https://jhu-orgo-pilot.github.io/FA25-Orgo-Greenberg/

Greenberg Midterm 1 Pilot Review

09/21/2025

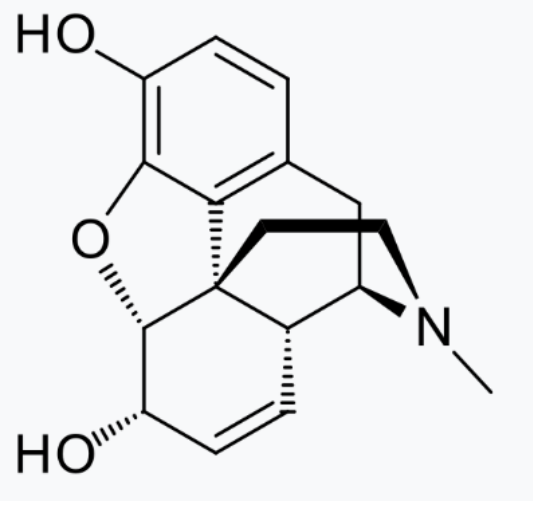
Important Concepts

- Molecular Orbital Theory
  - Conservation of orbitals
  - Bonding/Antibonding orbitals
  - Bond order
- Valence Bond Theory
  - Hybridization
  - Orbital Overlap
  - Resonance
- Acid/Base Chemistry
  - pKa
  - Comparing acidity
  - Favoring products or reactants

- Structures
  - Skeletal Structures
  - Newman Projections
  - Fischer Projections
- Stereochemistry
  - Isomers
  - Chairs
  - Absolute configuration
- Chemical Reactivity
  - Nucleophiles
  - Electrophiles
  - Acid/Base

Problem 1

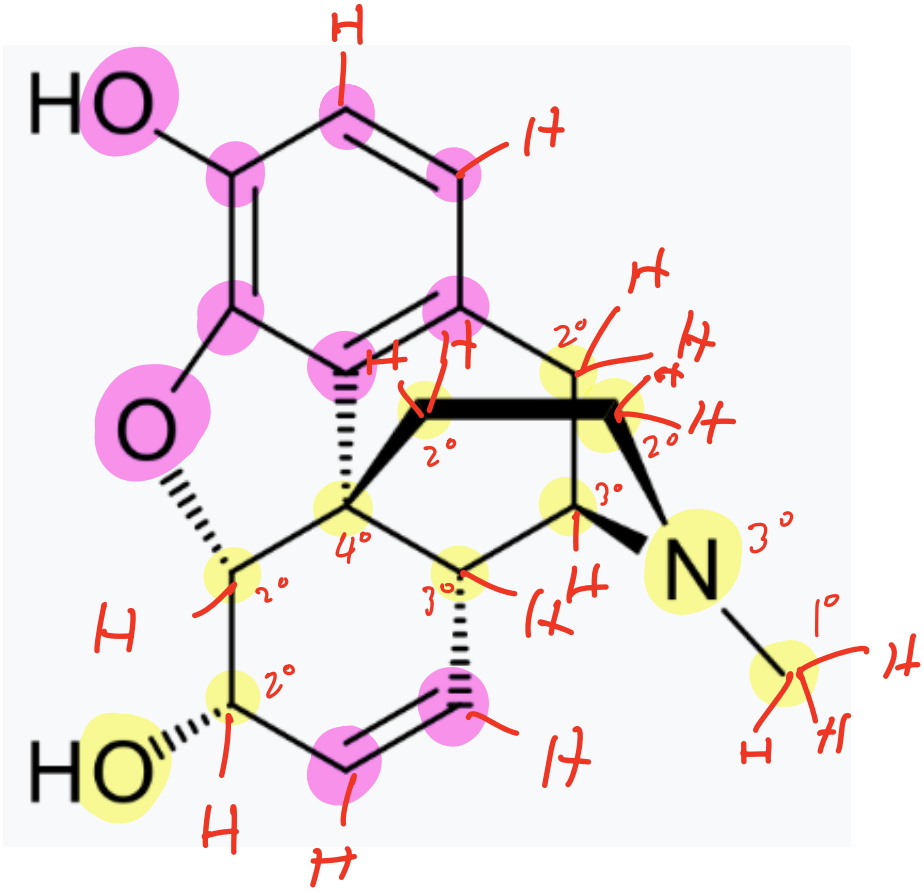
- Draw all implicit hydrogens on the molecule below and name the hybridizations of each atom. For all sp3 hybridized atoms, determine whether they are primary, secondary, tertiary, or quaternary.



Problem 1 Solution

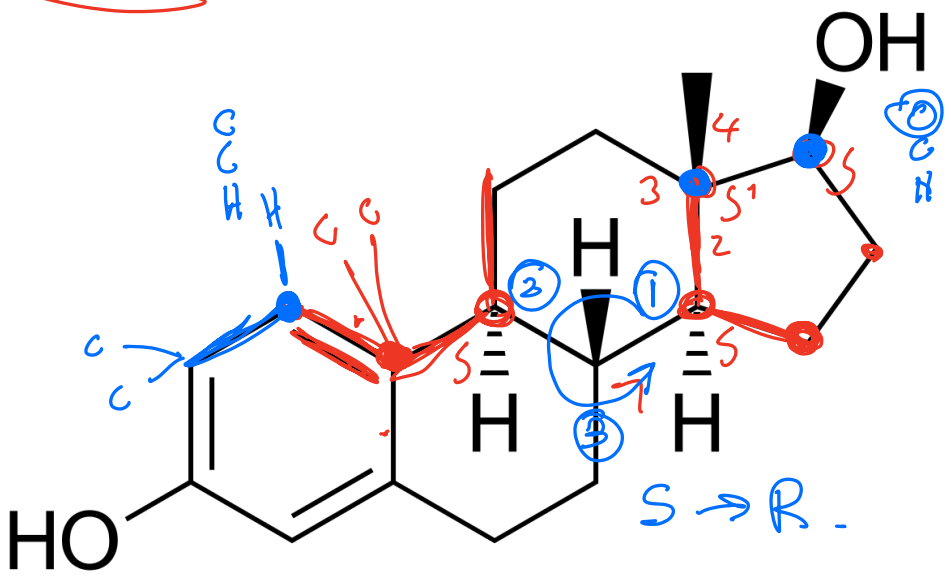
- sp^3

- sp^2

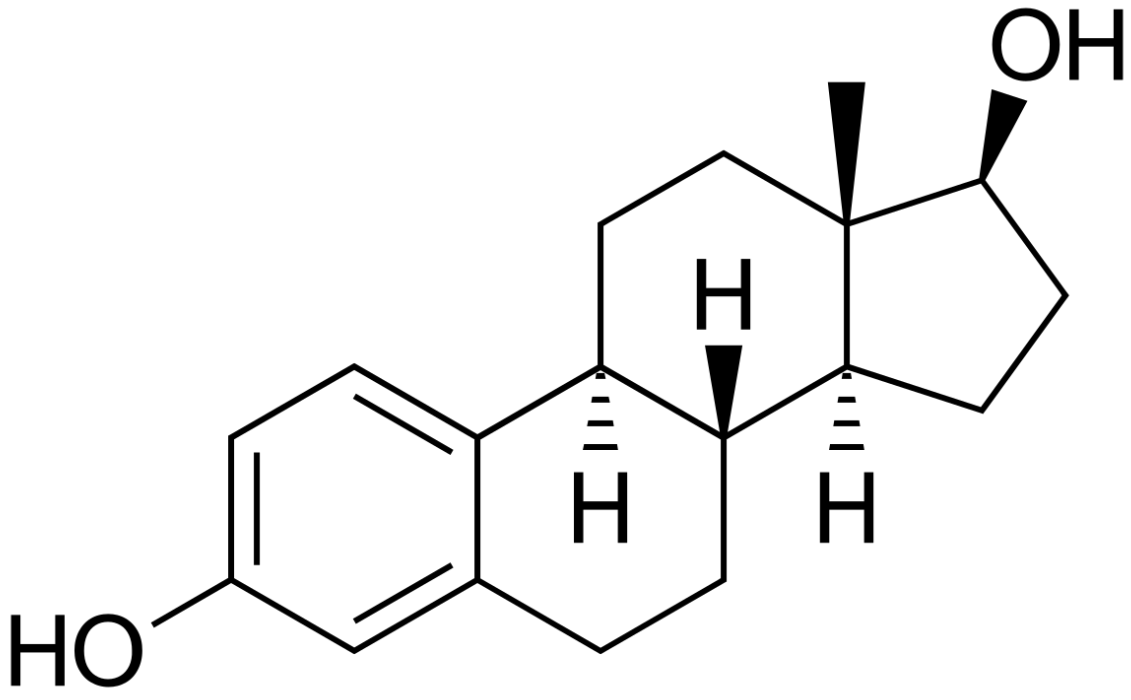


Problem 2

- Determine the number of chiral centers, total number of stereoisomers, absolute configuration of each stereoisomer and the degree of unsaturation.

