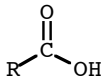
O R G A N I C C H E M I S T R Y I

Functional groups

Functional groups

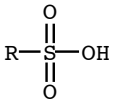
Atoms combine in patterns called functional groups. Each functional group exhibits characteristic chemical properties. The following list presents various ways in which some of the most important functional groups in organic chemistry can be written. The symbol R (from the German word *Radikal*) can be interpreted as standing for "the rest of the molecule".

Carboxylic acids



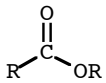
R—CO_2H R—COOH

Sulfonic acids



R—SO_2OH R—SO_3H

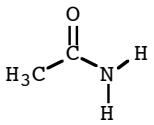
Esters



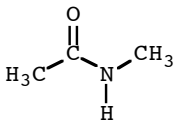
R—CO_2R R—COOR

Amides

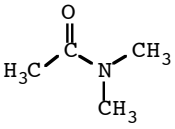
There are three kinds of amides: primary (1º), secondary (2º), and tertiary (3º) depending on the number of carbons bonded to the amide nitrogen. In a 1º amide, the amide nitrogen is bonded to one carbon; in a 2º amide, to two carbons; in a 3º amide, to three carbons. Specific examples of each kind of amide are



1º

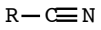


2º



3º

Nitriles



R—CN

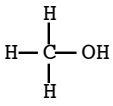
Aldehydes

R—CHO

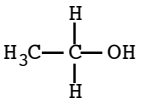
Ketones

Alcohols

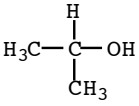
There are four kinds of alcohols: superprimary (0º) or methyl, primary (1º), secondary (2º), and tertiary (3º) depending on the number of carbons bonded to the carbon atom that bears the —OH group. In a 0º alcohol, the carbon atom that bears the OH group is bonded to zero carbons; in a 1º alcohol, the carbon atom that bears the OH group is bonded to one carbon; in a 2º alcohol, to two carbons; in a 3º alcohol, to three carbons. Some specific examples of each kind of alcohol are



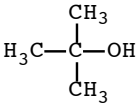
0º



1º



2º

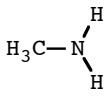


3º

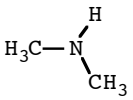
Thiols

Amines

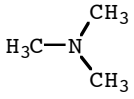
There are three kinds of amines: primary (1º), secondary (2º), and tertiary (3º) depending on the number of carbons bonded to the amine nitrogen. In a 1º amine, the amine nitrogen is bonded to one carbon; in a 2º amine, to two carbons; in a 3º amine, to three carbons. Specific examples of each kind of amine are



1º



2º

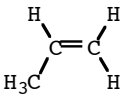


3º

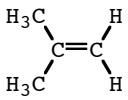
Alkenes

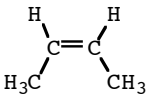
There are five kinds of alkenes: unsubstituted, monosubstituted, disubstituted, trisubstituted, and tetrasubstituted depending on the total number of carbons bonded to the double-bonded carbons. In an unsubstituted alkene the double-bonded carbons are bonded to zero carbons, one in a monosubstituted alkene, two in a disubstituted alkene, etc.

unsubstituted

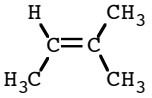


monosubstituted

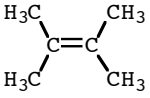




disubstituted



trisubstituted



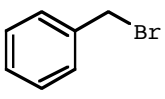
tetrasubstituted

Arenes

The term “arene” most commonly refers to a molecule that has a benzene ring:

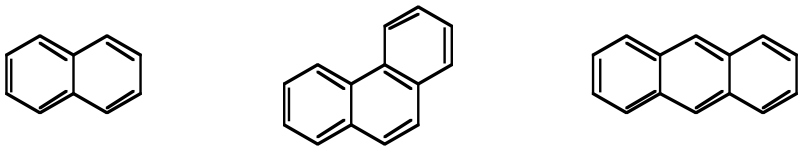
benzene

A benzene ring is frequently abbreviated “Ph” which stands for “phenyl”, for example

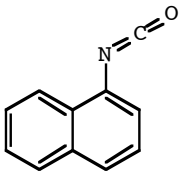


can be abbreviated 

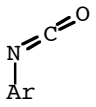
A molecule can have two or more benzene rings fused in such a way that they share an edge:



