

**Exercise 1.** What is the geometry around an sp-hybridized carbon?

- a) Tetrahedral
- b) Trigonal planar
- c) Bent
- d) Linear

**Solution:**

d) Linear: sp hybridization produces two orbitals  $180^\circ$  apart, giving linear geometry.

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**Exercise 2.** How many unhybridized p orbitals remain in an sp<sup>2</sup>-hybridized carbon?

- a) 0
- b) 1
- c) 2
- d) 3

**Solution:**

b) 1: sp<sup>2</sup> hybridization uses one s and 2p orbitals, leaving one p orbital unhybridized.

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**Exercise 3.** Which hybridization is found in the carbons of a typical alkene?

- a) sp
- b) sp<sup>2</sup>
- c) sp<sup>3</sup>
- d) Depends on substituents

**Solution:**

b) sp<sup>2</sup>: Carbons in C=C double bonds are sp<sup>2</sup>-hybridized.

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**Exercise 4.** Isomers are molecules that:

- a) Have different molecular formulas
- b) Have the same molecular formula but different structures
- c) Are mirror images only
- d) Must have double bonds

**Solution:**

b) Isomers differ in atom arrangement while keeping the same formula.

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**Exercise 5.** Hydrocarbons (containing only C and H) are generally:

- a) Strongly polar
- b) Slightly polar
- c) Nonpolar
- d) Ionic

**Solution:**

c) C–H and C–C bonds have similar electronegativities, resulting in nonpolar molecules.

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**Exercise 6.** For each of the statements below, write if it is TRUE or FALSE:

- a) The boiling point of alkanes increases as the carbon chain becomes longer.
- b) Branched alkanes are more reactive than straight-chain alkanes because they have weaker C–H bonds.
- c) Alkanes can undergo addition reactions readily.
- d) Cycloalkanes have the general formula  $C_nH_{2n}$ .
- e) Geometric isomerism is possible in alkenes when each carbon of the C=C bond has two different substituents.
- f) All carbons in benzene are  $sp^2$ -hybridized.
- g) Aromatic compounds typically undergo substitution reactions rather than addition reactions.

**Solution:**

- a) TRUE – Longer carbon chains have stronger London dispersion forces, raising the boiling point.
  - b) FALSE – Branched alkanes do not have weaker C–H bonds than straight-chain alkanes.
  - c) FALSE – Alkanes lack  $\pi$  bonds, so they do not undergo addition reactions easily.
  - d) TRUE – Cycloalkanes follow the formula  $C_nH_{2n}$  because ring closure removes two hydrogens.
  - e) TRUE – Cis/trans (geometric) isomerism requires each carbon in the double bond to have two different substituents.
  - f) TRUE – Benzene's six carbons are all  $sp^2$ -hybridized, forming a planar conjugated ring.
  - g) TRUE – Aromatic compounds prefer substitution reactions to preserve their stable aromatic  $\pi$  system.
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**Exercise 7.** For each of the statements below, write if it is TRUE or FALSE:

- a) Oxidation of an alcohol typically increases the number of C–O bonds in a molecule.
- b) Reduction reactions in organic chemistry usually involve adding hydrogen or removing oxygen.
- c) Ethers and esters have two carbon atoms bonded to the same oxygen atom.
- d) Halogenoalkanes (alkyl halides) cannot undergo substitution reactions.
- e) Oxygen-containing functional groups generally make a molecule more hydrophobic.
- f) C–O bond is generally more polar than C–X (halogen).
- g) Aldehydes and ketones have the same functional group (C=O) located at the terminal carbon or non-terminal carbon, respectively.


**Solution:**

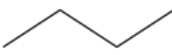
- a) TRUE – Oxidation of an alcohol converts C–H bonds to C–O bonds, increasing the degree of oxidation.
- b) TRUE – Organic reductions commonly involve adding hydrogen or removing oxygen, lowering the oxidation state of carbon.
- c) TRUE – Both contain an oxygen between two carbons, but esters also include a carbonyl (C=O) adjacent to the oxygen, unlike ethers.
- d) FALSE – Halogenoalkanes readily undergo nucleophilic substitution because the carbon–halogen bond is polarized.
- e) FALSE – Oxygen-containing groups usually increase polarity and often make molecules more hydrophilic, not hydrophobic.
- f) FALSE – C–F bond is more polar than C–O due to larger electronegativity differences.
- g) TRUE – Both aldehydes and ketones contain a carbonyl group, with aldehydes at the end of a chain and ketones on internal carbons.
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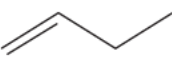
**Exercise 8.** Draw line structures of the following molecules and identify each as an alkane, alkene or alkyne

