SECTION 1

ORGANIC COMPOUNDS

1.1 NOMENCLATURE OF ORGANIC COMPOUNDS

The following synopsis of rules for naming organic compounds and the examples given in explanation are not intended to cover all the possible cases. For a more comprehensive and detailed description, see J. Rigaudy and S. P. Klesney, *Nomenclature of Organic Chemistry,* Sections A, B, C, D, E, F, and H, Pergamon Press, Oxford, 1979. This publication contains the recommendations of the Commission on Nomenclature of Organic Chemistry and was prepared under the auspices of the International Union of Pure and Applied Chemistry (IUPAC).

1.1.1 Nonfunctional Compounds

1.1.1.1 Alkanes. The saturated open-chain (acyclic) hydrocarbons (C_nH_{2n+2}) have names ending in -ane. The first four members have the trivial names *methane* (CH_4), *ethane* (CH_3CH_3 or C_2H_6), *propane* (C_3H_8), and *butane* (C_4H_{10}). For the remainder of the alkanes, the first portion of the name is derived from the Greek prefix (see Table 2.4) that cites the number of carbons in the alkane followed by -ane with elision of the terminal -a from the prefix, as shown in Table 1.1.

TABLE 1.1 Names of Straight-Chain Alkanes

*n**	Name	*n**	Name	*n**	Name	*n**	Name
1	Methane	11	Undecane‡	21	Henicosane	60	Hexacontane
2	Ethane	12	Dodecane	22	Docosane	70	Heptacontane
3	Propane	13	Tridecane	23	Tricosane	80	Octacontane
4	Butane	14	Tetradecane			90	Nonacontane
5	Pentane	15	Pentadecane	30	Triacontane	100	Hectane
6	Hexane	16	Hexadecane	31	Hentriacontane	110	Decahectane
7	Heptane	17	Heptadecane	32	Dotriacontane	120	Icosahectane
8	Octane	18	Octadecane			121	Henicosahectane
9	Nonane†	19	Nonadecane	40	Tetracontane		
10	Decane	20	Icosane§	50	Pentacontane		

* n = total number of carbon atoms.
† Formerly called enneane.
‡ Formerly called hendecane.
§ Formerly called eicosane.

For branching compounds, the parent structure is the longest continuous chain present in the compound. Consider the compound to have been derived from this structure by replacement of hydrogen by various alkyl groups. Arabic number prefixes indicate the carbon to which the alkyl group is attached. Start numbering at whichever end of the parent structure that results in the lowest-numbered locants. The arabic prefixes are listed in numerical sequence, separated from each other by commas and from the remainder of the name by a hyphen.

If the same alkyl group occurs more than once as a side chain, this is indicated by the prefixes di-, tri-, tetra-, etc. Side chains are cited in alphabetical order (before insertion of any multiplying prefix). The name of a complex radical (side chain) is considered to begin with the first letter of its complete name. Where names of complex radicals are composed of identical words, priority for citation is given to that radical which contains the lowest-numbered locant at the first cited point of difference in the radical. If two or more side chains are in equivalent positions, the one to be assigned the lowest-numbered locant is that cited first in the name. The complete expression for the side chain may be enclosed in parentheses for clarity or the carbon atoms in side chains may be indicated by primed locants.

If hydrocarbon chains of equal length are competing for selection as the parent, the choice goes in descending order to (1) the chain that has the greatest number of side chains, (2) the chain whose side chains have the lowest-numbered locants, (3) the chain having the greatest number of carbon atoms in the smaller side chains, or (4) the chain having the least-branched side chains.

These trivial names may be used for the unsubstituted hydrocarbon only:

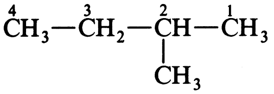
Isobutane	$(CH_3)_2CHCH_3$	Neopentane	$(CH_3)_4C$
Isopentane	$(CH_3)_2CHCH_2CH_3$	Isohexane	$(CH_3)_2CHCH_2CH_2CH_3$

Univalent radicals derived from saturated unbranched alkanes by removal of hydrogen from a terminal carbon atom are named by adding -yl in place of -ane to the stem name. Thus the alkane *ethane* becomes the radical *ethyl.* These exceptions are permitted for unsubstituted radicals only:

Isopropyl	$(CH_3)_2CH—$	Isopentyl	$(CH_3)_2CHCH_2CH_2—$
Isobutyl	$(CH_3)_2CHCH_2—$	Neopentyl	$(CH_3)_3CCH_2—$
sec-Butyl	$CH_3CH_2CH(CH_3)—$	*tert*-Pentyl	$CH_3CH_2C(CH_3)_2—$
tert-Butyl	$(CH_3)_3C—$	Isohexyl	$(CH_3)_2CHCH_2CH_2CH_2—$

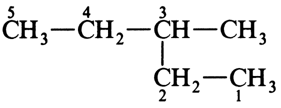
Note the usage of the prefixes iso-, neo-, *sec*-, and *tert*-, and note when italics are employed. Italicized prefixes are never involved in alphabetization, except among themselves; thus *sec*-butyl would precede isobutyl, isohexyl would precede isopropyl, and *sec*-butyl would precede *tert*-butyl.

Examples of alkane nomenclature are



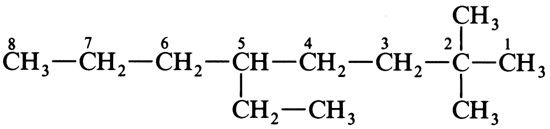
$\overset{4}{C}H_3-\overset{3}{C}H_2-\underset{\underset{\displaystyle CH_3}{|}}{\overset{2}{C}H}-\overset{1}{C}H_3$

2-Methylbutane (or the trivial name, isopentane)



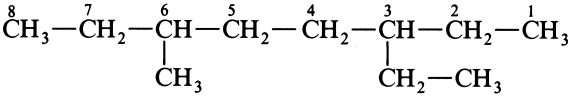
$\overset{5}{C}H_3-\overset{4}{C}H_2-\underset{\underset{\displaystyle \underset{2}{C}H_2-\underset{1}{C}H_3}{|}}{\overset{3}{C}H}-CH_3$

3-Methylpentane (not 2-ethylbutane)



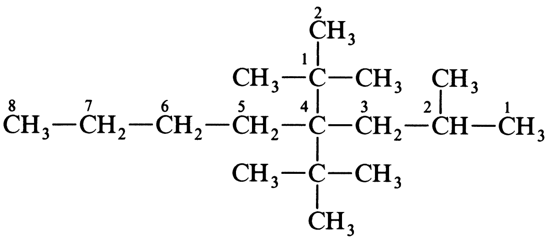
$\overset{8}{C}H_3-\overset{7}{C}H_2-\overset{6}{C}H_2-\underset{\underset{\displaystyle CH_2-CH_3}{|}}{\overset{5}{C}H}-\overset{4}{C}H_2-\overset{3}{C}H_2-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{\overset{2}{C}}}-\overset{1}{C}H_3$

