Organic Compounds: Methane Ethane

Before beginning a systematic study of the different functional groups, let's look at the simplest family of molecules—the alkane family. Alkanes are hydrocarbons, which are molecules that consist of carbon and hydrogen atoms. Each carbon atom in an alkane has four bonds, three of which are to other carbon atoms, and one to a hydrogen atom. The alkane family includes a wide range of molecules, from methane (CH₄) to butane (C₄H₁₀), and beyond.

Problem 3.1
Identify the functional groups in each of the following molecules:

(a) Methionine, an amino acid:  
(b) Ibuprofen, a pain reliever:

(c) Capsaicin, the pungent substance in chili peppers:

Problem 3.3
Identify the functional groups in the following model of arecoline, a veterinary drug used to control worms in animals. Convert the drawing into a line-bond structure and a molecular formula (red = O, blue = N).

Problem 3.4
Draw structures of the five isomers of C₅H₁₄.

Problem 3.5
Propose structures that meet the following descriptions:

(a) Two isomeric esters with the formula C₅H₁₀O₂
(b) Two isomeric nitriles with the formula C₄H₇N
(c) Two isomeric disulfides with the formula C₄H₁₀S₂

Problem 3.7
Draw the eight 5-carbon alkyl groups (pentyl isomers).

Problem 3.8
Identify the carbon atoms in the following molecules as primary, secondary, tertiary, or quaternary:

(a) CH₃
(b) CH₃CH₃
(c) CH₃CH₂CH(CH₃)₂
(d) CH₃CH₂CH₂CH₃
(e) CH₃CH₂CH₂CH₂CH₃
(f) CH₃CH₂CH₂CH₂CH₂CH₃
(g) CH₃CH₂CH₂CH₂CH₂CH₂CH₃
(h) CH₃CH₂CH₂CH₂CH₂CH₂CH₂CH₃
Problem 3.9
Identify the hydrogen atoms on the compounds shown in Problem 3.8 as primary, secondary, or tertiary.

Problem 3.11
Give IUPAC names for the following compounds:

(a) The three isomers of C₅H₁₂
(b) \[\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\]
(c) \[(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3\]
(d) \[(\text{CH}_3)_3\text{CC}_2\text{H}_2\text{CH}_3\]

Problem 3.12
Draw structures corresponding to the following IUPAC names:

(a) 3,4-Dimethylnonane  (b) 3-Ethyl-4,4-dimethylheptane
(c) 2,2-Dimethyl-4-propyloctane  (d) 2,2,4-Trimethylpentane

Problem 3.14
Give the IUPAC name for the following hydrocarbon, and convert the drawing into a skeletal structure.

Problem 3.16
Sight along the C₂–C₁ bond, 2-methylpropane (isobutane) and
(a) draw a Newman projection of the most stable conformation.
(b) draw a Newman projection of the least stable conformation.
(c) make a graph of energy versus angle of rotation around the C₂–C₁ bond.
(d) Since an H↔H eclipsing interaction costs 4.0 kJ/mol and an H↔CH₃ eclipsing interaction costs 6.0 kJ/mol, assign relative values to the maxima and minima in your graph.
**Problem 3.17**
Sight along the C2 – C3 bond of 2,3-dimethylbutane, and draw a Newman projection of the most stable conformation.

**Problem 3.18**
Draw a Newman projection along the C2 – C3 bond of the following conformation of 2,3-dimethylbutane, and calculate a total strain energy:

**Functional Groups**

3.22 Locate and identify the functional groups in the following molecules.

(a) ![Molecule](image1.png)
(b) ![Molecule](image2.png)
(c) ![Molecule](image3.png)
(d) ![Molecule](image4.png)
(e) ![Molecule](image5.png)
(f) ![Molecule](image6.png)

3.25 Predict the hybridization of the carbon atom in each of the following functional groups:
(a) Ketone  (b) Nitrile  (c) Carboxylic acid

**Isomers**

3.29 In each of the following sets, which structures represent the same compound and which represent different compounds?

(a) ![Structure](image7.png)
(b) ![Structure](image8.png)
(c) ![Structure](image9.png)
3.31 Draw as many compounds as you can that fit the following descriptions:
(a) Alcohols with formula C₄H₁₀O  
(b) Amines with formula C₅H₁₃N  
(c) Ketones with formula C₅H₁₀O  
(d) Aldehydes with formula C₅H₁₀O  

Naming Compounds

3.35 Draw structures for the following:
(a) 2-Methylheptane  
(b) 4-Ethyl-2,2-dimethylhexane  
(c) 4-Ethyl-3,4-dimethyloctane  
(d) 2,4,4-Trimethylheptane  
(e) 3,3-Diethyl-2,5-dimethylnonane  
(f) 4-Isopropyl-3-methylheptane  

3.38 Give IUPAC names for the following compounds:
(a) CH₃CH₂CH₂CH₂CH₃  
(b) CH₃CH₂CCH₃  
(c) CH₃CHCH₂CH₂CH₃  
(d) CH₂CH₃CH₃  
(e) CH₃CH₂CH₂CH₂CH₂CH₃  
(f) CH₃CH₂CH₂CH₂CH₂CH₃  

Conformations

3.42 Consider 2-methylbutane (isopentane). Sighting along the C₂–C₃ bond:
(a) Draw a Newman projection of the most stable conformation.  
(b) Draw a Newman projection of the least stable conformation.  
(c) If a CH₃ ↔ CH₃ eclipsing interaction costs 11 kJ/mol (2.5 kcal/mol) and a CH₃ ↔ CH₃ gauche interaction costs 3.8 kJ/mol (0.9 kcal/mol), make a quantitative plot of energy versus rotation about the C₂–C₃ bond.  

3.43 What are the relative energies of the three possible staggered conformations around the C₂–C₃ bond in 2,3-dimethylbutane? (See Problem 3.42.)  

General Problems

3.53 The cholesterol-lowering agents called statins, such as simvastatin (Zocor) and pravastatin (Pravachol), are among the most widely prescribed drugs in the world, with annual sales estimated at approximately $15 billion. Identify the functional groups in both, and tell how the two substances differ.