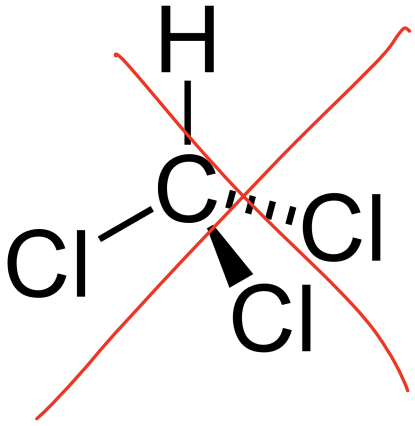


Problem 2 Solution

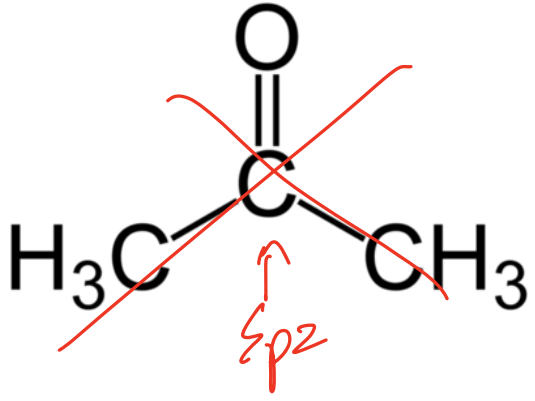


Problem 3

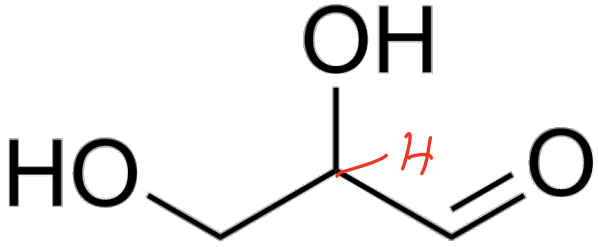
- Determine whether the molecule is chiral, and the 3D geometry of the central atom.



tetrahedral



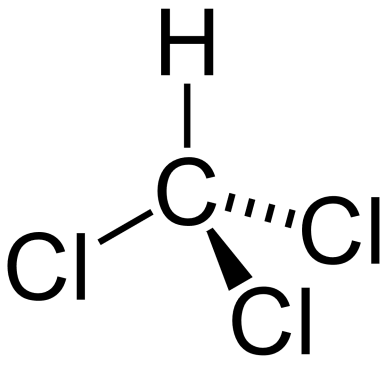
trigonal planar

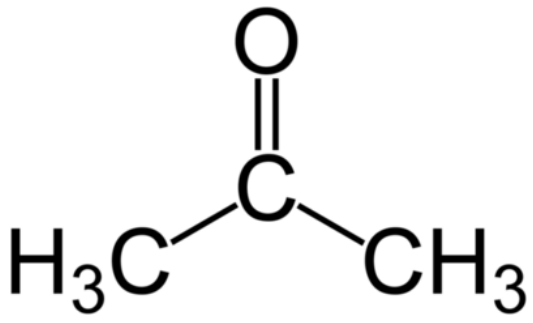


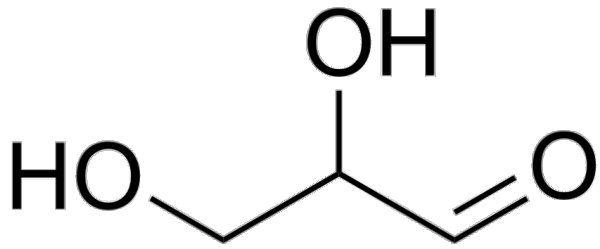
chiral

tetrahedral

Problem 3 Solution





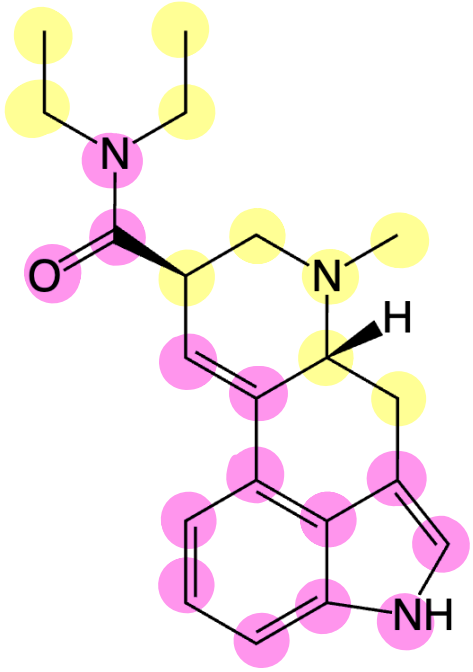


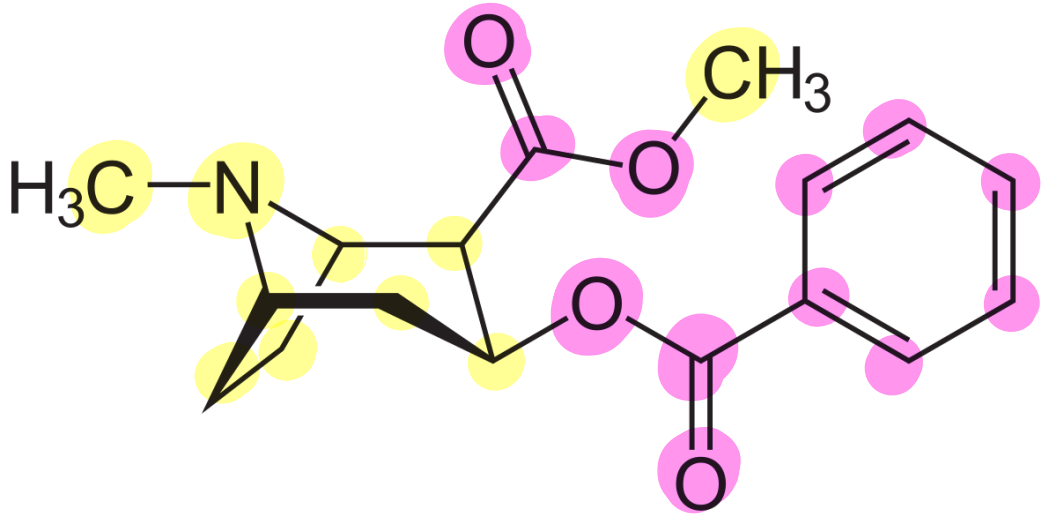
Problem 4

- Determine the hybridization of every atom.