5-Ethyl-2,2-dimethyloctane (note cited order)



$\overset{8}{C}H_3-\overset{7}{C}H_2-\underset{\underset{\displaystyle CH_3}{|}}{\overset{6}{C}H}-\overset{5}{C}H_2-\overset{4}{C}H_2-\underset{\underset{\displaystyle CH_2-CH_3}{|}}{\overset{3}{C}H}-\overset{2}{C}H_2-\overset{1}{C}H_3$

3-Ethyl-6-methyloctane (note locants reversed)



4,4-Bis(1,1-dimethylethyl)-2-methyloctane
4,4-Bis-1′,1′-dimethylethyl-2-methyloctane
4,4-Bis(*tert*-butyl)-2-methyloctane

Bivalent radicals derived from saturated unbranched alkanes by removal of two hydrogen atoms are named as follows: (1) If both free bonds are on the same carbon atom, the ending -ane of the hydrocarbon is replaced with -ylidene. However, for the first member of the alkanes it is methylene rather than methylidene. Isopropylidene, *sec*-butylidene, and neopentylidene may be used for the unsubstituted group only. (2) If the two free bonds are on different carbon atoms, the straight-chain group terminating in these two carbon atoms is named by citing the number of methylene groups comprising the chain. Other carbon groups are named as substituents. Ethylene is used rather than dimethylene for the first member of the series, and propylene is retained for $CH_3{-}\underset{|}{CH}{-}CH_2{-}$ (but trimethylene is $-CH_2-CH_2-CH_2-$).

Trivalent groups derived by the removal of three hydrogen atoms from the same carbon are named by replacing the ending -ane of the parent hydrocarbon with -ylidyne.

1.1.1.2 Alkenes and Alkynes. Each name of the corresponding saturated hydrocarbon is converted to the corresponding alkene by changing the ending -ane to -ene. For alkynes the ending is -yne. With more than one double (or triple) bond, the endings are -adiene, -atriene, etc. (or -adiyne, -atriyne, etc.). The position of the double (or triple) bond in the parent chain is indicated by a locant obtained by numbering from the end of the chain nearest the double (or triple) bond; thus $CH_3CH_2CH{=}CH_2$ is 1-butene and $CH_3C{\equiv}CCH_3$ is 2-butyne.

For multiple unsaturated bonds, the chain is so numbered as to give the lowest possible locants to the unsaturated bonds. When there is a choice in numbering, the double bonds are given the lowest locants, and the alkene is cited before the alkyne where both occur in the name. Examples:

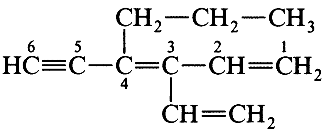
$CH_3CH_2CH_2CH_2CH{=}CH{-}CH{=}CH_2$	1,3-Octadiene
$CH_2{=}CHC{\equiv}CCH{=}CH_2$	1,5-Hexadiene-3-yne
$CH_3CH{=}CHCH_2C{\equiv}CH$	4-Hexen-1-yne
$CH{\equiv}CCH_2CH{=}CH_2$	1-Penten-4-yne

Unsaturated branched acyclic hydrocarbons are named as derivatives of the chain that contains the maximum number of double and/or triple bonds. When a choice exists, priority goes in sequence to (1) the chain with the greatest number of carbon atoms and (2) the chain containing the maximum number of double bonds.

These nonsystematic names are retained:

Ethylene	$CH_2{=}CH_2$
Allene	$CH_2{=}C{=}CH_2$
Acetylene	$HC{\equiv}CH$

An example of nomenclature for alkenes and alkynes is



$$\overset{6}{HC}\equiv\overset{5}{C}-\underset{4}{\overset{CH_2-CH_2-CH_3}{\overset{|}{C}}}=\underset{CH=CH_2}{\underset{|}{\overset{3}{C}}}-\overset{2}{CH}=\overset{1}{CH_2}$$

4-Propyl-3-vinyl-1,3-hexadien-5-yne

Univalent radicals have the endings -enyl, -ynyl, -dienyl, -diynyl, etc. When necessary, the positions of the double and triple bonds are indicated by locants, with the carbon atom with the free valence numbered as 1. Examples:

$CH_2{=}CH{-}CH_2{-}$	2-Propenyl
$CH_3{-}C{\equiv}C{-}$	1-Propynyl
$CH_3{-}C{\equiv}C{-}CH_2CH{=}CH_2{-}$	1-Hexen-4-ynyl

These names are retained:

Vinyl (for ethenyl) $CH_2{=}CH{-}$

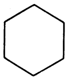
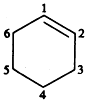
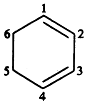
Allyl (for 2-propenyl) $CH_2{=}CH{-}CH_2{-}$

Isopropenyl (for 1-methylvinyl but for unsubstituted radical only) $CH_2{=}C(CH_3){-}$

Should there be a choice for the fundamental straight chain of a radical, that chain is selected which contains (1) the maximum number of double and triple bonds, (2) the largest number of carbon atoms, and (3) the largest number of double bonds. These are in descending priority.

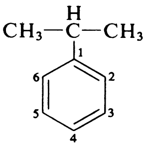
Bivalent radicals derived from unbranched alkenes, alkadienes, and alkynes by removing a hydrogen atom from each of the terminal carbon atoms are named by replacing the endings -ene, -diene, and -yne by -enylene, -dienylene, and -ynylene, respectively. Positions of double and triple bonds are indicated by numbers when necessary. The name *vinylene* instead of ethenylene is retained for $-CH{=}CH-$.

1.1.1.3 ***Monocyclic Aliphatic Hydrocarbons.*** Monocyclic aliphatic hydrocarbons (with no side chains) are named by prefixing cyclo- to the name of the corresponding open-chain hydrocarbon having the same number of carbon atoms as the ring. Radicals are formed as with the alkanes, alkenes, and alkynes. Examples:

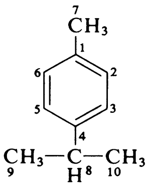
	Cyclohexane	Cyclohexyl- (for the radical)
	Cyclohexene	1-Cyclohexenyl- (for the radical with the free valence at carbon 1)
	1,3-Cyclohexandiene	Cyclohexadienyl- (the unsaturated carbons are given numbers as low as possible, numbering from the carbon atom with the free valence given the number 1)

For convenience, aliphatic rings are often represented by simple geometric figures: a triangle for cyclopropane, a square for cyclobutane, a pentagon for cyclopentane, a hexagon (as illustrated) for cyclohexane, etc. It is understood that two hydrogen atoms are located at each corner of the figure unless some other group is indicated for one or both.