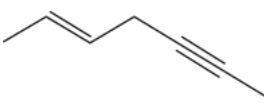
- a)  $\text{CH}_3\text{CCCH}_3$
- b)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
- c)  $\text{CH}_2\text{CHCH}_2\text{CH}_3$
- d)  $\text{CH}_3\text{CHCHCH}_2\text{CCCH}_3$
- e)  $\text{CH}_2\text{CHCH}_2\text{CHCH}_2$

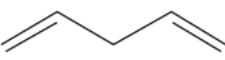
**Solution:**

a) Alkyne: 

b) Alkane: 

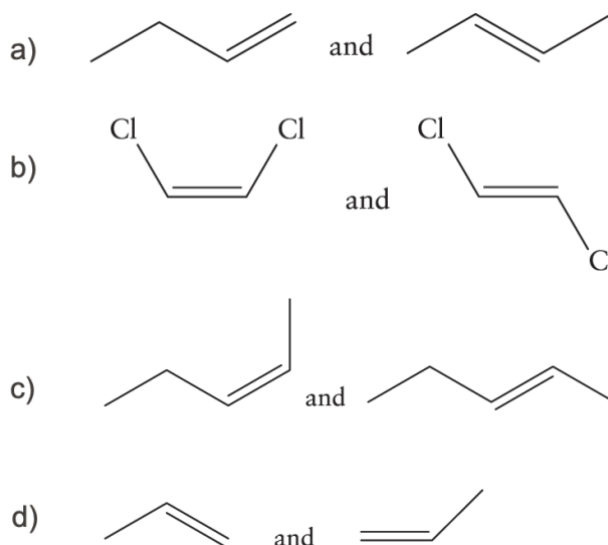
c) Alkene: 

d) Alkene and Alkyne: 

e) Alkene: 

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**Exercise 9.** Identify each of the following pairs as structural isomers, geometric isomers, or not isomers:

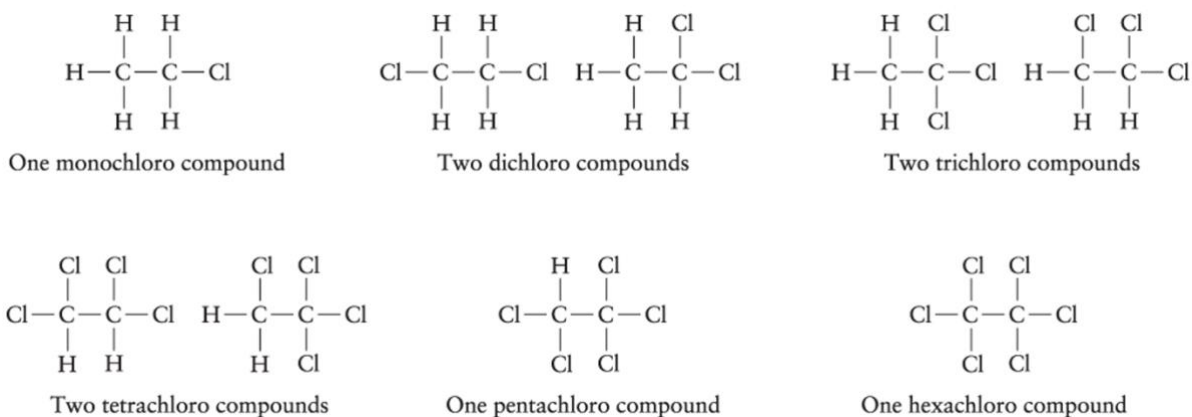


**Solution:**

- a) Structural isomers
- b) Geometric isomers
- c) Geometric isomers
- d) Not isomers. Same molecule just rotated by  $\sim 210^\circ$ .

**Exercise 10.** How many different products containing 2 carbon atoms are possible in substitution reactions of chlorine and ethane? Do any of the products exist as geometric or optical stereoisomers?

**Solution:**

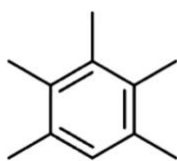


None of these are geometric isomers since there is no double bond to form cis-trans isomers.

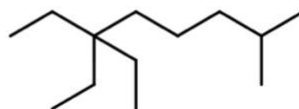
None of these are optical isomers, since there is no carbon attached to 4 **different** groups. Therefore, there can be no compounds related with mirror-symmetry.