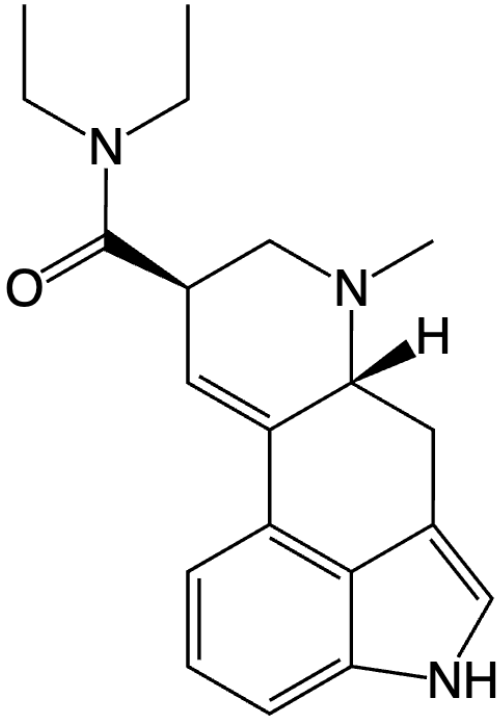
sp^2

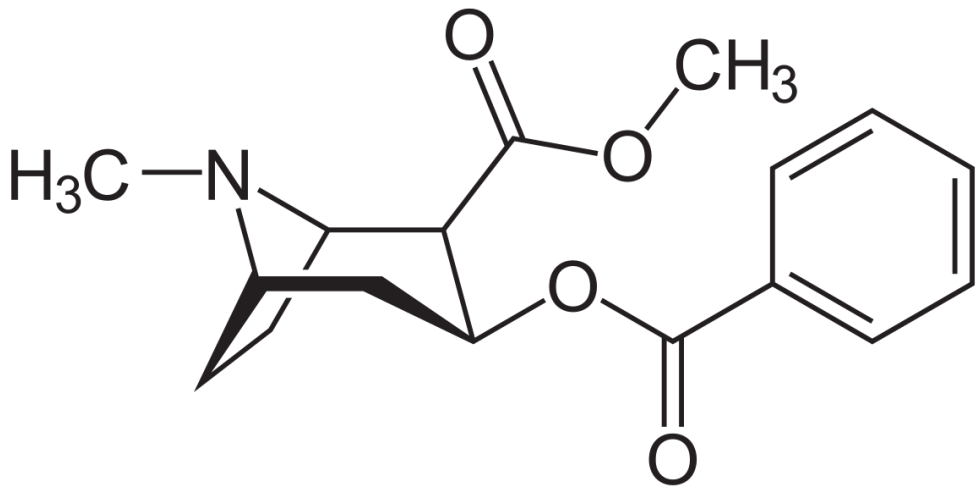
sp^3





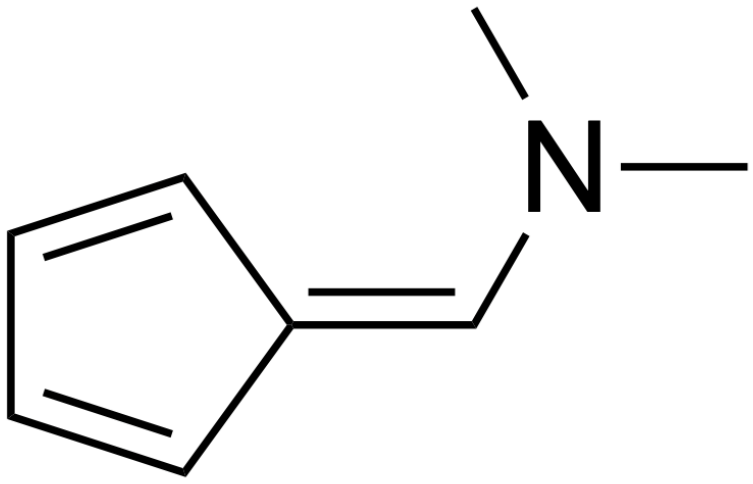
Problem 4 Solution

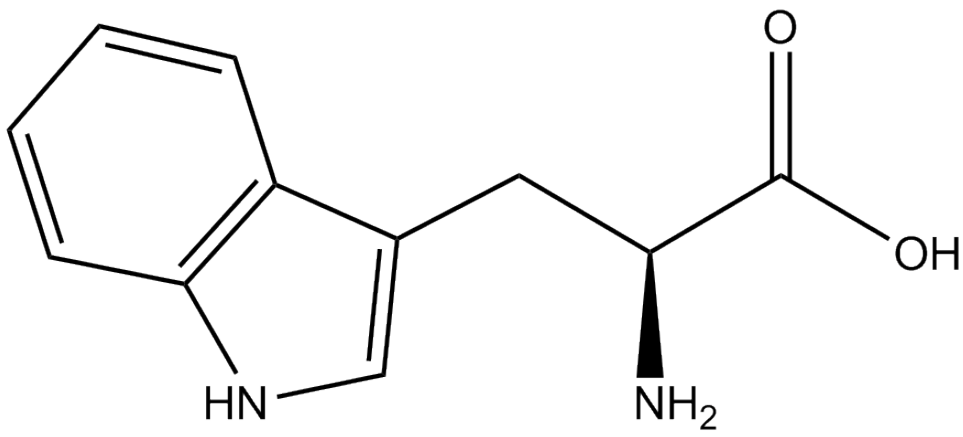




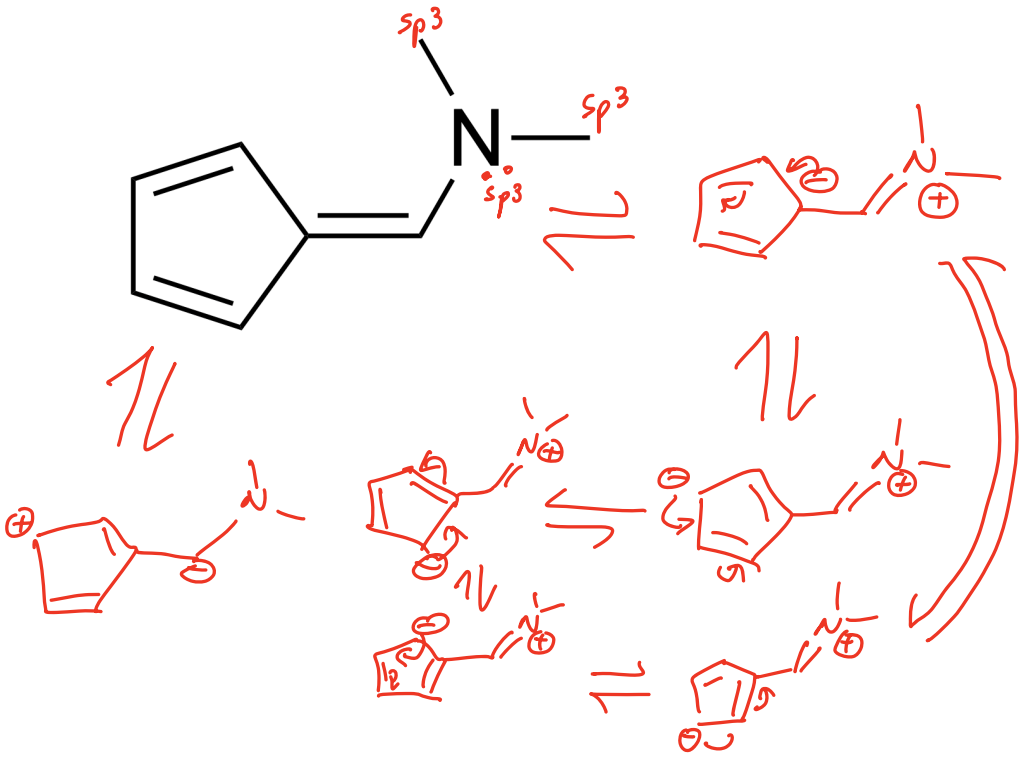
Problem 5

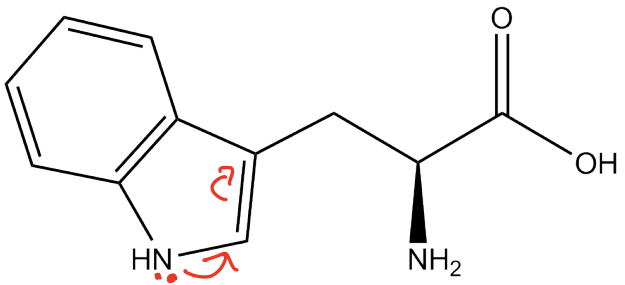
- Draw resonance structures for the following molecules (for the right molecule, just consider the resonance in the rings)





Problem 5 Solution

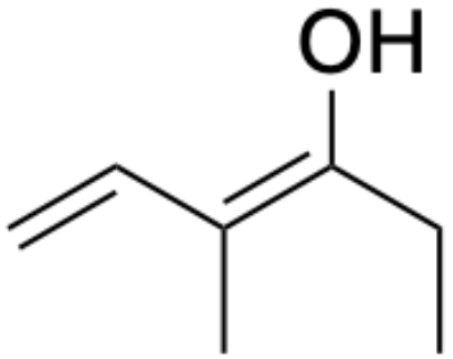


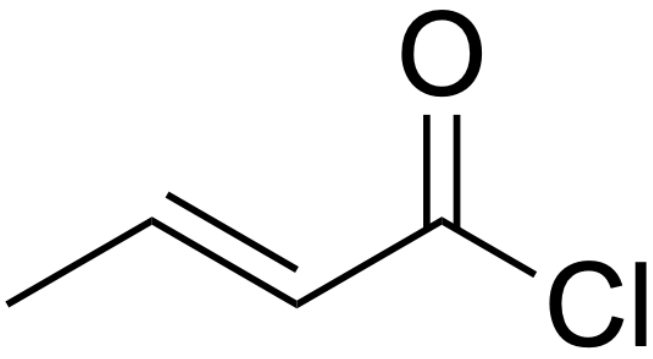


etc.