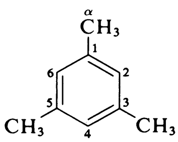
1.1.1.4 ***Monocyclic Aromatic Compounds.*** Except for six retained names, all monocyclic substituted aromatic hydrocarbons are named systematically as derivatives of benzene. Moreover, if the substituent introduced into a compound with a retained trivial name is identical with one already present in that compound, the compound is named as a derivative of benzene. These names are retained:



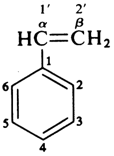
Cumene



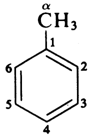
Cymene (all three forms; *para*- shown)



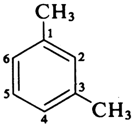
Mesitylene



Styrene



Toluene



Xylene (all three forms; *meta-* shown)

The position of substituents is indicated by numbers, with the lowest locant possible given to substituents. When a name is based on a recognized trivial name, priority for lowest-numbered locants is given to substituents implied by the trivial name. When only two substituents are present on a benzene ring, their position may be indicated by *o-* (*ortho-*), *m-* (*meta-*), and *p-* (*para-*) (and alphabetized in the order given) used in place of 1,2-, 1,3-, and 1,4-, respectively.

Radicals derived from monocyclic substituted aromatic hydrocarbons and having the free valence at a ring atom (numbered 1) are named phenyl (for benzene as parent, since benzyl is used for the radical $C_6H_5CH_2—$), cumenyl, mesityl, tolyl, and xylyl. All other radicals are named as substituted phenyl radicals. For radicals having a single free valence in the side chain, these trivial names are retained:

Benzyl	$C_6H_5CH_2—$
Benzhydryl (alternative to diphenylmethyl)	$(C_6H_5)_2CH—$
Cinnamyl	$C_6H_5CH{=}CH—CH_2—$
Phenethyl	$C_6H_5CH_2CH_2—$
Styryl	$C_6H_5CH{=}CH—$
Trityl	$(C_6H_5)_3C—$

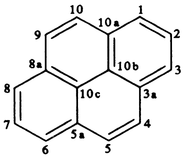
Otherwise, radicals having the free valence(s) in the side chain are named in accordance with the rules for alkanes, alkenes, or alkynes.

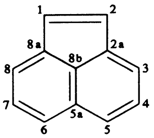
The name *phenylene* (*o-*, *m-*, or *p-*) is retained for the radical $—C_6H_4—$. Bivalent radicals formed from substituted benzene derivatives and having the free valences at ring atoms are named as substituted phenylene radicals, with the carbon atoms having the free valences being numbered 1,2-, 1,3-, or 1,4-, as appropriate.

Radicals having three or more free valences are named by adding the suffixes -triyl, -tetrayl, etc. to the systematic name of the corresponding hydrocarbon.

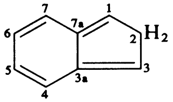
1.1.1.5 Fused Polycyclic Hydrocarbons. The names of polycyclic hydrocarbons containing the maximum number of conjugated double bonds end in -ene. Here the ending does not denote one double bond. Names of hydrocarbons containing five or more fixed benzene rings in a linear arrangement are formed from a numerical prefix (see Table 2.4) followed by -acene. A partial list of the names of polycyclic hydrocarbons is given in Table 1.2. Many names are trivial.

Numbering of each ring system is fixed, as shown in Table 1.2, but it follows a systematic pattern. The individual rings of each system are oriented so that the greatest number of rings are (1) in a horizontal row and (2) the maximum number of rings are above and to the right (upper-right quadrant) of the horizontal row. When two orientations meet these requirements, the one is chosen that has the fewest rings in the lower-left quadrant. Numbering proceeds in a clockwise direction, commencing with the carbon atom not engaged in ring fusion that lies in the most counterclockwise position of the uppermost ring (upper-right quadrant); omit atoms common to two or more rings. Atoms common to two or more rings are designated by adding lowercase roman letters to the number of the position immediately preceding. Interior atoms follow the highest number, taking a clockwise sequence wherever there is a choice. Anthracene and phenanthrene are two exceptions to the rule on numbering. Two examples of numbering follow:

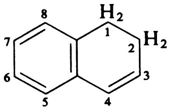




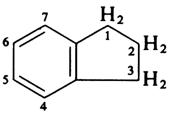
When a ring system with the maximum number of conjugated double bonds can exist in two or more forms differing only in the position of an "extra" hydrogen atom, the name can be made specific by indicating the position of the extra hydrogen(s). The compound name is modified with a locant followed by an italic capital *H* for each of these hydrogen atoms. Carbon atoms that carry an indicated hydrogen atom are numbered as low as possible. For example, 1*H*-indene is illustrated in Table 1.2; 2*H*-indene would be



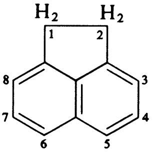
Names of polycyclic hydrocarbons with less than the maximum number of noncumulative double bonds are formed from a prefix dihydro-, tetrahydro-, etc., followed by the name of the corresponding unreduced hydrocarbon. The prefix perhydro- signifies full hydrogenation. For example, 1,2-dihydronaphthalene is



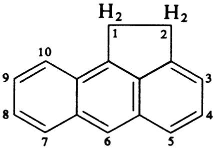
Examples of retained names and their structures are as follows:



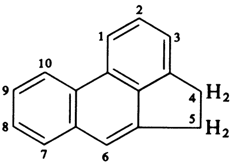
Indan



Acenaphthene



Aceanthrene



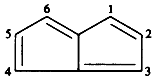
Acephenanthrene

Polycyclic compounds in which two rings have two atoms in common or in which one ring contains two atoms in common with each of two or more rings of a contiguous series of rings and which contain at least two rings of five or more members with the maximum number of noncumu-

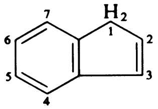
TABLE 1.2 Fused Polycyclic Hydrocarbons

Listed in order of increasing priority for selection as parent compound.

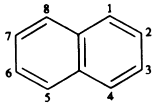
1. Pentalene



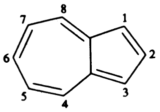
2. Indene



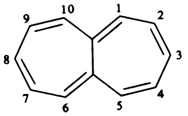
3. Naphthalene



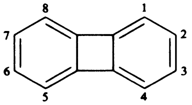
4. Azulene



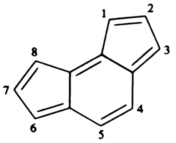
5. Heptalene



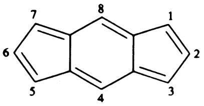
6. Biphenylene



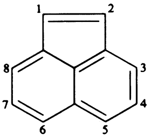
7. *asym*-Indacene



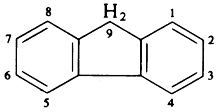
8. *sym*-Indacene



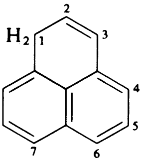
9. Acenaphthylene



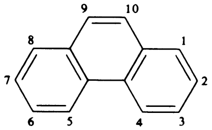
10. Fluorene



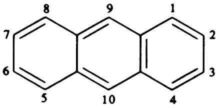
11. Phenalene



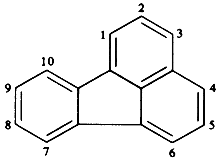
12. Phenanthrene*



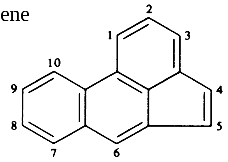
13. Anthracene*



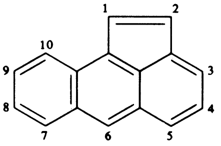
14. Fluoranthene



15. Acephenanthrylene

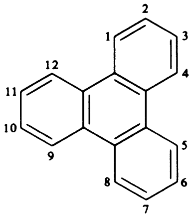
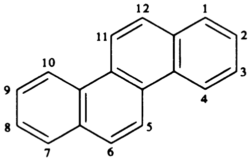
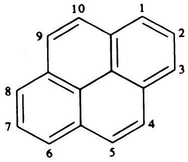
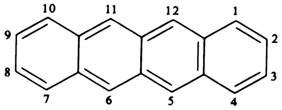


16. Aceanthrylene



* Asterisk after a compound denotes exception to systematic numbering.

