the substituents on one of the sp2 carbons are the same then you **cannot** have Cis or Trans. You instead have E or Z.

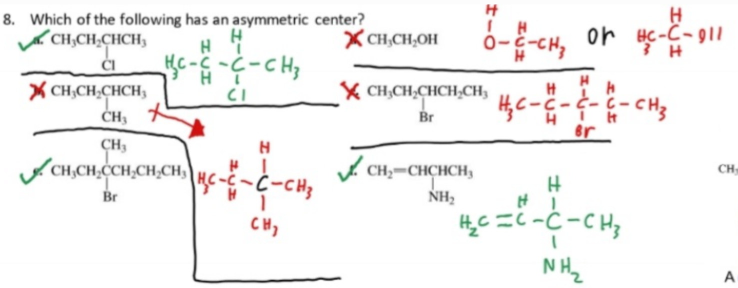
Problem 6

To draw the E and Z isomers draw them at the double bonds as you would for Cis and Trans.
(1) If the highest priority groups are on **opposite** sides of the double bond then it is E (Entgegen is German for opposite).
(2) If The highest priority groups are on **"Zee Zame Zide"** then the molecule is Z (Zusammen: German for together)
(3) to determine the the highest prioritys compare the Atomic numbers between atoms.
(4) If there is a tie, compare the next atom on the chain.
(5) If a atom is bonded to a triple or double bond act as though it is bonded to as many carbons as the number of bonds. For example double bond would be 2 extra carbons.

Problem 7

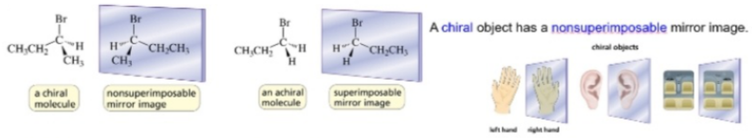
(1) If the molecule is complex, draw the Isomer around the double bond (just like for cis or trans) to determine whether E or Z.
(2) Then name the molecule as normal and put an E or Z in the beginning in parentheses, for example (Z). If there is E and Z encapsulate them in parentheses as well for example (2E,3Z).

8. Which of the following has an asymmetric center?

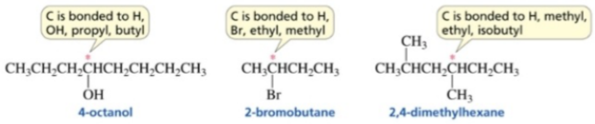


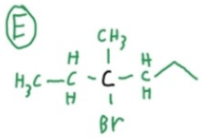
Problem 8

To determine if there is an asymmetric center, see if there are four different groups attached to that one atom you are looking at. If **yes** you have an asymmetric center, if **no** you don't have one.

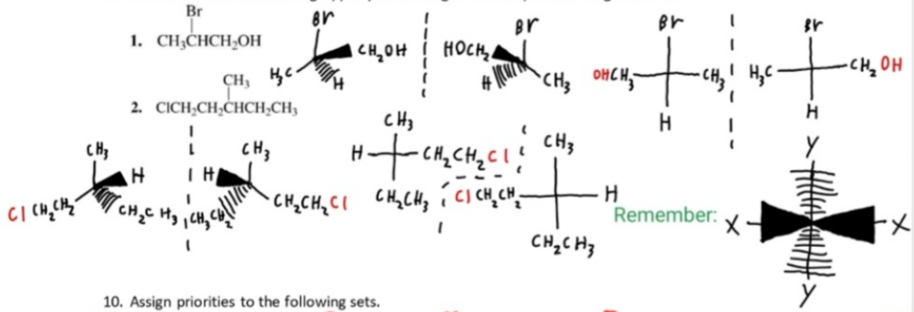


A chiral compound has a nonsuperimposable mirror image.



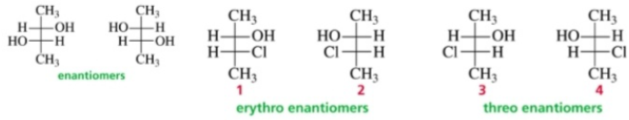


9. Draw the enantiomers using a) perspective diagrams and b) Fischer diagrams for:

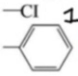


Problem 9

(1) To draw an **Enantiomer** draw the **mirror** image of the compound.
(2) Or switch both asymmetric centers.