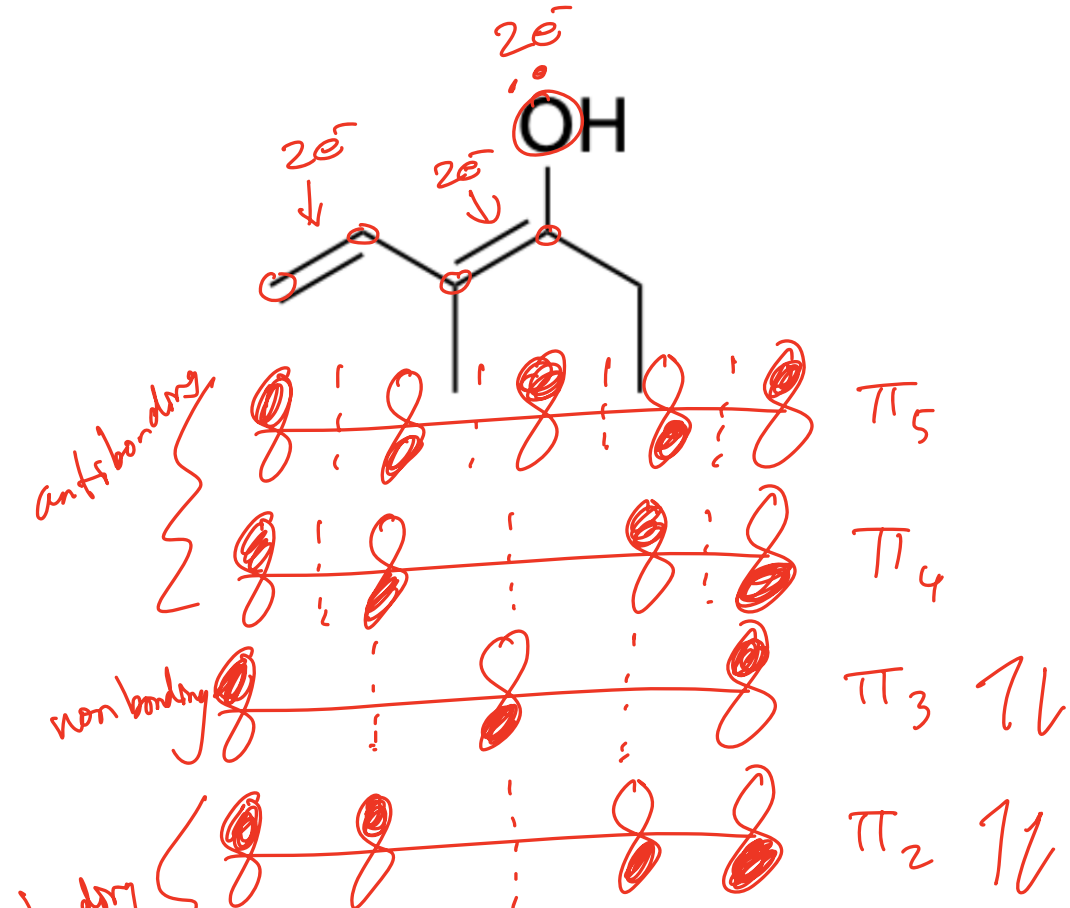
Problem 6

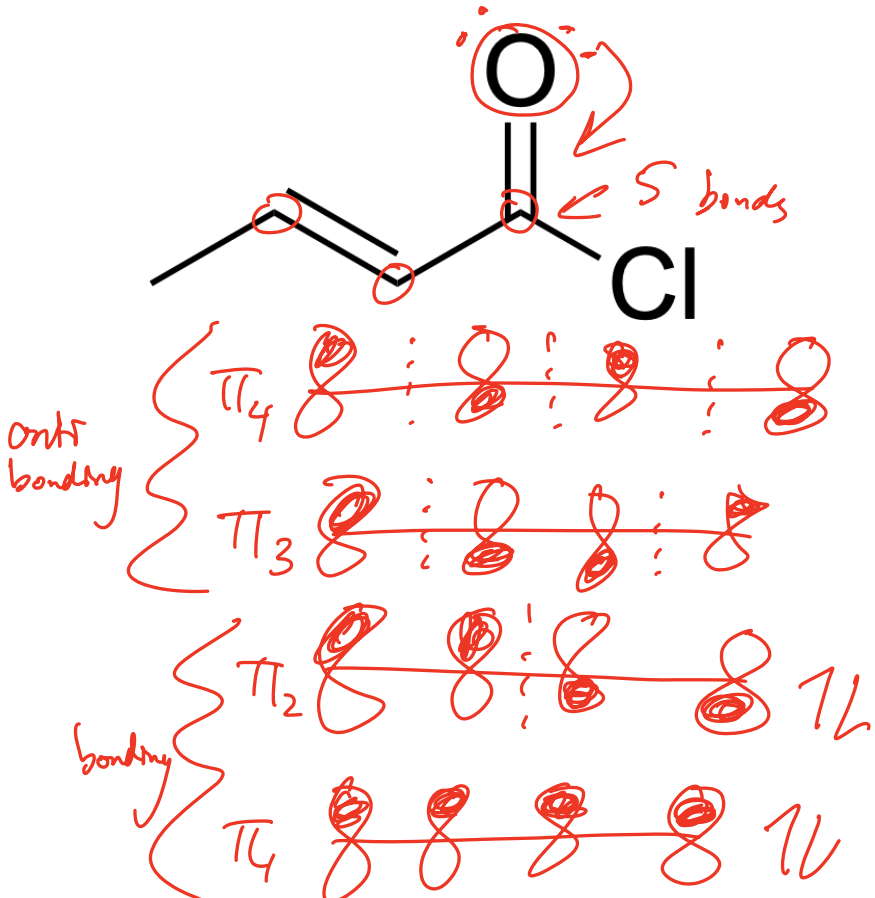
- Determine the HOMO and LUMO for the following molecules.





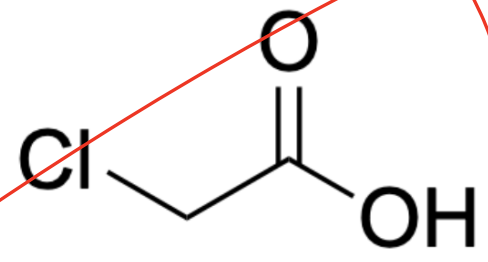
Problem 6 Solution

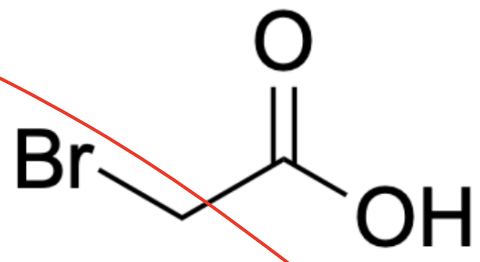




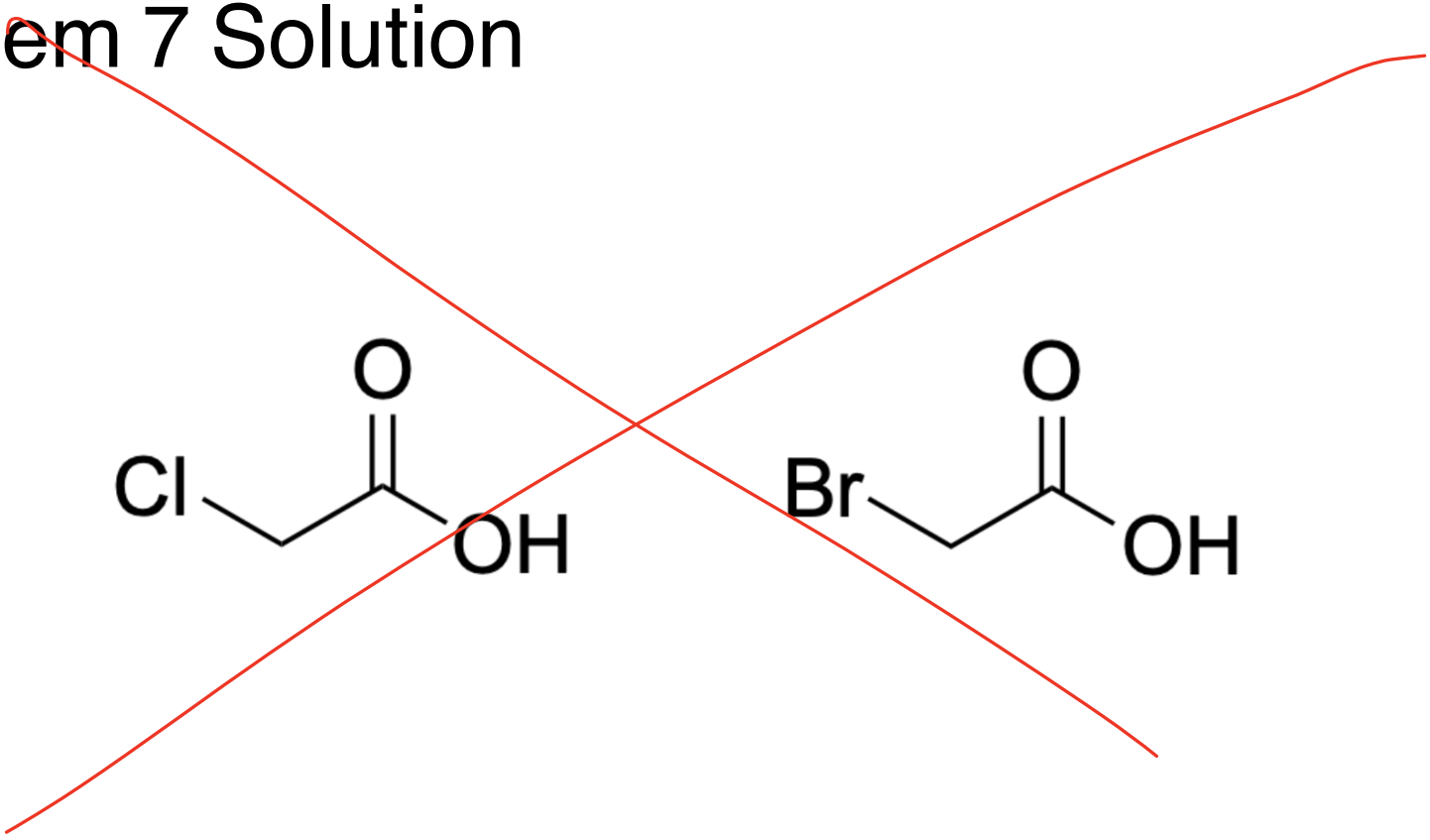
Problem 7

- Determine which molecule is more acidic and explain why.



