PROBLEM 1

Draw good diagrams of saturated hydrocarbons with seven carbon atoms having (a) linear, (b) branched, and (c) cyclic structures. Draw molecules based on each framework having both ketone and carboxylic acid functional groups in the same molecule.

Purpose of the problem

To get you drawing simple structures realistically and to steer you away from rules and names towards more creative ideas.

Suggested solution

There is only one linear hydrocarbon but there are many branched and cyclic options. We offer some possibilities, but you may have thought of others.

linear saturated hydrocarbon (n-heptane)

some branched hydrocarbons

some cyclic hydrocarbons

We give you a few examples of keto-carboxylic acids based on these structures. A ketone has to have a carbonyl group not at the end of a chain; a carboxylic acid functional group by contrast has to be at the end of a chain. You will notice that no carboxylic acid based on the first three cyclic structures is possible without adding another carbon atom.
linear molecules containing ketone and carboxylic acid

some branched keto-acids

some cyclic keto-acids

PROBLEM 2

Draw for yourself the structures of amoxicillin and Tamiflu on page 10 of the textbook. Identify on your diagrams the functional groups present in each molecule and the ring sizes. Study the carbon framework: is there a single carbon chain or more than one? Are they linear, branched, or cyclic?

SmithKline Beecham’s amoxicillin
β-lactam antibiotic for treatment of bacterial infections

Tamiflu (oseltamivir)
invented by Gilead Sciences
marketed by Roche

Purpose of the problem

To persuade you that functional groups are easy to identify even in complicated structures: an ester is an ester no matter what company it keeps and it can be helpful to look at the nature of the carbon framework too.

Suggested solution

The functional groups shouldn’t have given you any problem except perhaps for the sulfide (or thioether) and the phenol (or alcohol). You should have seen that both molecules have an amide as well as an amine.
The ring sizes are easy and we hope you noticed that the black bond between the four- and the five-membered ring in the penicillin is shared by both rings.

The carbon chains are quite varied in length and style and are broken up by N, O, and S atoms.
**PROBLEM 3**
What is wrong with these structures? Suggest better ways to represent these molecules.

![Molecules](image)

**Purpose of the problem**
To shock you with two dreadful structures and to try to convince you that well drawn realistic structures are more attractive to the eye as well as easier to understand and quicker to draw.

**Suggested solution**
The bond angles are grotesque with square planar saturated carbon atoms, bent alkynes with 120° bonds, linear alkenes with bonds at 90° or 180°, bonds coming off a benzene ring at the wrong angles and so on. If properly drawn, the left hand structure will be clearer without the hydrogen atoms. Here are better structures for each compound but you can think of many other possibilities.

![Solutions](image)

**PROBLEM 4**
Draw structures for the compounds named systematically here. In each case suggest alternative names that might convey the structure more clearly if you were speaking to someone rather than writing.
(a) 1,4-di-(1,1-dimethylethyl)benzene
(b) 1-(prop-2-enyloxy)prop-2-ene
(c) cyclohexa-1,3,5-triene

**Purpose of the problem**
To help you appreciate the limitations of systematic names, the usefulness of part structures and, in the case of (c), to amuse.
Suggested solution

(a) A more helpful name would be para-di-\textit{t}-butyl benzene. It is sold as 1,4-di-\textit{t}-butyl benzene, an equally helpful name. There are two separate numerical relationships.

(b) This name fails to convey neither the simple symmetrical structure nor the fact that it contains two allyl groups. Most chemists would call it ‘diallyl ether’ though it is sold as ‘allyl ether’.

(c) This is of course simply benzene!

PROBLEM 5

Translate these very poor structural descriptions into something more realistic. Try to get the angles about right and, whatever you do, don't include any square planar carbon atoms or any other bond angles of 90°.

(a) $C_9H_{12}CH(OH)(CH_2)_4COC_2H_5$
(b) $O(CH_2CH_2)_2O$
(c) $(CH_3O)_2CH=CHCH(OMe)_2$

Purpose of the problem

An exercise in interpretation and composition. This sort of ‘structure’ is sometimes used in printed text. It gives no clue to the shape of the molecule.