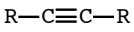
Such molecules are also called arenes and the assembly of fused benzene rings is frequently abbreviated as “Ar”. For example



can be abbreviated

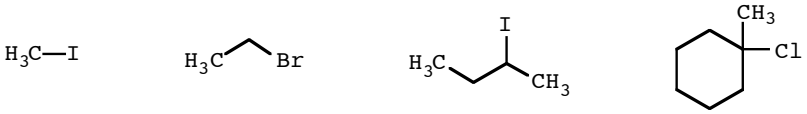


Alkynes



Halides

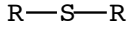
In the structures that follow, X represents any Group VIIA element (F, Cl, Br, or I). There are four kinds of halides: superprimary (0º) or methyl, primary (1º), secondary (2º), and tertiary (3º) depending on the number of carbons bonded to the carbon atom that bears the Group VIIA element. In a 0º halide, the carbon atom that bears the Group VIIA element is bonded to zero carbons; in a 1º halide, the carbon atom that bears the Group VIIA element is bonded to one carbon; in a 2º halide, to two carbons; in a 3º halide, to three carbons. Specific examples of each kind of halide are



0º 1º 2º 3º

Nitro compounds

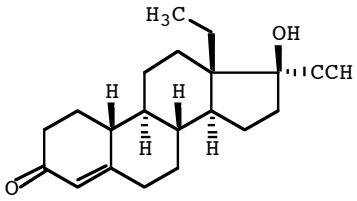
Sulfides



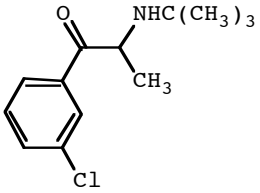
Ethers

R—O—R

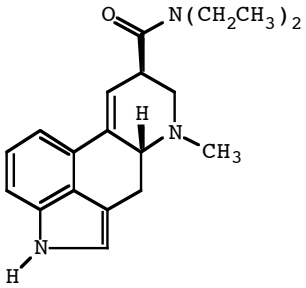
Problem Circle and identify the functional groups in these drug molecules. If the functional group is an amide, an amine, an alcohol, or a halide, classify it as 0º, 1º, 2º or 3º. If the functional group is an alkene, classify it as unsubstituted, monosubstituted, disubstituted, trisubstituted, or tetrasubstituted.