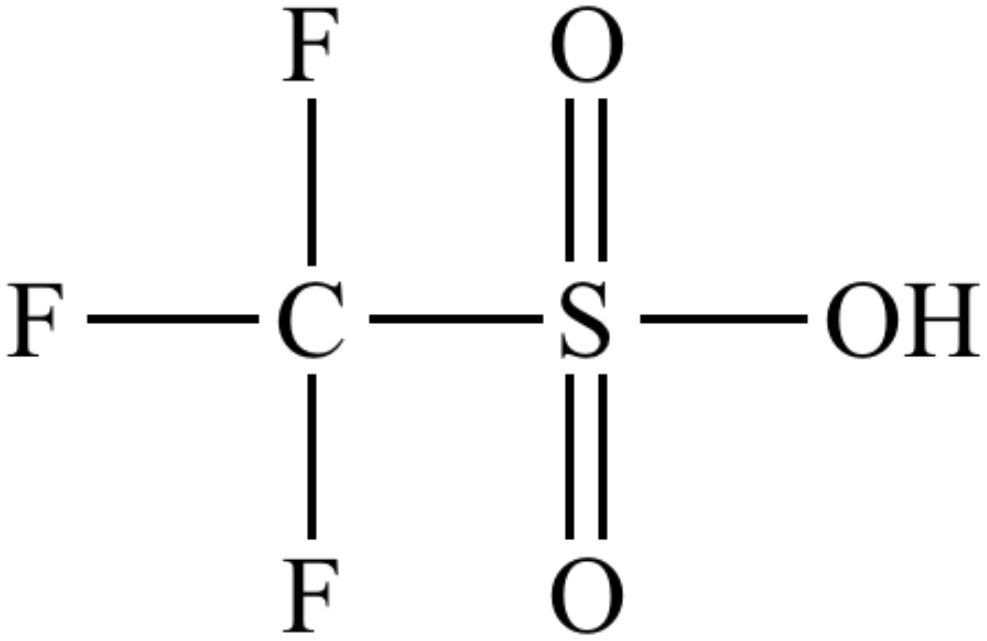


Problem 7 Solution

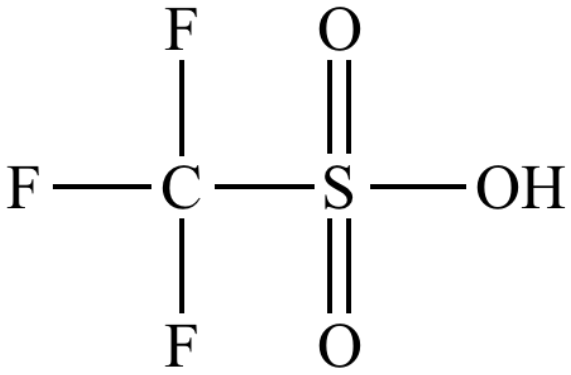


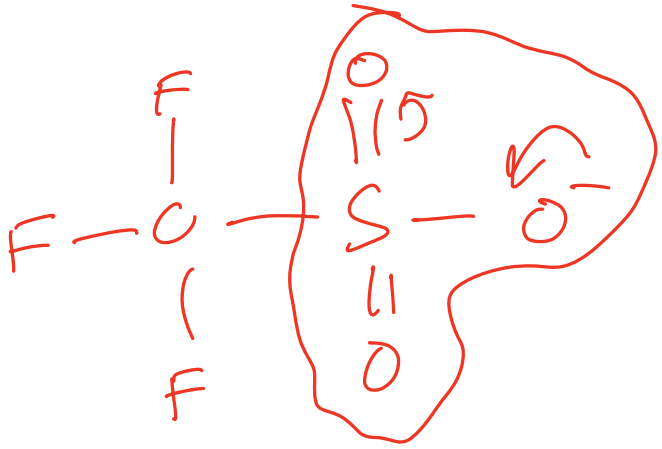
Problem 8

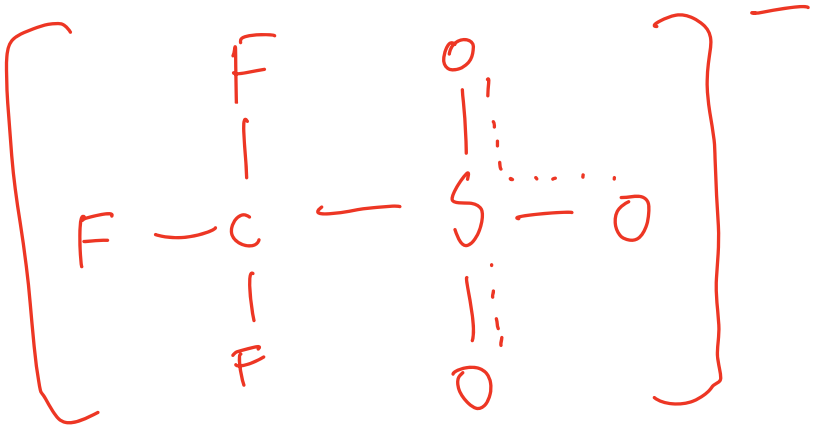
- Shown below is trifluoromethanesulfonic acid, which is classified as a superacid. Draw the conjugate base and explain why.



Problem 8 Solution

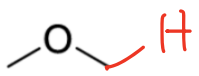




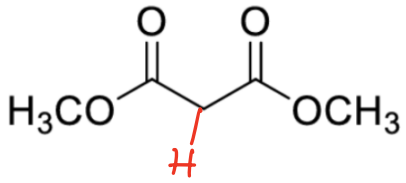


Problem 9

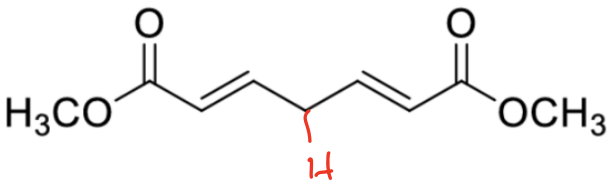
- Determine the most acidic proton and rank the molecules from most to least acidic.



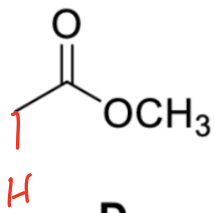
A



B

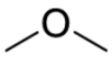


C

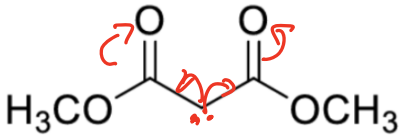


D

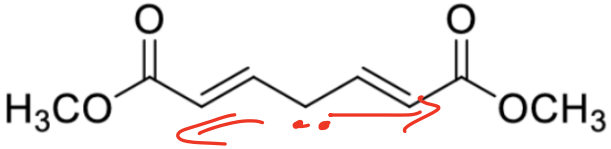
Problem 9 solution



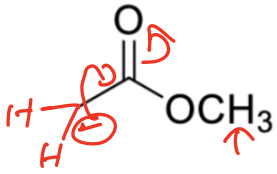
A



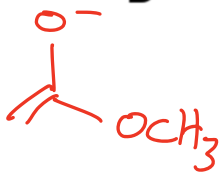
B



C



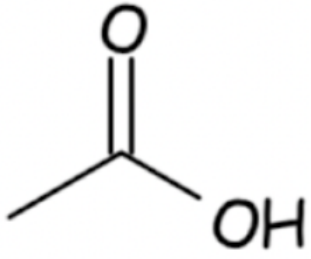
D

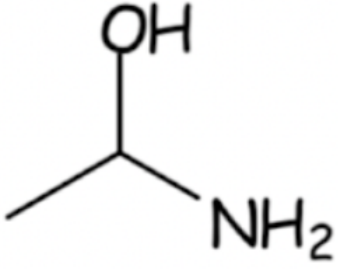


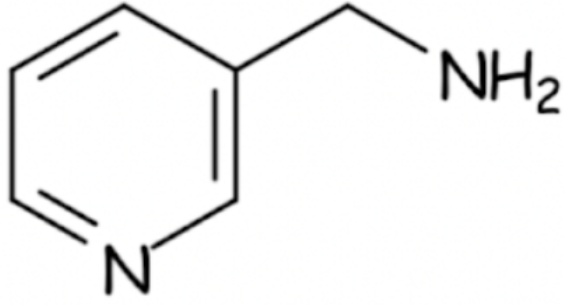
C > B > D > A

Problem 10

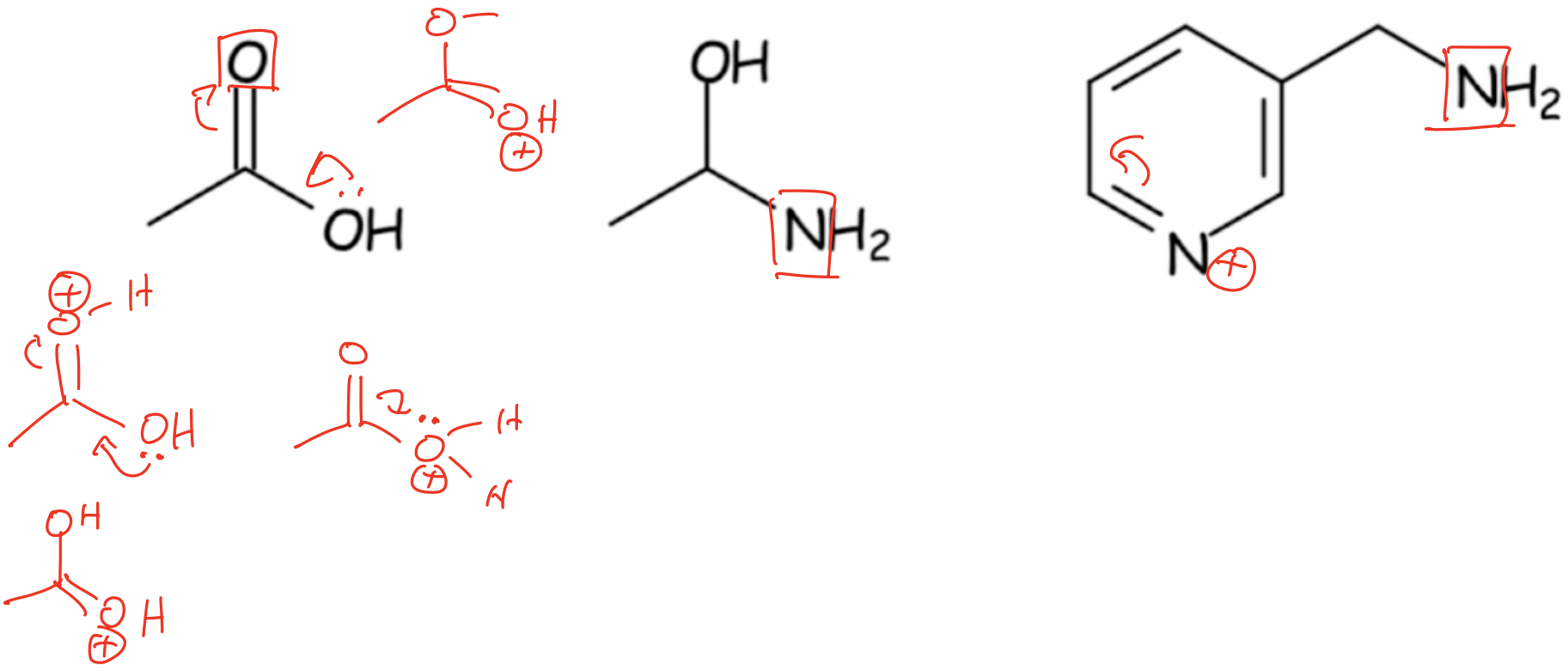
- For the following molecules, choose the atom which is most likely to be protonated when acid is added.