TABLE 1.2 Fused Polycyclic Hydrocarbons (*Continued*)

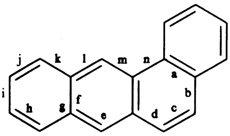
17. Triphenylene 	19. Chrysene 
18. Pyrene 	20. Naphthacene 

lative double bonds and which have no accepted trivial name (Table 1.2) are named by prefixing to the name of the parent ring or ring system designations of the other components. The parent name should contain as many rings as possible (provided it has a trivial name) and should occur as far as possible from the beginning of the list in Table 1.2. Furthermore, the attached component(s) should be as simple as possible. For example, one writes dibenzophenanthrene and not naphthophenanthrene because the attached component benzo- is simpler than napththo-. Prefixes designating attached components are formed by changing the ending -ene into -eno-; for example, indeno- from indene. Multiple prefixes are arranged in alphabetical order. Several abbreviated prefixes are recognized; the parent is given in parentheses:

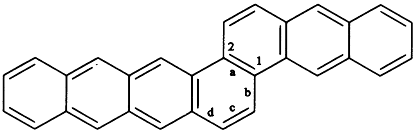
Acenaphtho-	(acenaphthylene)	Naphtho-	(naphthalene)
Anthra-	(anthracene)	Perylo-	(perylene)
Benzo-	(benzene)	Phenanthro-	(phenanthrene)

For monocyclic prefixes other than benzo-, the following names are recognized, each to represent the form with the maximum number of noncumulative double bonds: cyclopenta-, cyclohepta-, cycloocta-, etc.

Isomers are distinguished by lettering the peripheral sides of the parent beginning with *a* for the side 1,2, and so on, lettering every side around the periphery. If necessary for clarity, the numbers of the attached position (1,2, for example) of the substituent ring are also denoted. The prefixes are cited in alphabetical order. The numbers and letters are enclosed in square brackets and placed immediately after the designation of the attached component. Examples are

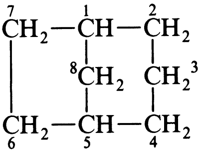


Benz[α]anthracene

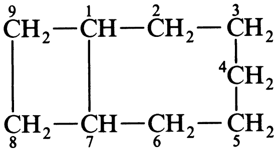


Anthra[2,1-α]naphthacene

1.1.1.6 Bridged Hydrocarbons. Saturated alicyclic hydrocarbon systems consisting of two rings that have two or more atoms in common take the name of the open-chain hydrocarbon containing the same total number of carbon atoms and are preceded by the prefix bicyclo-. The system is numbered commencing with one of the bridgeheads, numbering proceeding by the longest possible path to the second bridgehead. Numbering is then continued from this atom by the longer remaining unnumbered path back to the first bridgehead and is completed by the shortest path from the atom next to the first bridgehead. When a choice in numbering exists, unsaturation is given the lowest numbers. The number of carbon atoms in each of the bridges connecting the bridgeheads is indicated in brackets in descending order. Examples are

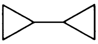


Bicyclo[3.2.1]octane

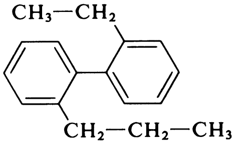


Bicyclo[5.2.0]nonane

1.1.1.7 Hydrocarbon Ring Assemblies. Assemblies are two or more cyclic systems, either single rings or fused systems, that are joined directly to each other by double or single bonds. For identical systems naming may proceed (1) by placing the prefix bi- before the name of the corresponding radical or (2), for systems joined through a single bond, by placing the prefix bi- before the name of the corresponding hydrocarbon. In each case, the numbering of the assembly is that of the corresponding radical or hydrocarbon, one system being assigned unprimed numbers and the other primed numbers. The points of attachment are indicated by placing the appropriate locants before the name; an unprimed number is considered lower than the same number primed. The name *biphenyl* is used for the assembly consisting of two benzene rings. Examples are



1,1′-Bicyclopropyl or 1,1′-bicyclopropane



2-Ethyl-2′-propylbiphenyl

For nonidentical ring systems, one ring system is selected as the parent and the other systems are considered as substituents and are arranged in alphabetical order. The parent ring system is assigned unprimed numbers. The parent is chosen by considering the following characteristics in turn until a decision is reached: (1) the system containing the larger number of rings, (2) the system containing the larger ring, (3) the system in the lowest state of hydrogenation, and (4) the highest-order number of ring systems set forth in Table 1.2. Examples are given, with the deciding priority given in parentheses preceding the name:

(1) 2-Phenylnaphthalene
(2) and (4) 2-(2′-Naphthyl)azulene
(3) Cyclohexylbenzene

1.1.1.8 Radicals from Ring Systems. Univalent substituent groups derived from polycyclic hydrocarbons are named by changing the final *e* of the hydrocarbon name to -yl. The carbon atoms having free valences are given locants as low as possible consistent with the fixed numbering of the hydrocarbon. Exceptions are naphthyl (instead of naphthalenyl), anthryl (for anthracenyl), and phenanthryl (for phenanthrenyl). However, these abbreviated forms are used only for the simple ring systems. Substituting groups derived from fused derivatives of these ring systems are named systematically. Substituting groups having two or more free bonds are named as described in Monocyclic Aliphatic Hydrocarbons on p. 1.5.

1.1.1.9 Cyclic Hydrocarbons with Side Chains. Hydrocarbons composed of cyclic and aliphatic chains are named in a manner that is the simplest permissible or the most appropriate for the chemical intent. Hydrocarbons containing several chains attached to one cyclic nucleus are generally named as derivatives of the cyclic compound, and compounds containing several side chains and/or cyclic radicals attached to one chain are named as derivatives of the acyclic compound. Examples are

2-Ethyl-1-methylnaphthalene

1,5-Diphenylpentane

Diphenylmethane

2,3-Dimethyl-1-phenyl-1-hexene

Recognized trivial names for composite radicals are used if they lead to simplifications in naming. Examples are

1-Benzylnaphthalene

1,2,4-Tris(3-*p*-tolylpropyl)benzene

Fulvene, for methylenecyclopentadiene, and stilbene, for 1,2-diphenylethylene, are trivial names that are retained.