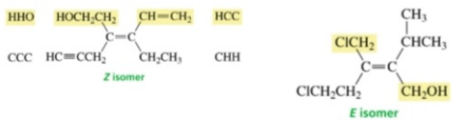
10. Assign priorities to the following sets.

		1	3	4	2
A	a.	$-CH_2OH$	$-CH_3$	$-H$	$-CH_2CH_2OH$
C	b.	$-CH_2Br$ 2	$-OH$ 1	$-CH_3$ 4	$-CH_2OH$ 3
B	c.	$-CH(CH_3)_2$ 2	$-CH_2CH_2Br$ 3	$-Cl$ 1	$-CH_2CH_2CH_2Br$ 4
d	d.	$-CH{=}CH_2$ 2	$-CH_2CH_3$ 3	 1	$-CH_3$ 4

(a) COH CH H CCOH
(b) CBr OH CH COH
(c) CCCH CCBr Cl CCCBr
(d) **(CCCCH)** CCH **(CCC)** CH
When looking at the double bonds count then as 2 extra carbons Such as the above in parentheses in red.

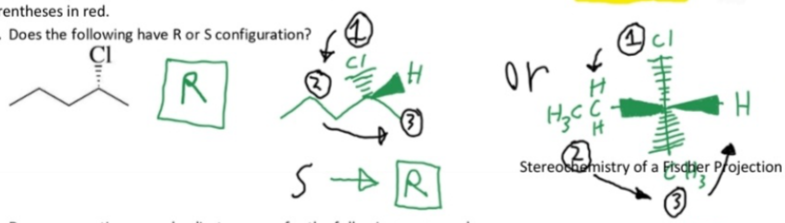
Problem 10

When assigning priorities use the **Atomic Number**. Highest atomic number is the highest priority. If you have a tie look at the next atom in the chain. Don't look at hydrogen unless it is the only atom on the chain left.
If there is a double bond pretend there is two extra carbons attached to that chain. If there is a triple bond pretend there are three extra carbons attached to that chain.



Fischer

11. Does the following have R or S configuration?



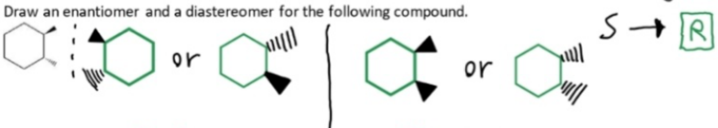
Stereochemistry of a Fischer Projection

Problem 11

(1) To determine R or S find the Highest priority, then the 2nd, 3rd and the 4th.
(2) The 4th priority must **ALWAYS** be on a **hatched wedge** pointing into the screen. If this is not the case then count as normal and then reverse your final answer to the **opposite** configuration.

If the priorities are clockwise it is an R configuration.
If the priorities are counterclockwise it is an S configuration.

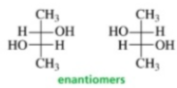
12. Draw an enantiomer and a diastereomer for the following compound.



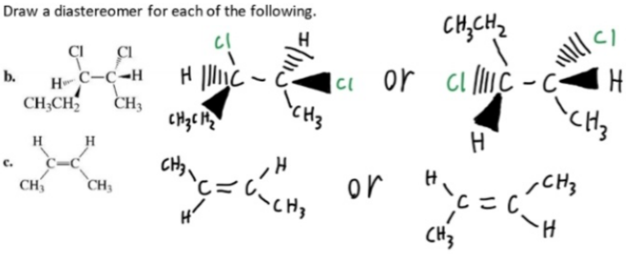
Enantiomers **Diastereomers**

Problem 12

(1) To draw an **Enantiomer** draw the **mirror** image of the compound.
(2) Or switch both asymmetric centers.
To draw a **Diastereomer** change only **one** of the asymmetric centers.