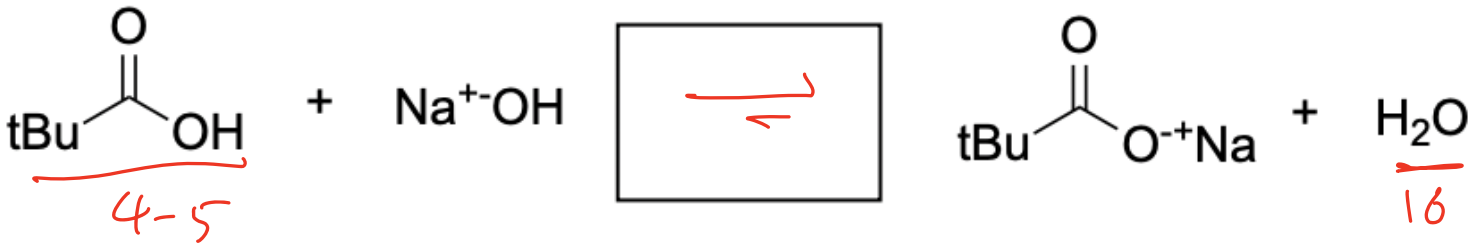


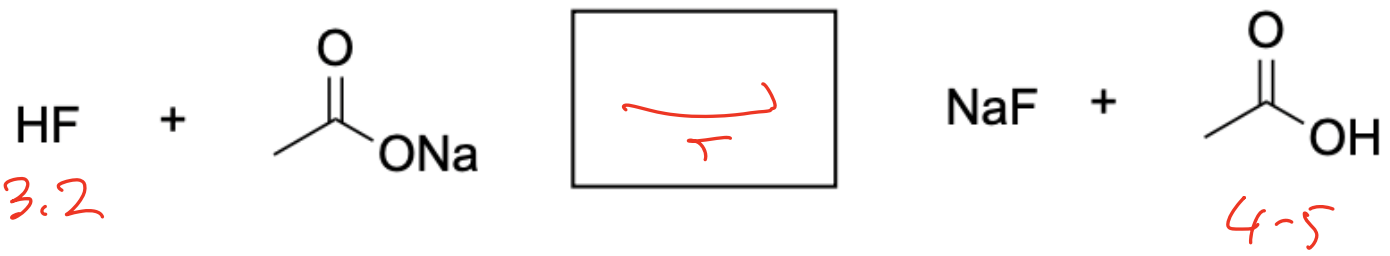
Problem 10 Solution



Problem 11

- Determine whether the following reactions favor products or reactants. (Hint: The pKa of HF is ~3.2)





Problem 11 Solution

Problem 12

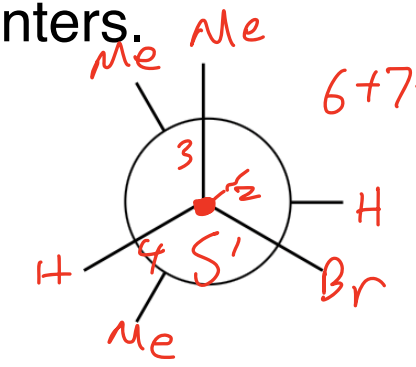
24 − 7.8 = 16.2

- Draw the eclipsed intermediate and calculate the barrier of rotation. Then, draw the molecule in its most stable conformation and determine the stereochemistry of all chiral centers.

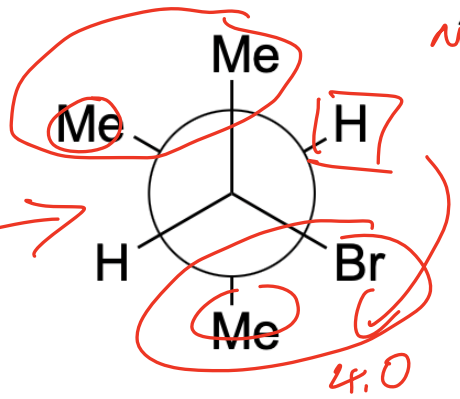
Interaction	Energy kJ/mol
Me-Br *gauche*	4.0
Me-Me *gauche*	3.8
H-H *eclipse*	4.0
Br-H *eclipse*	7.0
Me-Me *eclipse*	11.0
Br-Me *eclipse*	13.0
H-Me eclipse	6.0

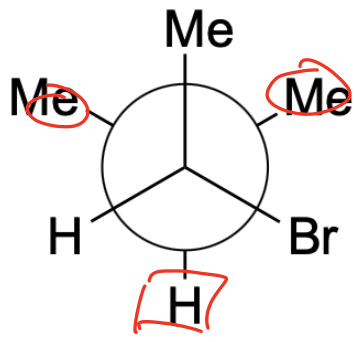
7.8

6+7+11=24

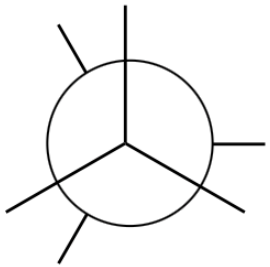


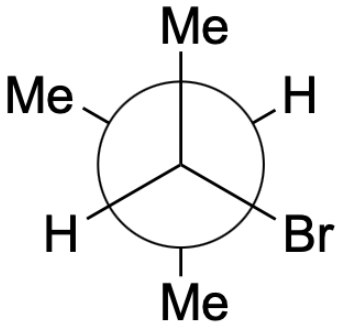
3.8

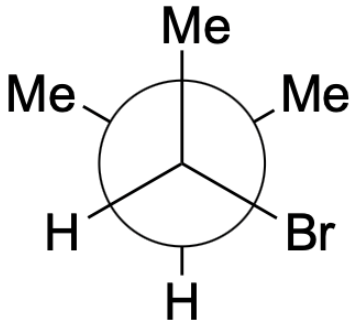




Problem 12 Solution



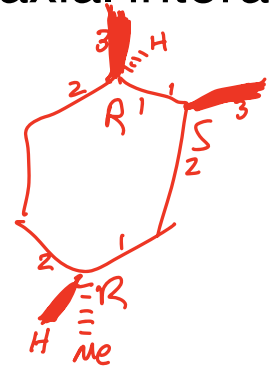


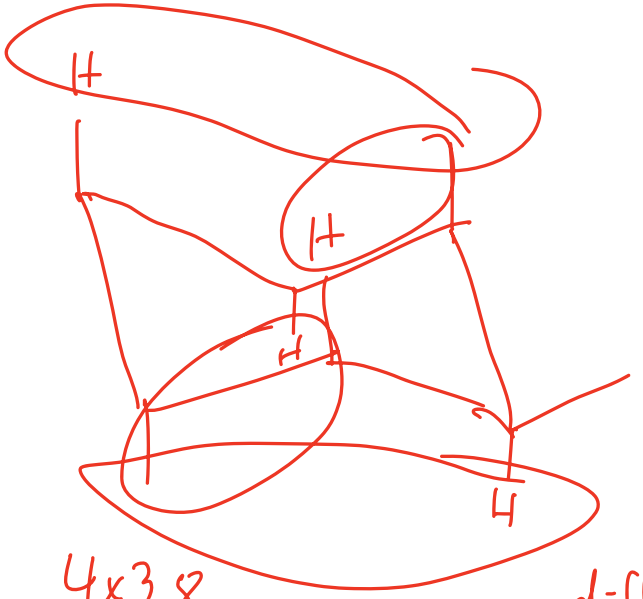


Interaction	**Energy kJ/mol**
Me-Br *gauche*	4.0
Me-Me *gauche*	3.8
H-H *eclipse*	4.0
Br-H *eclipse*	7.0
Me-Me *eclipse*	11.0
Br-Me *eclipse*	13.0

Problem 13

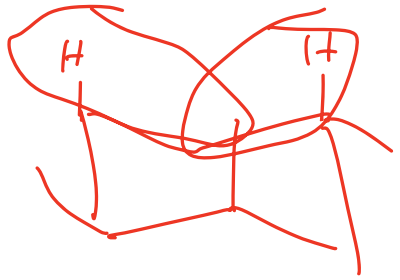
- Draw both conformations of (1R, 2S, 4R)-1,2,4-trimethylcyclohexane and determine the energy difference between the structures (Me-H 1,3-diaxial interactions are 3.8 kJ/mol).