1.1.1.10 Heterocyclic Systems. Heterocyclic compounds can be named by relating them to the corresponding carbocyclic ring systems by using replacement nomenclature. Heteroatoms are denoted by prefixes ending in *a*, as shown in Table 1.3. If two or more replacement prefixes are required in a single name, they are cited in the order of their listing in the table. The lowest possible numbers consistent with the numbering of the corresponding carbocyclic system are assigned to the heteroatoms and then to carbon atoms bearing double or triple bonds. Locants are cited immediately preceding the prefixes or suffixes to which they refer. Multiplicity of the same heteroatom is indicated by the appropriate prefix in the series: di-, tri-, tetra-, penta-, hexa-, etc.

TABLE 1.3 Specialist Nomenclature for Heterocyclic Systems

Heterocyclic atoms are listed in decreasing order of priority.

Element	Valence	Prefix	Element	Valence	Prefix
Oxygen	2	Oxa-	Antimony	3	Stiba-*
Sulfur	2	Thia-	Bismuth	3	Bisma-
Selenium	2	Selena-	Silicon	4	Sila-
Tellurium	2	Tellura-	Germanium	4	Germa-
Nitrogen	3	Aza-	Tin	4	Stanna-
Phosphorus	3	Phospha-*	Lead	4	Plumba-
Arsenic	3	Arsa-*	Boron	3	Bora-
			Mercury	2	Mercura-

* When immediately followed by -in or -ine, phospha- should be replaced by phosphor-, arsa- by arsen-, and stiba- by antimon-. The saturated six-membered rings corresponding to phosphorin and arsenin are named *phosphorinane* and *arsenane.* A further exception is the replacement of borin by borinane.

TABLE 1.4 Suffixes for Specialist Nomenclature of Heterocyclic Systems

Number of ring members	Rings containing nitrogen		Rings containing no nitrogen	
	Unsaturation*	Saturation	Unsaturation*	Saturation
3	-irine	-iridine	-irene	-irane
4	-ete	-etidine	-ete	-etane
5	-ole	-olidine	-ole	-olane
6	-ine†	‡	-in	-ane§
7	-epine	‡	-epin	-epane
8	-ocine	‡	-ocin	-ocane
9	-onine	‡	-onin	-onane
10	-ecine	‡	-ecin	-ecane

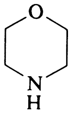
* Unsaturation corresponding to the maximum number of noncumulative double bonds. Heteroatoms have the normal valences given in Table 1.3.

† For phosphorus, arsenic, antimony, and boron, see the special provisions in Table 1.3.

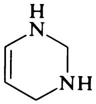
‡ Expressed by prefixing perhydro- to the name of the corresponding unsaturated compound.

§ Not applicable to silicon, germanium, tin, and lead; perhydro- is prefixed to the name of the corresponding unsaturated compound.

If the corresponding carbocyclic system is partially or completely hydrogenated, the additional hydrogen is cited using the appropriate *H*- or hydro- prefixes. A trivial name from Tables 1.5 and 1.6, if available, along with the state of hydrogenation may be used. In the specialist nomenclature for heterocyclic systems, the prefix or prefixes from Table 1.3 are combined with the appropriate stem from Table 1.4, eliding an *a* where necessary. Examples of acceptable usage, including (1) replacement and (2) specialist nomenclature, are



(1) 1-Oxa-4-azacyclohexane
(2) 1,4-Oxazoline
Morpholine



(1) 1,3-Diazacyclohex-5-ene
(2) 1,2,3,4-Tetrahydro-1,3-diazine

(1) Thiacyclopropane
(2) Thiirane
Ethylene sulfide

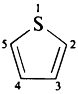
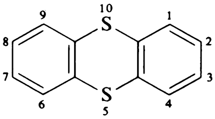
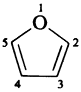
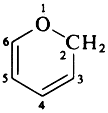
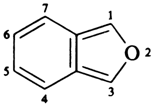
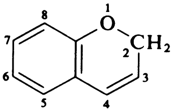
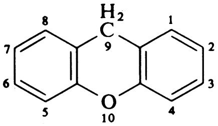
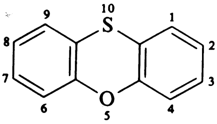
Radicals derived from heterocyclic compounds by removal of hydrogen from a ring are named by adding -yl to the names of the parent compounds (with elision of the final *e*, if present). These exceptions are retained:

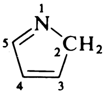
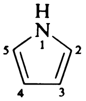
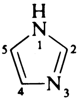
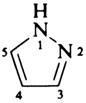
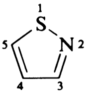
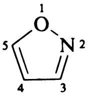
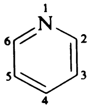
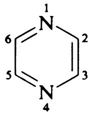
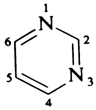
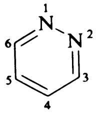
Furyl (from furan)
Pyridyl (from pyridine)
Piperidyl (from piperidine)
Quinolyl (from quinoline)
Isoquinolyl
Thenylidene (for thienylmethylene)
Furfuryl (for 2-furylmethyl)
Furfurylidene (for 2-furylmethylene)
Thienyl (from thiophene)
Thenylidyne (for thienylmethylidyne)
Furfurylidyne (for 2-furylmethylidyne)
Thenyl (for thienylmethyl)

Also, piperidino- and morpholino- are preferred to 1-piperidyl- and 4-morpholinyl-, respectively.

TABLE 1.5 Trivial Names of Heterocyclic Systems Suitable for Use in Fusion Names

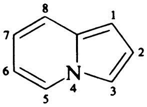
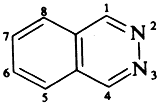
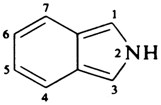
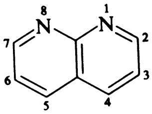
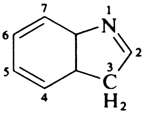
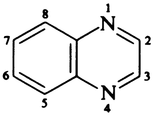
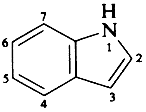
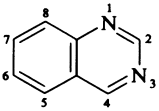
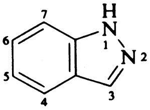
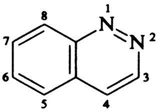
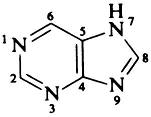
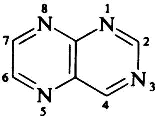
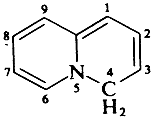
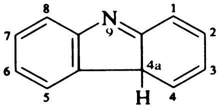
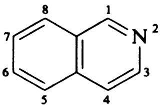
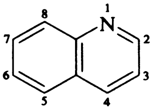
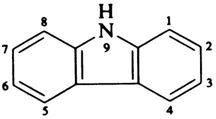
Listed in order of increasing priority as senior ring system.