**Exercise 11.** Name the following hydrocarbon molecules:

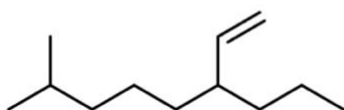
a)



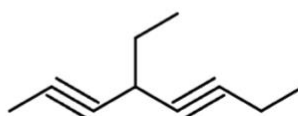
b)



c)



d)

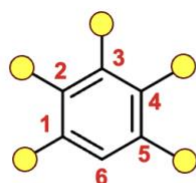


**Solution:**

The following rules were followed:

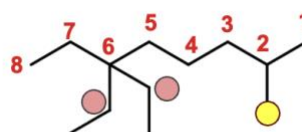
- Numbering in branched alkanes starts from the end that gives the lowest overall locant numbers, and the longest continuous carbon chain is selected as the parent structure.
- Numbering in benzene rings is assigned to give the lowest overall set of locants, and if a tie remains, the substituent that is alphabetically first receives the lowest number.
- Numbering in alkenes and alkynes must give the lowest possible locant to the multiple bond (C=C or C≡C); substituent numbering is determined afterward.
- The order of substituents in the name is alphabetical (e.g., butyl → ethyl → methyl → propyl), while ignoring multiplicative prefixes (di-, tri-, tetra-, etc.).
- Multiple double or triple bonds are indicated by both their locants (e.g., 1,3,5) and a numeric prefix (di-, tri-, tetra-) placed just before -ene or -yne in the parent name.

a)



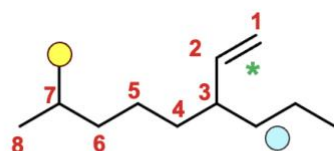
1,2,3,4,5-pentamethylbenzene

b)



6,6-Diethyl-2-methyloctane

c)

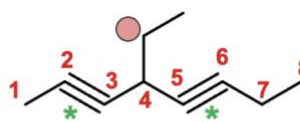


7-methyl-3-propyl-1-octene

or

7-methyl-3-propyloct-1-ene

d)