4x3.8

or



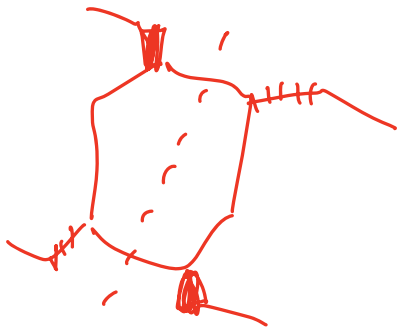
2x3.8

diff (4-2)3.8=7.6

Problem 13 Solution

Problem 14

- Draw a meso tetrasubstituted cyclohexane with a K_{eq} of 1. Use the molecular formula $C_{14}H_{28}$.

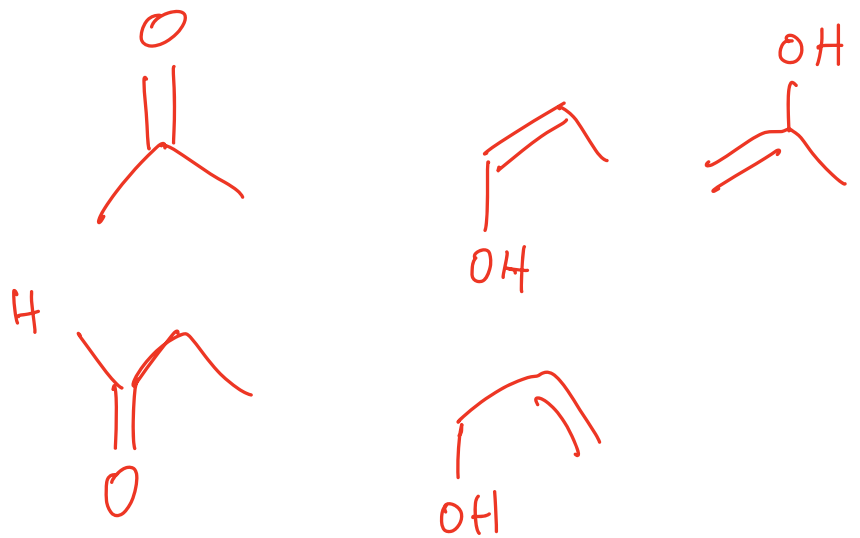


Problem 14 Solution

Problem 15

- Determine the degrees of unsaturation for C_3H_6O. Then draw all constitutional isomers.

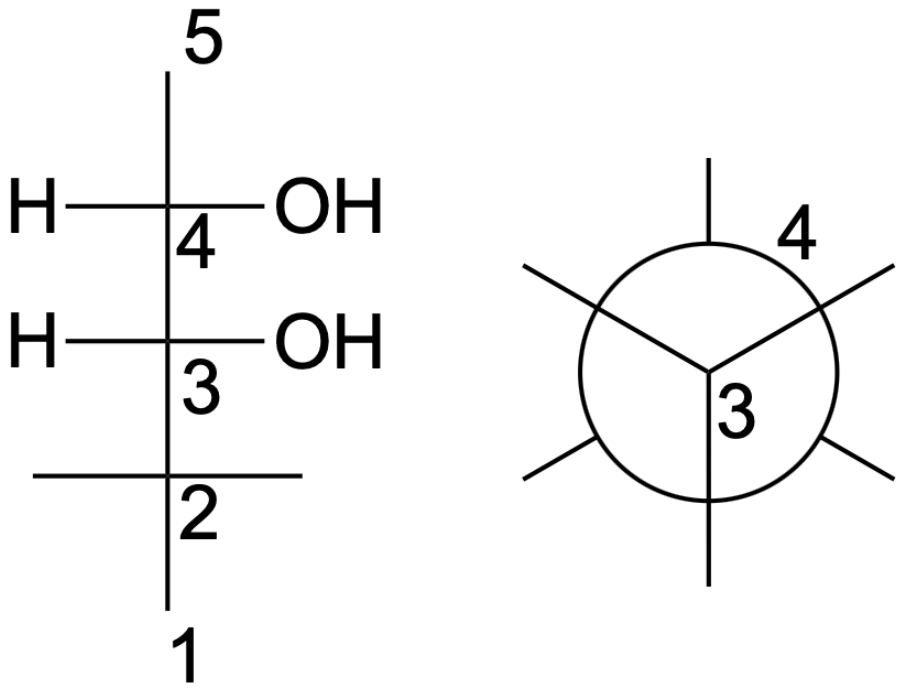
$$\frac{2C+2-H+N-X}{2}$$



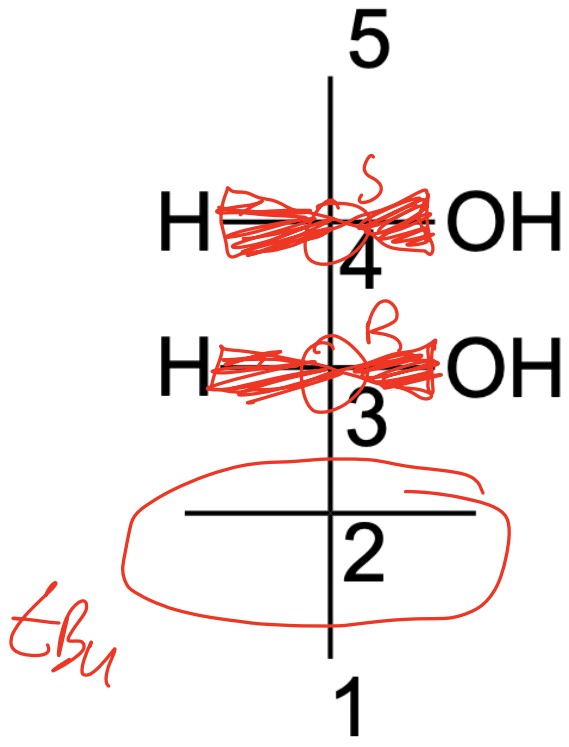
Problem 15 Solution

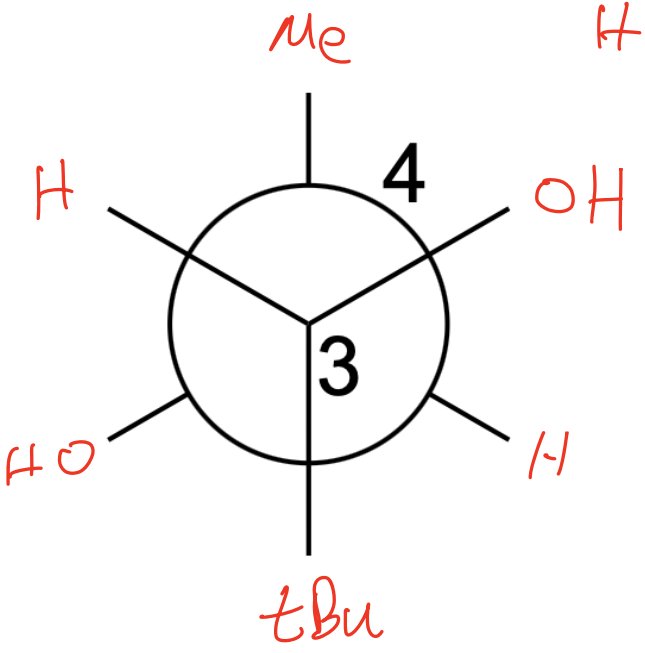
Problem 16

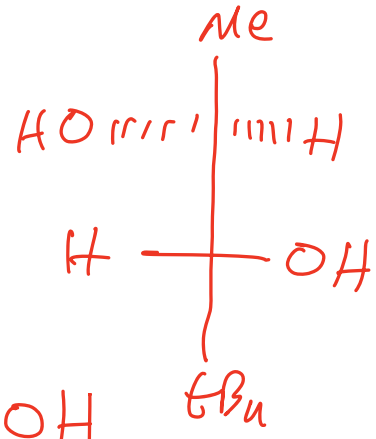
- Consider the following Fischer projection. Convert this molecule to a Newman projection and find the absolute configuration of all chiral centers.