Structure	Parent name	Radical name
	Thiophene	Thienyl
	Thianthrene	Thianthrenyl
	Furan	Furyl
	Pyran (2*H*-shown)	Pyranyl
	Isobenzofuran	Isobenzo-furanyl
	Chromene (2*H*-shown)	Chromenyl
	Xanthene*	Xanthenyl
	Phenoxathiin	Phenoxa-thiinyl

Structure	Parent name	Radical name
	2*H*-Pyrrole	2*H*-Pyrrolyl
	Pyrrole	Pyrrolyl
	Imidazole	Imidazolyl
	Pyrazole	Pyrazolyl
	Isothiazole	Isothiazolyl
	Isoxazole	Isoxazolyl
	Pyridine	Pyridyl
	Pyrazine	Pyrazinyl
	Pyrimidine	Pyrimidinyl
	Pyridazine	Pyridazinyl

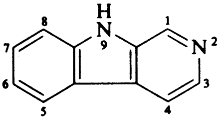
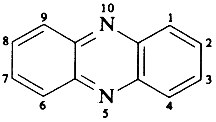
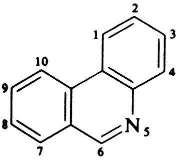
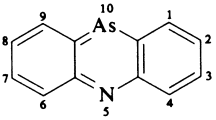
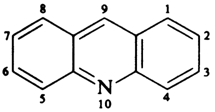
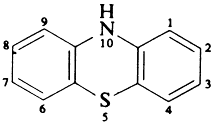
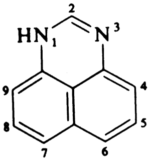
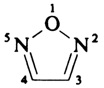
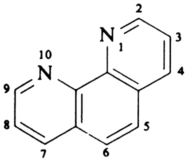
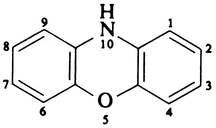
* Asterisk after a compound denotes exception to systematic numbering.

TABLE 1.5 Trivial Names of Heterocyclic Systems Suitable for Use in Fusion Names (*Continued*)

Structure	Parent name	Radical name	Structure	Parent name	Radical name
	Indolizine	Indolizinyl		Phthalazine	Phthalazinyl
	Isoindole	Isoindolyl		Naphthyridine (1,8-shown)	Naphthyridinyl
	3*H*-Indole	3*H*-Indolyl		Quinoxaline	Quinoxalinyl
	Indole	Indolyl		Quinazoline	Quinazolinyl
	1*H*-Indazole	1*H*-Indazolyl		Cinnoline	Cinnolinyl
	Purine*	Purinyl		Pteridine	Pteridinyl
	4*H*-Quinolizine	4*H*-Quinolizinyl		4α*H*-Carbazole*	4α*H*-Carbazolyl
	Isoquinoline	Isoquinolyl			
	Quinolone	Quinolyl		Carbazole*	Carbazolyl

* Asterisk after a compound denotes exception to systematic numbering.

TABLE 1.5 Trivial Names of Heterocyclic Systems Suitable for Use in Fusion Names (*Continued*)

Structure	Parent name	Radical name	Structure	Parent name	Radical name
	β-Carboline	β-Carbolinyl		Phenazine	Phenazinyl
	Phenanthridine	Phenanthridinyl		Phenarsazine	Phenarsazinyl
	Acridine*	Acridinyl		Phenothiazine	Phenothiazinyl
	Perimidine	Perimidinyl		Furazan	Furazanyl
	Phenanthroline (1,10-shown)	Phenanthrolinyl		Phenoxazine	Phenoxazinyl

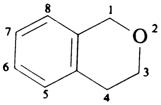
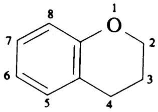
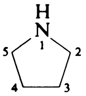
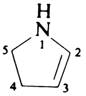
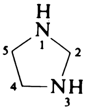
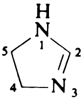
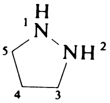
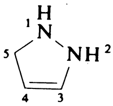
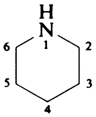
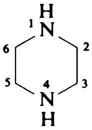
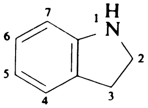
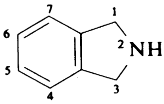
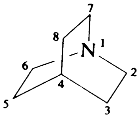
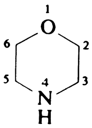
* Asterisk after a compound denotes exception to systematic numbering.

If there is a choice among heterocyclic systems, the parent compound is decided in the following order of preference:

1. A nitrogen-containing component
2. A component containing a heteroatom, in the absence of nitrogen, as high as possible in Table 1.3
3. A component containing the greater number of rings

TABLE 1.6 Trivial Names of Heterocyclic Systems That Are Not Recommended for Use in Fusion Names

Listed in order of increasing priority.

Structure	Parent name	Radical name
	Isochroman	Isochromanyl
	Chroman	Chromanyl
	Pyrrolidine	Pyrrolinyl
	Pyrroline (2-shown*)	Pyrrolinyl
	Imidazolidine	Imidazolidinyl
	Imidazoline (2-shown*)	Imidazolinyl
	Pyrazolidine	Pyrazolidinyl
	Pyrazoline (3-shown*)	Pyrazolinyl
	Piperidine	Piperidyl†
	Piperazine	Piperazinyl
	Indoline	Indolinyl
	Isoindoline	Isoindolinyl
	Quinuclidine	Quinuclidinyl
	Morpholine	Morpholinyl‡

* Denotes position of double bond.
† For 1-piperidyl, use piperidino.
‡ For 4-morpholinyl, use morpholino.

4. A component containing the largest possible individual ring
5. A component containing the greatest number of heteroatoms of any kind
6. A component containing the greatest variety of heteroatoms
7. A component containing the greatest number of heteroatoms first listed in Table 1.3

If there is a choice between components of the same size containing the same number and kind of heteroatoms, choose as the base component that one with the lower numbers for the heteroatoms before fusion. When a fusion position is occupied by a heteroatom, the names of the component rings to be fused are selected to contain the heteroatom.

1.1.2 Functional Compounds

There are several types of nomenclature systems that are recognized. Which type to use is sometimes obvious from the nature of the compound. Substitutive nomenclature, in general, is preferred because of its broad applicability, but radicofunctional, additive, and replacement nomenclature systems are convenient in certain situations.

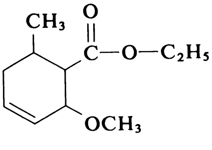
1.1.2.1 Substitutive Nomenclature. The first step is to determine the kind of characteristic (functional) group for use as the principal group of the parent compound. A characteristic group is a recognized combination of atoms that confers characteristic chemical properties on the molecule in which it occurs. Carbon-to-carbon unsaturation and heteroatoms in rings are considered nonfunctional for nomenclature purposes.