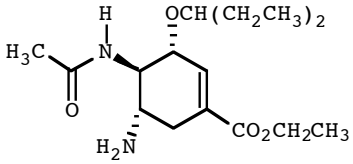
Levonorgestrel
Plan B



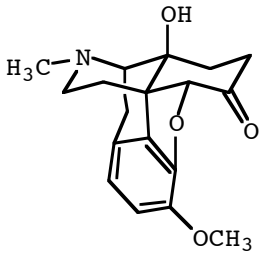
Zyban, Wellbutrin
antidepressant



LSD
hallucinogen

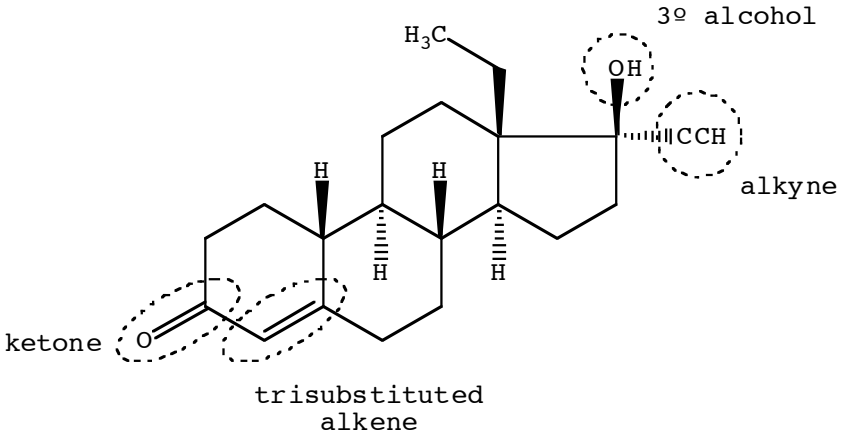


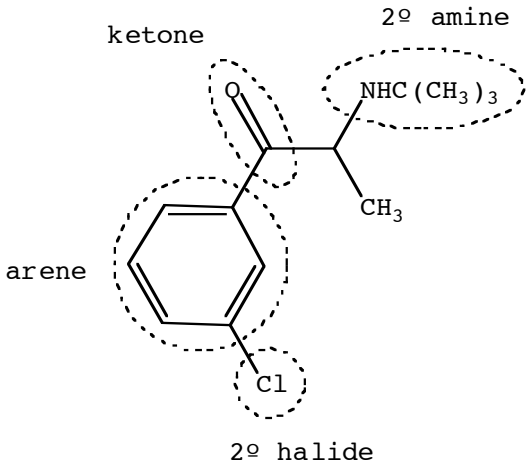
TamifluA
swine & avian flu drug

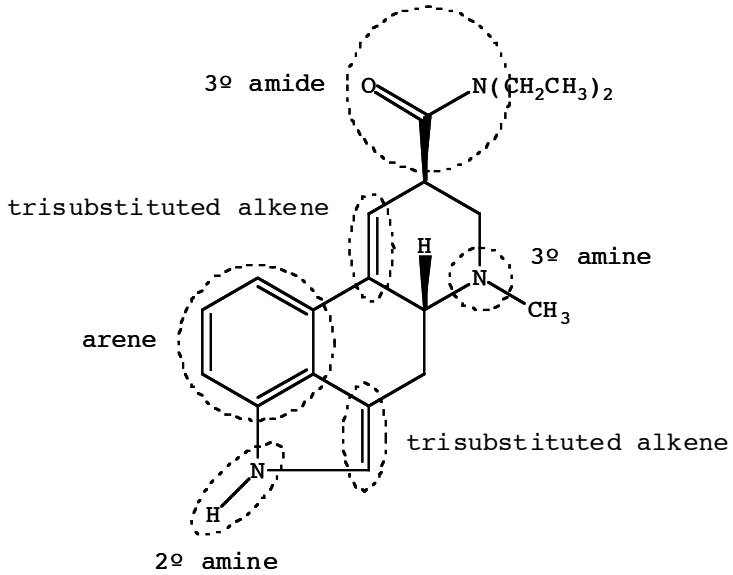


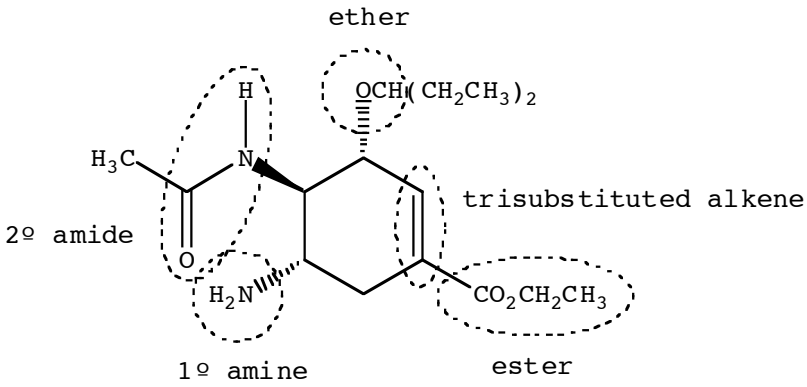
OxyContin
narcotic

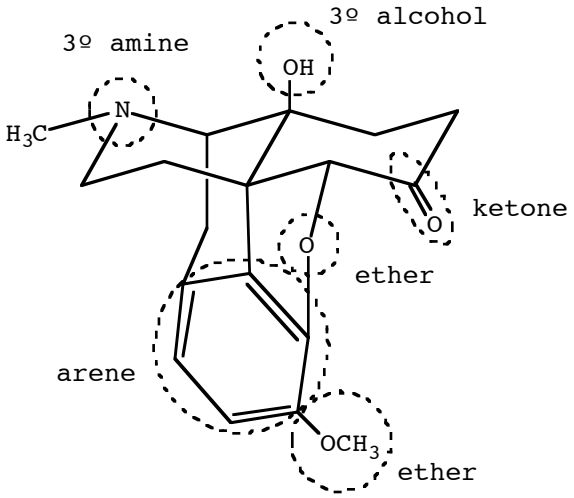
Answer


3º alcohol
H_3C
OH
CCH
alkyne
H
H
H
H
ketone
O
trisubstituted
alkene


ketone
2º amine
O
$NHC(CH_3)_3$
CH_3
arene
Cl
2º halide


3º amide
O
$N(CH_2CH_3)_2$
trisubstituted alkene
H
3º amine
N
CH_3
arene
trisubstituted alkene
N
H
2º amine



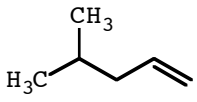


While we're on the subject of functional groups, we should finish this lecture by pointing out a few additional important bonding patterns:

• The carbonyl group (C=O) ranks as the most important functionality in organic chemistry. The carbonyl group is not a free standing functional group in its own right: it forms a part of the carboxylic acid, ester, amide, aldehyde and ketone functional groups. Most biomolecules (e.g., proteins, carbohydrates, fats, nucleic acids) contain the carbonyl group; biochemistry is in many ways the chemistry of the carbonyl group.

• A carbon bonded to three hydrogens is called a methyl group; a carbon bonded to two hydrogens is called a methylene group; a carbon bonded to one hydrogen is called a methine group. Like the carbonyl group, these are not considered free standing functional groups in their own right.

Problem Identify the methyl, methylene, and methine groups in the molecule below.



Answer