1. Identify which of the following structures are chiral and which are achiral. Assign R,S configurations to all stereocenters in the chiral structures.

   a) \[
   \text{Cl} \quad \text{CH}_3 \quad 1 \quad 4 \quad \text{H} \quad \text{D} \quad 3
   \]
   Chiral, Rotate Clockwise: \textbf{R}

   d) \[
   \text{H} \quad \text{Cl}
   \]
   achiral (two identical groups)

   f) \[
   \text{Cl} \quad \text{H} \quad \text{D} \quad 3 \quad 2 \quad \text{CD}_3 \quad 1 \quad \text{CD}_3
   \]
   Rotate-180° about vertical axis

2. Classify the following pairs of compounds as structural isomers, diastereomers, or enantiomers

   a) \[
   \text{A} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H}
   \]
   Constitutional isomers

   b) \[
   \text{A} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H}
   \]
   Diastereomers

   c) \[
   \text{A} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H}
   \]
   enantiomers

3. Assign R,S configurations to each stereocenter in 2cA and 2dB. {See Above}

4. Assign R,S designations to each of the stereocenters in the following compounds. Use Chemsketch or Isis/Draw with Chem3D to visualize the structures and to assign the R,S configuration. Construct the molecule and then rotate it into the proper orientation to apply the technique. Print out 3-D structures of all in the correct orientation and turn this in with your problem set.
5. a) Draw clear 3-dimensional structures of the four different stereoisomers of 1,2,3-
trichlorocyclopentane.

b) Identify:
   - achiral structures
   - meso compounds
   - pairs of enantiomers
   - pairs of diastereomers

\[ \text{Meso A} \quad \text{Meso B} \quad \text{Chiral} \quad \text{Chiral} \]

\[ \text{Diastereomers: A,B; A,C; A,D; B,C; B,D} \]

\[ \text{Enantiomers: C,D} \]

c) Which of the compounds, if taken separately would show optical activity?  **C and D only**

d) If an equal molar mixture of all 4 isomers were distilled, how many fractions would be collected?

3-fractions since the pair of enantiomers would distill together.

e) How many of the fractions in (d) would be expected to show optical activity?

None since an equal molar mixture of C and D would be a racemic mixture which would
be optically inactive.

6. A sample of a natural carboxylic acid, mandelic acid (C\(_6\)H\(_5\))CH(OH)CO\(_2\)H, is obtained that is an unequal mixture of
enantiomers (not optically pure). If the impure sample has an optical rotation of -34° and that of pure (S)-(−)-mandelic
acid is -158°, determine the following:

a) The percent optical purity of the sample of (S)-(−)-mandelic acid.

\[ \% \text{optical purity} = \left( \frac{\text{rotation of sample}}{\text{rotation of pure enantiomer}} \right) \times 100\% \]

\[ \% \text{optical purity} = \left( \frac{-34°}{-158°} \right) \times 100\% = 21.5\% \text{op. pure} \]

b) The ee comes from a comparison of the moles of each enantiomer present.

\[ \text{Enantiomeric Excess} = \left( \frac{\text{moles (−) enantiomer} - \text{moles (+) enantiomer}}{\text{total moles both enantiomers}} \right) \times 100\% \]

Which in this case is the same as the % optical purity

\[ \text{Enantiomeric Excess} = \left( \frac{60.75 - 39.25}{100} \right) \times 100\% = 21.5\% \text{ee} \]

c) 21.5% ee, means there is 78.5% racemic form present, or 39.25% (-) enantiomer and 39.25% (+) enantiomer. That gives a total of 60.75% (-) enantiomer.

d)