Substitution means the replacement of one or more hydrogen atoms in a given compound by some other kind of atom or group of atoms, functional or nonfunctional. In substitutive nomenclature, each substituent is cited as either a prefix or a suffix to the name of the parent (or substituting radical) to which it is attached; the latter is denoted the parent compound (or parent group if a radical).

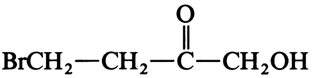
In Table 1.7 are listed the general classes of compounds in descending order of preference for citation as suffixes, that is, as the parent or characteristic compound. When oxygen is replaced by sulfur, selenium, or tellurium, the priority for these elements is in the descending order listed. The higher valence states of each element are listed before considering the successive lower valence states. Derivative groups have priority for citation as principal group after the respective parents of their general class.

In Table 1.8 are listed characteristic groups that are cited only as prefixes (never as suffixes) in substitutive nomenclature. The order of listing has no significance for nomenclature purposes.

Systematic names formed by applying the principles of substitutive nomenclature are single words except for compounds named as acids. First one selects the parent compound, and thus the suffix, from the characteristic group listed earliest in Table 1.7. All remaining functional groups are handled as prefixes that precede, in alphabetical order, the parent name. Two examples may be helpful:



Structure I



$$BrCH_2—CH_2—\overset{\overset{\displaystyle O}{\|}}{C}—CH_2OH$$

Structure II

Structure I contains an ester group and an ether group. Since the ester group has higher priority, the name is ethyl 2-methoxy-6-methyl-3-cyclohexene-1-carboxylate. Structure II contains a carbonyl group, a hydroxy group, and a bromo group. The latter is never a suffix. Between the other two, the carbonyl group has higher priority, the parent has -one as suffix, and the name is 4-bromo-1-hydroxy-2-butanone.

Selection of the principal alicyclic chain or ring system is governed by these selection rules:

1. For purely alicyclic compounds, the selection process proceeds successively until a decision is reached: (a) the maximum number of substituents corresponding to the characteristic group cited earliest in Table 1.7, (b) the maximum number of double and triple bonds considered together, (c) the maximum length of the chain, and (d) the maximum number of double bonds. Additional criteria, if needed for complicated compounds, are given in the IUPAC nomenclature rules.

2. If the characteristic group occurs only in a chain that carries a cyclic substituent, the compound is named as an aliphatic compound into which the cyclic component is substituted; a radical prefix is used to denote the cyclic component. This chain need not be the longest chain.

3. If the characteristic group occurs in more than one carbon chain and the chains are not directly

TABLE 1.7 Characteristic Groups for Substitutive Nomenclature

Listed in order of decreasing priority for citation as principal group or parent name.

Class	Formula*	Prefix	Suffix
1. Cations:		-onio-	-onium
	H_4N^+	Ammonio-	-ammonium
	H_3O^+	Oxonio-	-oxonium
	H_3S^+	Sulfonio-	-sulfonium
	H_3Se^+	Selenonio-	-selenonium
	H_2Cl^+	Chloronio-	-chloronium
	H_2Br^+	Bromonio-	-bromonium
	H_2I^+	Iodonio-	-iodonium
2. Acids:			
Carboxylic	$-\mathrm{COOH}$	Carboxy-	-carboxylic acid
	$-\mathrm{(C)OOH}$		-oic acid
	$-\mathrm{C({=}O)OOH}$		-peroxy···carboxylic acid
	$-\mathrm{(C{=}O)OOH}$		-peroxy···oic acid
Sulfonic	$-\mathrm{SO_3H}$	Sulfo-	-sulfonic acid
Sulfinic	$-\mathrm{SO_2H}$	Sulfino-	-sulfinic acid
Sulfenic	$-\mathrm{SOH}$	Sulfeno-	-sulfenic acid
Salts	$-\mathrm{COOM}$		Metal···carboxylate
	$-\mathrm{(C)OOM}$		Metal···oate
	$-\mathrm{SO_3M}$		Metal···sulfonate
	$-\mathrm{SO_2M}$		Metal···sulfinate
	$-\mathrm{SOM}$		Metal···sulfenate
3. Derivatives of acids:			
Anhydrides	$-\mathrm{C({=}O)OC({=}O)}-$		-carboxylic anhydride
	$-\mathrm{(C{=}O)O(C{=}O)}-$		-oic anhydride
Esters	$-\mathrm{COOR}$	R-oxycarbonyl-	R···carboxylate
	$-\mathrm{C(OOR)}$		R···oate
Acid halides	$-\mathrm{CO}-$halogen	Haloformyl	-carbonyl halide
Amides	$-\mathrm{CO}-\mathrm{NH_2}$	Carbamoyl-	-carboxamide
	$\mathrm{(C)O}-\mathrm{NH_2}$		-amide

TABLE 1.7 Characteristic Groups for Substitutive Nomenclature (*Continued*)

Class	Formula*	Prefix	Suffix
Hydrazides	$-\mathrm{CO}-\mathrm{NHNH_2}$	Carbonylhydrazino-	-carbohydrazide
	$-(\mathrm{CO})-\mathrm{NHNH_2}$		-ohydrazide
Imides	$-\mathrm{CO}-\mathrm{NH}-\mathrm{CO}-$	R-imido-	-carboximide
Amidines	$-\mathrm{C}(=\mathrm{NH})-\mathrm{NH_2}$	Amidino-	-carboxamidine
	$-(\mathrm{C}=\mathrm{NH})-\mathrm{NH_2}$		-amidine
4. Nitrile (cyanide)	$-\mathrm{CN}$	Cyano-	-carbonitrile
	$-(\mathrm{C})\mathrm{N}$		-nitrile
5. Aldehydes	$-\mathrm{CHO}$	Formyl-	-carbaldehyde
	$-(\mathrm{C}=\mathrm{O})\mathrm{H}$	Oxo-	-al
	(then their analogs and derivatives)		
6. Ketones	$>(\mathrm{C}=\mathrm{O})$	Oxo-	-one
	(then their analogs and derivatives)		
7. Alcohols (and phenols)	$-\mathrm{OH}$	Hydroxy-	-ol
Thiols	$-\mathrm{SH}$	Mercapto-	-thiol
8. Hydroperoxides	$-\mathrm{O}-\mathrm{OH}$	Hydroperoxy-	
9. Amines	$-\mathrm{NH_2}$	Amino-	-amine
Imines	$>\mathrm{NH}$	Imino-	-imine
Hydrazines	$-\mathrm{NHNH_2}$	Hydrazino-	-hydrazine
10. Ethers	$-\mathrm{OR}$	R-oxy-	
Sulfides	$-\mathrm{SR}$	R-thio-	
11. Peroxides	$-\mathrm{O}-\mathrm{OR}$	R-dioxy-	

* Carbon atoms enclosed in parentheses are included in the name of the parent compound and not in the suffix or prefix.