13. Draw a diastereomer for each of the following.

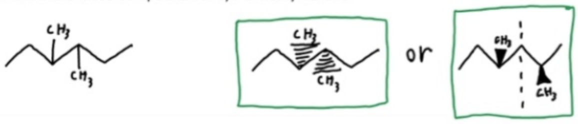


Problem 13

To draw the Diastereomer for a compound:
(1) Switch any pair of substituents bonded to one of the asymmetric centers.
Since any pair of substituents can be swapped you can get multiple different answers. I only put down two for this problem.
Remember for the 2^n=number of steriosimers (n=number of asymmetric centers)

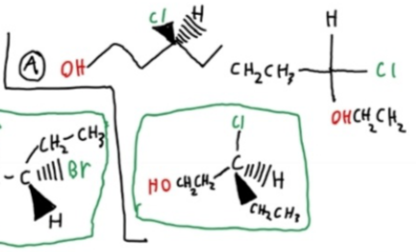
maximum # of stereoisomers = 2^n
(n = # of asymmetric centers)

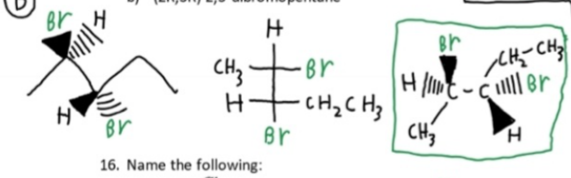
14. Draw the meso compound for 3,4-dimethylhexane.



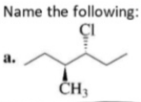
15. Draw the perspective diagram for:

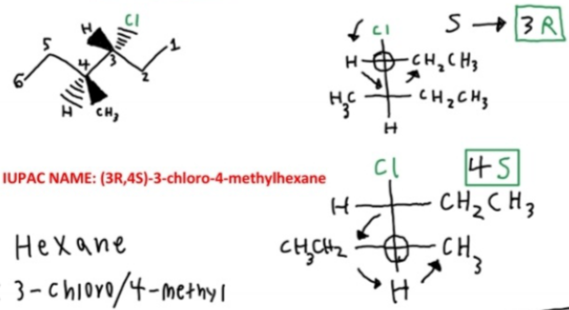
a) (S)-3-chloro-1-pentanol
b) (2R,3R) 2,3-dibromopentane

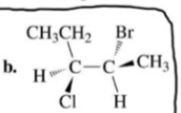




16. Name the following:

a. 

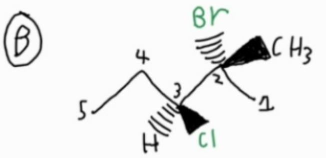


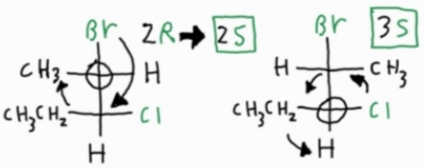
b. 

IUPAC NAME: (3R,4S)-3-chloro-4-methylhexane

PC: Hexane
sub: 3-chloro/4-methyl

B

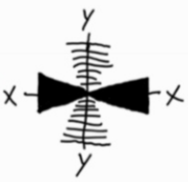




PC: pentane
sub: 2-bromo/3-chloro

IUPAC NAME: (2S,3S)-2-bromo-3-chloropentane

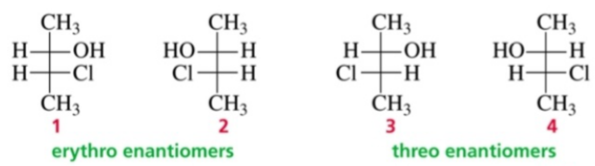
This is the stereochemistry of a Fischer Projection

Remember: 

Extra information and vocabulary:

If a compound is **Chiral** it is also **optically** active.
Stereochemistry means structures in three dimensions.
Isomers are compounds with the same molecular formula but different structures.
Constitutional isomers differ in the way their atoms are connected.
Stereoisomers differ in the way their atoms are arranged in space.
A **racemic mixture** is a mixture of equal amounts of two enantiomers.
Diastereomers are stereoisomers that are not enantiomers.
A **meso** compound has two or more asymmetric centers and a plane of symmetry, it is optically inactive.
Atoms **other** than carbon can be asymmetric if they are bonded to four different atoms or groups.