Suggested solution

You probably needed a few ‘trial and error’ drawings first but simply drawing out the carbon chain gives you a good start. The first is straightforward—the (OH) group is a substituent joined to the chain and not part of it. The second compound must be cyclic—it is the ether solvent commonly known as dioxane. The third gives no hint as to the shape of the alkene and we have chosen \textit{trans}. It also has two ways of
representing a methyl group. Either is fine, but it is better not to mix the two in one structure.

\[ \text{C}_6\text{H}_5\text{CH(OH)}(\text{CH}_2\text{C}_2\text{H}_5) \quad \text{O(\text{CH}_2\text{C}_2\text{H}_2)O} \quad \text{(CH}_3\text{O})_2\text{CH=CH(OMe)}_2 \]

\[ \begin{array}{c}
\text{OH} \\
\begin{array}{c}
\text{O} \\
\text{O(CH}_2\text{CH}_2\text{O}) \\
\text{MeO} \\
\text{OMe} \\
\text{OMe} \\
\text{OMe}
\end{array}
\end{array} \\
\begin{array}{c}
\begin{array}{c}
\text{OH} \\
\text{NH}_2
\end{array} \\
\begin{array}{c}
\text{H} \\
\text{N}
\end{array}
\end{array} \\
\begin{array}{c}
\text{H}_2\text{N} \\
\text{Me}
\end{array} \\
\begin{array}{c}
\text{O} \\
\text{N}
\end{array}
\]

PROBLEM 6
Suggest at least six different structures that would fit the formula \( \text{C}_4\text{H}_7\text{NO} \). Make good realistic diagrams of each one and say which functional groups are present.

Purpose of the problem
The identification and naming of functional groups is more important than the naming of compounds, because the names of functional groups tell you about their chemistry. This was your chance to experiment with different groups and different carbon skeletons and to experience the large number of compounds you could make from a formula with few atoms.

Suggested solution
We give twelve possible structures – there are of course many more. You need not have used the names in brackets as they are ones more experience chemists might use.
**PROBLEM 7**

Draw full structures for these compounds, displaying the hydrocarbon framework clearly and showing all the bonds in the functional groups. Name the functional groups.

(a) \( \text{AcO(CH}_2\text{)}_3\text{NO}_2 \)

(b) \( \text{MeO}_2\text{CCH}_2\text{OCOEt} \)

(c) \( \text{CH}_2=\text{CHCONH(CH}_2\text{)}_2\text{CN} \)

**Purpose of the problem**

This problem extends the purpose of problem 5 as more thought is needed and you need to check your knowledge of the ‘organic elements’ such as Ac.

**Suggested solution**

For once the solution can be simply stated as no variation is possible. In the first structure ‘AcO’ represents an acetate ester and that the nitro group can have only four bonds (not five) to N. The second has two ester groups on the central carbon, but one is joined to it by a C–O and the other by a C–C bond. The last is straightforward.

\[
\begin{align*}
\text{AcO(CH}_2\text{)}_3\text{NO}_2 & \quad \text{MeO}_2\text{CCH}_2\text{OCOEt} & \quad \text{CH}_2=\text{CHCONH(CH}_2\text{)}_2\text{CN} \\
\text{ester} & \quad \text{ester} & \quad \text{nitrile} \\
\text{nitrile} & \quad \text{alkene} & \quad \text{amide}
\end{align*}
\]

**PROBLEM 8**

Identify the oxidation level of all the carbon atoms of the compounds in problem 7.

**Purpose of the problem**

This important exercise is one you will get used to very quickly and, before long, do without thinking. If you do will save you from many trivial errors. Remember that the oxidation state of all the carbon atoms is +4 or C(IV). The oxidation level of a carbon atom tells you to which oxygen-based functional group it can be interconverted without oxidation or reduction.
Suggested solution

Just count the number of bonds between the carbon atom and heteroatoms (atoms which are not H or C). If none, the atom is at the hydrocarbon level (□), if one, the alcohol level (○), if two the aldehyde or ketone level, if three the carboxylic acid level (●) and, if four, the carbon dioxide level.

Why alkenes have the alcohol oxidation level is explained on page 33 of the textbook.