Problem 16 Solution

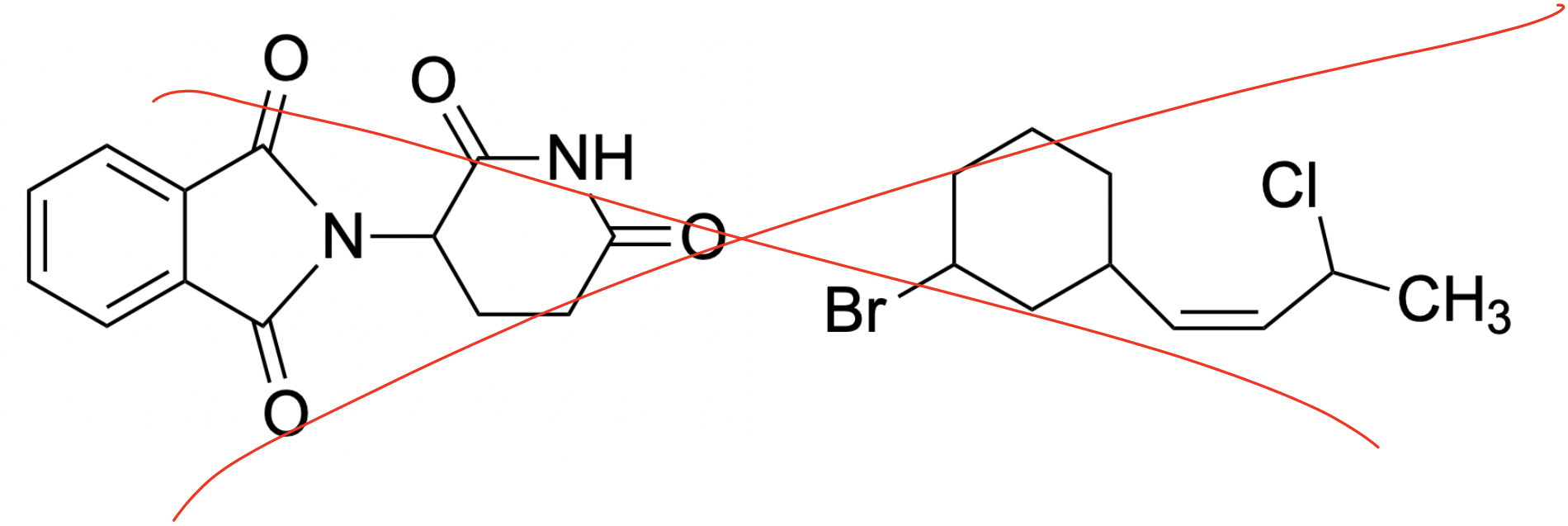




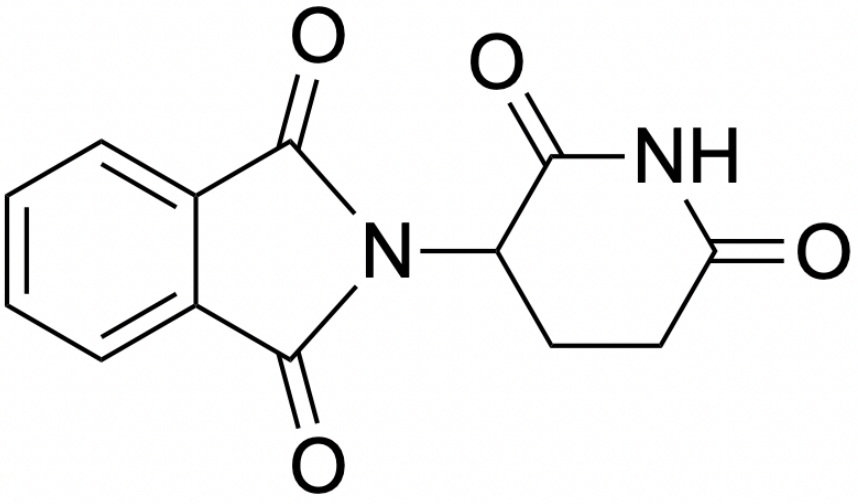


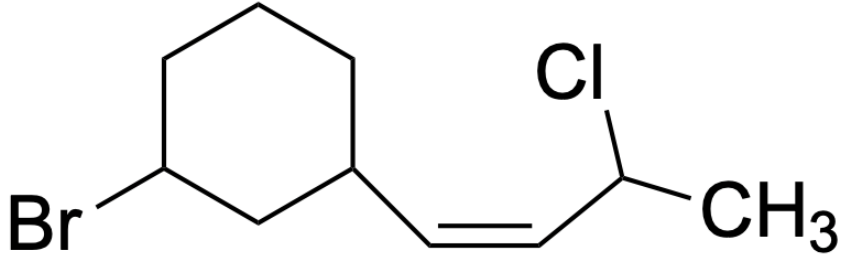
Problem 17

- How many stereoisomers do the following molecules have?



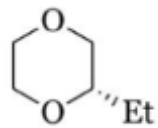
Problem 17 Solution

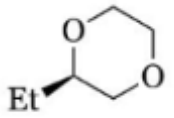


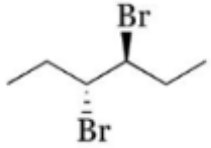


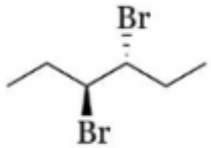
Problem 18

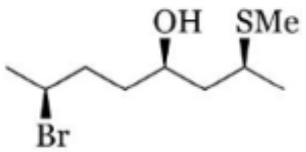
- Determine if the following molecules are enantiomers, diastereomers, identical, or meso. Constitutional

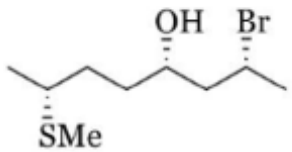


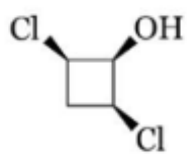


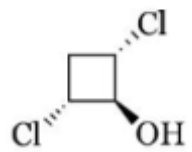


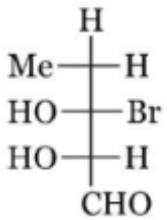


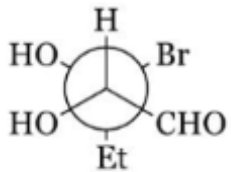


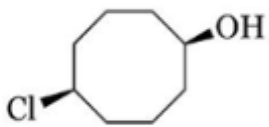


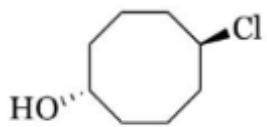




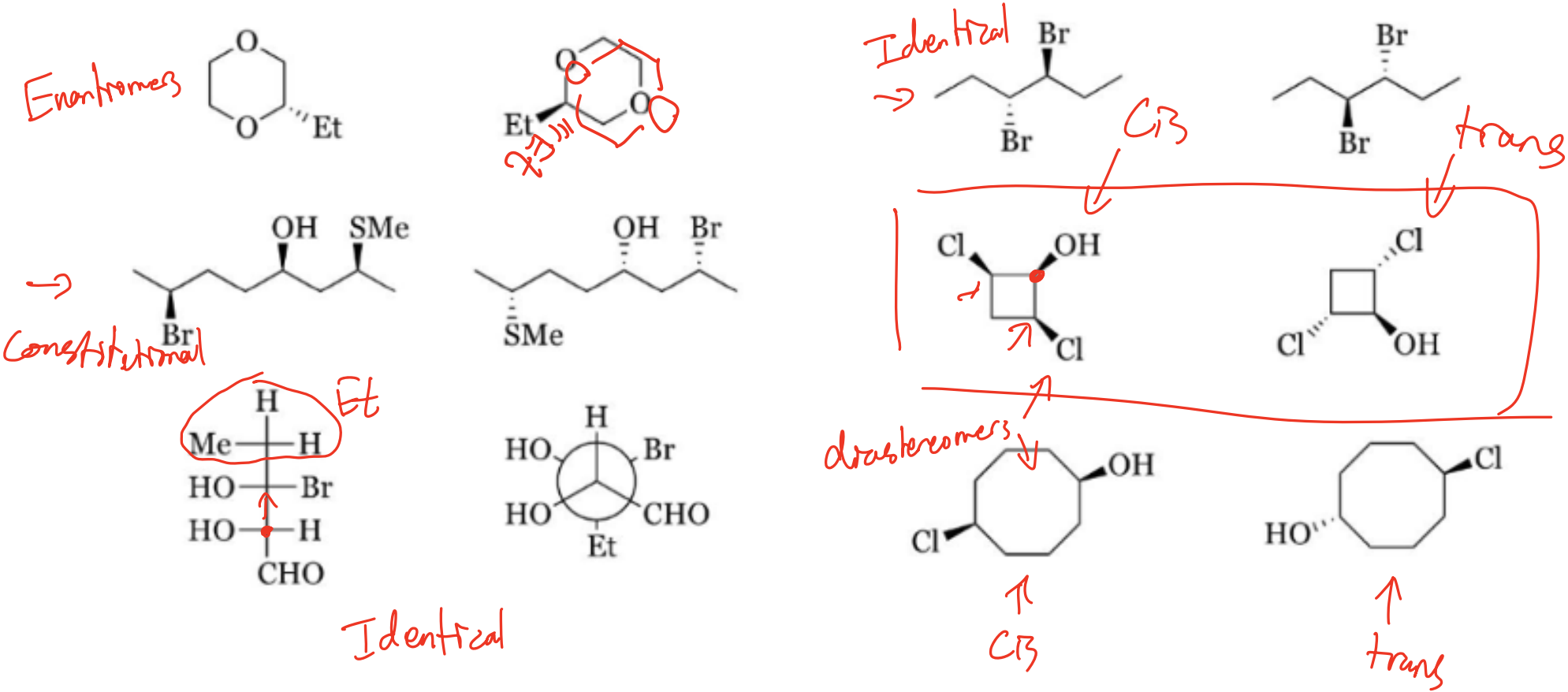








Problem 18 Solution



Good luck on your midterm!