Differences between Diastereomers and Enantiomers



Fischer projections of the stereoisomers of 3-chloro-2-butanol (eclipsed)

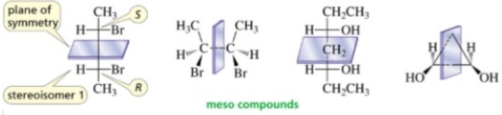
1 and 2 are enantiomers. 3 and 4 are enantiomers.

Diastereomers are stereoisomers that are not enantiomers.

1 and 3 are diastereomers. 2 and 3 are diastereomers.
1 and 4 are diastereomers. 2 and 4 are diastereomers.

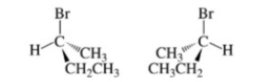
Problem 14

To draw the Meso Isomer for a compound make sure there is a plane of symmetry (Achiral). In other words make sure you can fold it on some axis to completely cover itself and be superimposable.



Problem 15

To draw the perspective diagram for a compound draw the hatched group on a hatched wedge and the solid group on the solid wedge. Then draw the other hatched wedge up and the other solid wedge down.



perspective formulas of the enantiomers of 2-bromobutane

Problem 16

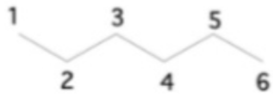
To name compounds with Stereochemistry:
(1) Write out the compound using either the perspective form or Fischer projections
(2) Find out if you are using E,Z or Cis,Trans or R,S
(3) Find the longest continues chain and name as normal with the addition of E, Cis, R, etc in the beginning of the name.

Note Cis and trans do not have numbers, E, Z, R, or S you have to specify the location.

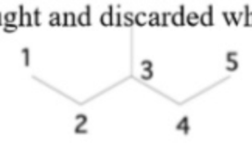
STEPS FOR DRAWING ISOMERS:

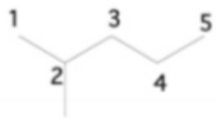
The following five steps will help you to draw the isomers once you are given a molecular formula. I am using the formula C_6H_{14} as an example.

1. Draw the *main chain* (*i.e.* the straight chain containing all the C atoms).



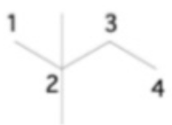
2. Draw the *main chain minus 1 carbon*, and *add a methyl group to as many positions as possible*; in other words, chop a C from one of the ends and attach it in as many places as you possibly can. Never add the methyl groups to the end of the chain, and watch not to repeat structures (it's okay if you accidentally repeat structures, for they will be caught and discarded when you do step 5).

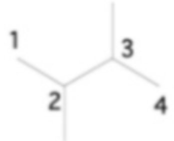




(These are the only two options in this case)

3. Draw the *main chain minus 2 carbons*, and *add two one-carbon groups (two methlyls) or one 2-carbon group (an ethyl) to as many positions possible*, trying not to repeat structures.



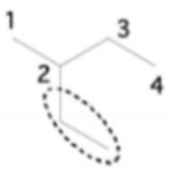
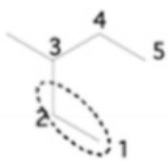


(These are the only two options. We cannot add an ethyl group.)

Note: To add a particular alkyl group:

i. Count the number of C's on the alkyl group. (The alkyl chain has '**k**' – Carbon atoms.)

ii. The carbon at which you add the alkyl group should be at least $\boldsymbol{k+1}$ counting from both ends of the main chain; otherwise, the only thing you are doing is repeating structures (i.e. increasing the size of the chain again.). Look at the following example and convince yourself that this is the case.

A)  → B)  *(repeated structure!*

Notice the structures on step 2.)

An ethyl group (with 2 C's) cannot be added to a carbon chain with 4 carbons. We need at least a $\boldsymbol{k+1}$ carbon (counting from both ends!) to attach this alkyl group; otherwise, we repeat structures.

4. Continue subtracting and adding groups in this fashion until you run out of carbons or doing so only results in repeated structures.

5. Give the IUPAC name to all the compounds you drew. If you accidentally drew the same one twice, they will have identical names, and you can cross one of them off.