Problem Set 4

1. Read Chapter 5 Section 1. You are responsible for knowing the terms stereochemistry and stereoisomers. What are stereoiosomers? How do they differ from constitutional isomers?

2. Read Chapter 5 Section 2. You should know what chirality is and how to determine if an object is chiral or achiral. How is chirality defined? What are the requirements for an object to exhibit chirality? You should be familiar with what an asymmetric carbon atom is and other terms that are used synonymously (i.e., stereogenic center, stereocenter, chiral or chirality center, chiral carbon atom, etc.). What are the requirements for a carbon atom to be asymmetric? You are responsible for knowing that stereoisomers that contain an asymmetric carbon have no internal mirror symmetry (an internal mirror plane) such that the two molecules are nonsuperimposable mirror images called enantiomers. Molecules that have internal mirror symmetry necessarily are achiral. Study Solved Problem 5-1.

Work the following problems found in Section 2 of Chapter 5: **Problems 1-5.**

3. Read Chapter 5 Section 3. Learn the Cahn-Ingold-Prelog (CIP) prioritization rules for assigning (R) and (S) configuration to asymmetric carbon atoms in molecules. Study Solved Problems 2 and 3.

Work the following problems found in Section 3 of Chapter 5: **Problems 6 and 7.**

4. Read Chapter 5 Section 4: Optical Activity. You are responsible for knowing that chiral compounds that are pure (not racemic) exhibit optical activity when placed in the path of plane, polarized light in a polarimeter—that is, they rotate polarized light either in a positive (+), clockwise, dextrorotatory (*d*) direction or in a negative (-) counter-clockwise, levorotatory (*l*) direction. The designations (+) and (-) and the designations (*d*) and (*l*) are used synonymously to indicate that a compound is optically active. You should be familiar with term specific rotation, $[\alpha]_D$, and that $[\alpha]_D = \alpha_{observed}/c \bullet l$, where c is the concentration in g/mL and l is the path length in decimeters (dm).

   Work the following problems found in Section 4 of Chapter 5: **Problems 8-10.**

5. Read Chapter 5 Section 5: Biological Discrimination of Enantiomers. You should be aware that biological molecules such as proteins, complex sugars, DNA/RNA, etc. are chiral because they are composed of chiral building blocks (i.e., amino acids and simple sugars). Accordingly, biological molecules are able to discriminate between enantiomers (e.g., substrate in a binding pocket of a protein) because of differences in fit and interaction energies. See the examples described in the text.

   Work the following problem found in Section 5 of Chapter 5: **Problem 11.**

6. Read Chapter 5 Section 6: Racemic Mixtures. You are responsible for knowing what a racemic mixture is, that racemic mixtures exhibit no optical activity (why?), and that organic reactions involving achiral reactants/catalysts give racemic products when a stereocenter is created.

7. Read Chapter 5 Section 7: Enantiomeric Excess. *You will not tested on this material*. You should be aware that organic reactions using chiral reagents/catalysts produce chiral products either as single enantiomers or as a mixture of two enantiomers with one enantiomer in excess. The material in this section describes how to calculate optical purity—also called enantiomeric excess. It is useful to know this material if you go on in chemistry.

8. Read Chapter 5 Section 8: Chirality of Conformationally Mobile Systems. You are responsible for knowing that a molecule cannot be optically active (is achiral) if its chiral conformations are in equilibrium with their mirror images. To determine if a conformationally flexible molecule is optically active (chiral), examine the most symmetrical conformation—that is, determine if it is a *meso* compound. Study Solved Problem 5-6.

   Work the following problem found in Section 8 of Chapter 5: **Problem 14.**

9. Read Chapter 5 Section 9: Chiral Compounds Without Asymmetric Atoms. You are responsible for knowing that molecules lacking asymmetric atoms can exhibit chirality (be optically active) if different conformations of the molecule are highly strained or the positions of substituents are locked such that the mirror image stereoisomers are enantiomers that cannot interconvert.

   Work the following problem found in Section 9 of Chapter 5: **Problem 15.**

10. Read Chapter 5 Section 10: Fischer Projections. You should know how to draw Fischer projections, how to determine (*R*) and (*S*) configuration of stereocenters, and how to compare mirror images of Fischer projections to determine if the two are enantiomers or a meso compound. Be aware that rotating a Fischer projection by 90° is not allowed because doing so inverts the stereochemical configuration. Rotating a Fischer projection by 180° is allow because it preserves the stereochemical configuration.

    Work the following problems found in Section 10 of Chapter 5: **Problems 16-19.**

11. Read Chapter 5 Sections 11-13: Diastereomers, Stereochemistry of Molecules with Two or More Asymmetric Carbons, and Meso Compounds. You should know that compounds with two or more stereocenters (n) can form as many as 2^n stereoisomers. Stereoisomers that are not mirror images are called diastereomers. Any given stereoisomer has just one enantiomer; other stereoisomers are diastereomers. Unlike enantiomers, the physical properties (m.p., b.p., solubility, etc.) of diastereomers differ. Stereoisomers with two or more stereocenters that have internal mirror symmetry are called *meso* compounds and are achiral. Study Solved Problems 5-7 and 5-8.

    Work the following problems found in Sections 11-13 of Chapter 5: **Problems 20-22.**

12. Read Chapter 5 Section 14: Absolute and Relative Configuration. *You will not be tested on this material*. It is useful to know the difference between absolute and relative configuration if you go on in chemistry.

13. Read Chapter 5 Section 15: Physical Properties of Diastereomers. You should be aware that, unlike enantiomers, the physical properties of diastereomers differ. Why?

    Work the following problem found in Section 15 of Chapter 5: **Problem 23.**

14. Read Chapter 5 Section 16: Resolution of Enantiomers. *You will not be tested on this material*. One of the great challenges in the pharmaceutical industry is separation of enantiomers after chemical synthesis. This section discusses how enantiomers both chemically and chromatographically. It is useful to know this material if you go on in chemistry.

Work the following problems found at the back of Chapter 5: **Problems 25-31, 34a,b, 35 (optional: try challenge problems 37, 38 and 41)**