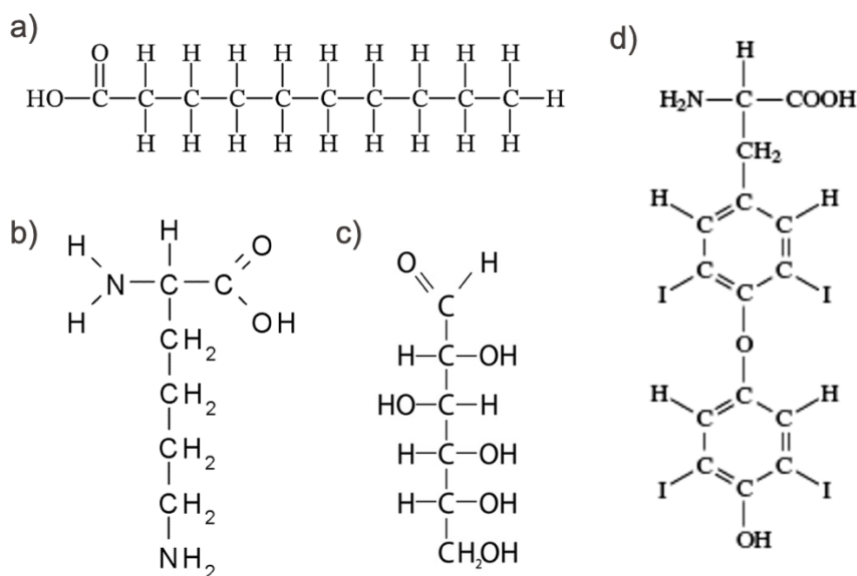


4-ethyl-2,5-octadiyne

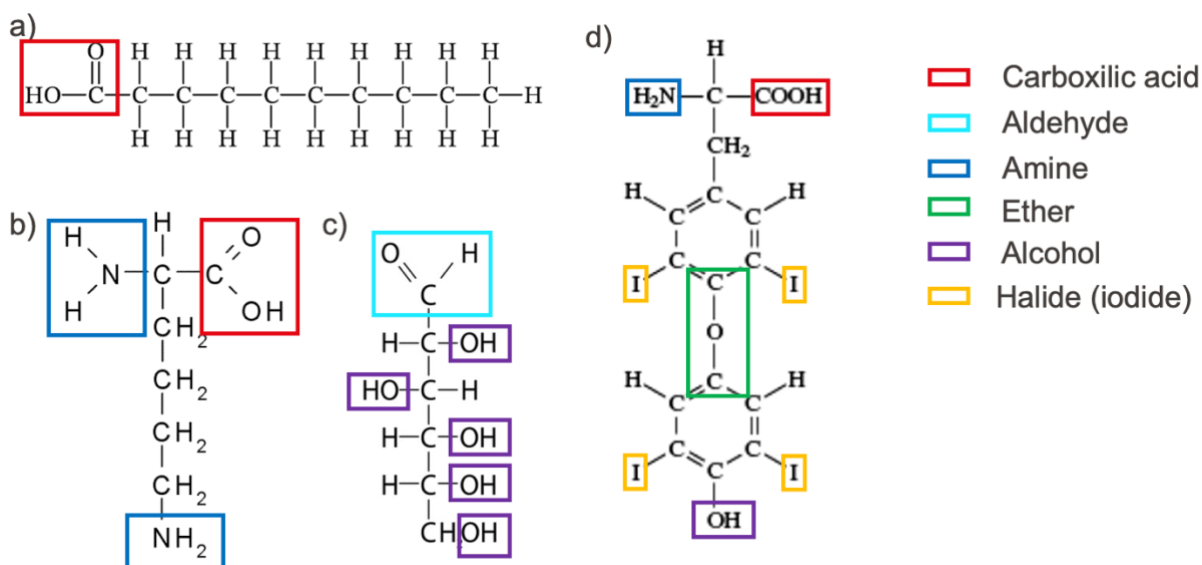
or

4-ethylocta-2,5-diyne

**Exercise 12.** Below are 4 important biomolecules found in human body: (a) capric acid, (b) lysine, (c) glucose, and (d) thyroxine. Identify and name all the heteroatom-containing functional groups:



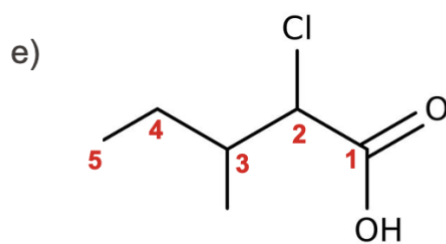
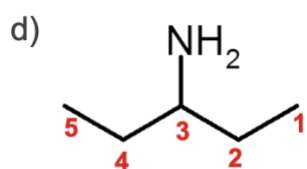
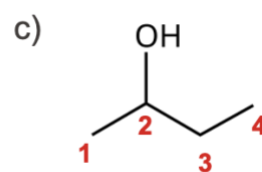
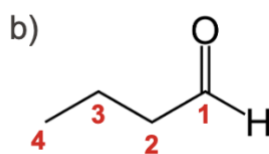
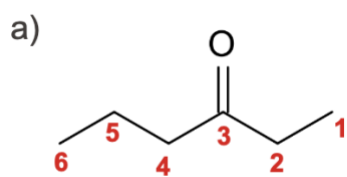
**Solution:**



**Exercise 13.** Draw the line structures of the following molecules:

- a) Hexan-3-one
- b) Butanal
- c) Butan-2-ol
- d) Pentan-3-amine
- e) 2-chloro-3-methylpentanoic acid

**Solution:**



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Quick Answers:

1. d)

2. b)

3. b)

4. b)

5. c)

6.

a) TRUE

b) FALSE

c) FALSE

d) TRUE

e) TRUE

f) TRUE

g) TRUE

7.

a) TRUE

b) TRUE

c) TRUE

d) FALSE

e) FALSE

f) FALSE

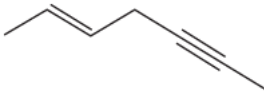
g) TRUE


8.

a) Alkyne: 

b) Alkane: 

c) Alkene: 

d) Alkene and Alkyne: 

e) Alkene: 

9.

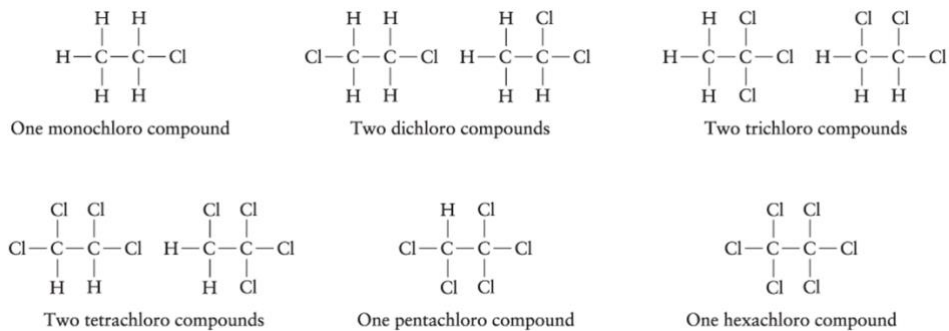
a) Structural isomers

b) Geometric isomers

c) Geometric isomers

d) Not isomers.

10.



No isomers among these compounds.

11.

- a) 1,2,3,4,5-pentamethylbenzene
- b) 6,6-Diethyl-2-methyloctane
- c) 7-methyl-3-propyloct-1-ene (or 7-methyl-3-propyl-1-octene)
- d) 4-ethylocta-2,5-diyne (or 4-ethyl-2,5-octadiyne)

12.

- a) Carboxylic acid (–COOH)
- b) Primary amines (–NH<sub>2</sub>) on 2 opposite ends; Carboxylic acid (–COOH)
- c) Aldehyde (–CHO); Multiple alcohols (–OH) on carbons 2, 3, 4, 5, and 6
- d) Alcohol OH groups (two of them); Ether linkage (Ar–O–Ar); Primary amine (–NH<sub>2</sub>); Carboxylic acid (–COOH); Iodo substituents on the aromatic rings (four iodine atoms)

13.

