1. Indicate whether each pair of compounds are enantiomeric (E), diastereomeric (D), constitutional isomers (C), or the same (S).

   \[
   \begin{align*}
   &\text{E} \quad \text{D} \\
   &\text{C} \\
   &\text{D} \\
   &\text{S} \\
   &\text{C} \\
   &\text{D} \\
   &\text{D} \\
   &\text{E} \\
   &\text{S} \\
   &\text{S}
   \end{align*}
   \]
2. In each of the following pairs of compounds one is chiral and the other achiral. Circle the chiral.

3. A sample made up of equal amounts of all the isomers of dimethylcyclopropane is injected into a gas chromatography (GC) instrument with an achiral column. The GC separates 3 components, none of which shows any optical rotation.

a) Draw all distinct isomers of dimethylcyclopropane and explain the findings.

These two compounds represent a pair of enantiomers that cannot be separated using an achiral chromatography column. Because the mixture possess equal amounts of both they constitute a racemic mixture.
4. The alkyl halide, (R)-2-chlorobutane, undergoes bromination through a radical mechanism. The monobromination products are: 1-bromo-2-chlorobutane, 1-bromo-3-chlorobutane, 2-bromo-3-chlorobutane, and 2-bromo-2-chlorobutane.

a) The 1-bromo-2-chlorobutane compound is about 1% of all the monobrominated products. What is the absolute configuration of this product?

b) The 1-bromo-3-chlorobutane constitutes about 7% of the monobrominated products. What is the absolute configuration of this product?

c) The 2-bromo-2-chlorobutane monobrominated product consists of a racemic mixture in about 46% of the total products. Explain the occurrence of this mixture.

d) The 2-bromo-3-chlorobutane is a mixture of 2 diastereomers. Careful separation of the components shows the (2S, 3R) diastereomer is about 28% of the mixture and the (2R, 3R) about 18%. Provide a brief explanation as to why these two diastereomers are not produced in equal amounts. Hint: Use the Newman projection of the intermediate to represent the formation of each diastereomer.

\[\text{Cl} \quad \text{(R)-2-chlorobutane} \rightarrow_{\text{Br}_2, \text{hv}} \text{Cl} \quad \text{(S)-1-bromo-2-chlorobutane} + \text{Cl} \quad \text{(R)-1-bromo-3-chlorobutane} \]

\[\text{Cl} \quad \text{(S)-2-bromo-2-chlorobutane} + \text{Cl} \quad \text{(R)-2-bromo-2-chlorobutane} \]

\[\text{Cl} \quad \text{(S)-1-bromo-3-chlorobutane} \sim 1\% \quad \text{(R)-1-bromo-3-chlorobutane} \sim 7\% \]

\[\text{Cl} \quad \text{(S)-2-bromo-2-chlorobutane} \quad \text{(R)-2-bromo-2-chlorobutane} \quad \sim 46\% \]

These 2 enantiomers come from the 2-chlorobutyl radical. The carbon radical is hybridized $sp^3$ with trigonal planar geometry. The probability of attack from either side of the plane is the same.

\[\text{Cl} \quad \text{(2S, 3R)-2-bromo-3-chlorobutane} \sim 28\% \quad \text{(2R, 3R)-2-bromo-3-chlorobutane} \sim 18\% \]

The 2-bromo-3-chlorobutane diastereomers are generated by the 2-chloro-3-butyl radical. The Newman projection of this radical through $C_2-C_3$ is shown below.

\[\text{Cl} \quad \text{Cl} \quad \text{H} \quad \text{CH}_3 \quad \text{H} \quad \text{CH}_3 \]

The less sterically-hindered side of the carbon radical has greater probability of attack.
5. Quinic acid, C₇H₁₂O₆, can be extracted from coffee beans. It gives coffee the bitter taste. The specific rotation of quinic acid is $[\alpha]^D_{20^\circ} = -43.9^\circ$. Which of the proposed structures, drawn below, is more likely to be correct? Briefly explain your choice.

![Proposed structures](image)

The molecule is chiral according to the data provided. Therefore the molecule should not have a plane of symmetry.

6. Circle the structure that represents the ozonolysis product under reducing conditions of (trans)-3,4-dimethylcyclopentene.

![Ozonolysis product](image)