TABLE 1.8 Characteristic Groups Cited Only as Prefixes in Substitutive Nomenclature

Characteristic group	Prefix	Characteristic group	Prefix
$-\mathrm{Br}$	Bromo-	$-\mathrm{IX_2}$	X may be halogen or a radical; dihalogenoiodo- or diacetoxyiodo-, e.g., $-\mathrm{ICl_2}$ is dichloroido-
$-\mathrm{Cl}$	Chloro-		
$-\mathrm{ClO}$	Chlorosyl-		
$-\mathrm{ClO_2}$	Chloryl-	$>\mathrm{N_2}$	Diazo-
$-\mathrm{ClO_3}$	Perchloryl-	$-\mathrm{N_3}$	Azido-
$-\mathrm{F}$	Fluoro-	$-\mathrm{NO}$	Nitroso-
$-\mathrm{I}$	Iodo-	$-\mathrm{NO_2}$	Nitro-
$-\mathrm{IO}$	Iodosyl-	$>\mathrm{N}(=\mathrm{O})\mathrm{OH}$	*aci*-Nitro-
$-\mathrm{IO_2}$	Iodyl*	$-\mathrm{OR}$	R-oxy-
$-\mathrm{I(OH)_2}$	Dihydroxyiodo-	$-\mathrm{SR}$	R-thio-
		$-\mathrm{SeR}$ ($-\mathrm{TeR}$)	R-seleno- (R-telluro-)

* Formerly iodoxy.

attached to one another, then the chain chosen as parent should carry the largest number of the characteristic group. If necessary, the selection is continued as in rule 1.

4. If the characteristic group occurs only in one cyclic system, that system is chosen as the parent.
5. If the characteristic group occurs in more than one cyclic system, that system is chosen as parent which (a) carries the largest number of the principal group or, failing to reach a decision, (b) is the senior ring system.
6. If the characteristic group occurs both in a chain and in a cyclic system, the parent is that portion in which the principal group occurs in largest number. If the numbers are the same, that portion is chosen which is considered to be the most important or is the senior ring system.
7. When a substituent is itself substituted, all the subsidiary substituents are named as prefixes and the entire assembly is regarded as a parent radical.
8. The seniority of ring systems is ascertained by applying the following rules successively until a decision is reached: (a) all heterocycles are senior to all carbocycles, (b) for heterocycles, the preference follows the decision process described under Heterocyclic Systems, p. 1.11, (c) the largest number of rings, (d) the largest individual ring at the first point of difference, (e) the largest number of atoms in common among rings, (f) the lowest letters in the expression for ring functions, (g) the lowest numbers at the first point of difference in the expression for ring junctions, (h) the lowest state of hydrogenation, (i) the lowest-numbered locant for indicated hydrogen, (j) the lowest-numbered locant for point of attachment (if a radical), (k) the lowest-numbered locant for an attached group expressed as a suffix, (l) the maximum number of substituents cited as prefixes, (m) the lowest-numbered locant for substituents named as prefixes, hydro prefixes, -ene, and -yne, all considered together in one series in ascending numerical order independent of their nature, and (n) the lowest-numbered locant for the substituent named as prefix which is cited first in the name.

Numbering of Compounds. If the rules for aliphatic chains and ring systems leave a choice, the starting point and direction of numbering of a compound are chosen so as to give lowest-numbered locants to these structural factors, if present, considered successively in the order listed below until a decision is reached. Characteristic groups take precedence over multiple bonds.

1. Indicated hydrogen, whether cited in the name or omitted as being conventional
2. Characteristic groups named as suffix following the ranking order of Table 1.7
3. Multiple bonds in acyclic compounds; in bicycloalkanes, tricycloalkanes, and polycycloalkanes, double bonds having priority over triple bonds; and in heterocyclic systems whose names end in -etine, -oline, or -olene
4. The lowest-numbered locant for substituents named as prefixes, hydro prefixes, -ene, and -yne, all considered together in one series in ascending numerical order
5. The lowest locant for that substituent named as prefix which is cited first in the name

For cyclic radicals, indicated hydrogen and thereafter the point of attachment (free valency) have priority for the lowest available number.

Prefixes and Affixes. Prefixes are arranged alphabetically and placed before the parent name; multiplying affixes, if necessary, are inserted and *do not* alter the alphabetical order already attained. The parent name includes any syllables denoting a change of ring member or relating to the structure of a carbon chain. Nondetachable parts of parent names include

1. Forming rings; cyclo-, bicyclo-, spiro-
2. Fusing two or more rings: benzo-, naphtho-, imidazo-
3. Substituting one ring or chain member atom for another: oxa-, aza-, thia-
4. Changing positions of ring or chain members: iso-, *sec-*, *tert-*, neo-
5. Showing indicated hydrogen
6. Forming bridges: ethano-, epoxy-
7. Hydro-

Prefixes that represent complete terminal characteristic groups are preferred to those representing only a portion of a given group. For example, for the prefix $-C(=O)CH_3$, the name (formylmethyl) is preferred to (oxoethyl).

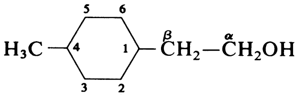
The multiplying affixes di-, tri-, tetra-, penta-, hexa-, hepta-, octa-, nona-, deca-, undeca-, and so on are used to indicate a set of *identical* unsubstituted radicals or parent compounds. The forms bis-, tris-, tetrakis-, pentakis-, and so on are used to indicate a set of identical radicals or parent compounds *each substituted in the same way.* The affixes bi-, ter-, quater-, quinque-, sexi-, septi-, octi-, novi-, deci-, and so on are used to indicate the number of identical rings joined together by a single or double bond.

Although multiplying affixes may be omitted for very common compounds when no ambiguity is caused thereby, such affixes are generally included throughout this handbook in alphabetical listings. An example would be ethyl ether for diethyl ether.

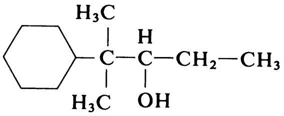
1.1.2.2 Conjunctive Nomenclature. Conjunctive nomenclature may be applied when a principal group is attached to an acyclic component that is directly attached by a carbon-carbon bond to a cyclic component. The name of the cyclic component is attached directly in front of the name of the acyclic component carrying the principal group. This nomenclature is not used when an unsaturated side chain is named systematically. When necessary, the position of the side chain is indicated by a locant placed before the name of the cyclic component. For substituents on the acyclic chain, carbon atoms of the side chain are indicated by Greek letters proceeding from the principal group to the cyclic component. The terminal carbon atom of acids, aldehydes, and nitriles is omitted when allocating Greek positional letters. Conjunctive nomenclature is not used when the side chain carries more than one of the principal group, except in the case of malonic and succinic acids.

The side chain is considered to extend only from the principal group to the cyclic component. Any other chain members are named as substituents, with appropriate prefixes placed before the name of the cyclic component.

When a cyclic component carries more than one identical side chain, the name of the cyclic component is followed by di-, tri-, etc., and then by the name of the acyclic component, and it is preceded by the locants for the side chains. Examples are



4-Methyl-1-cyclohexaneethanol



α-Ethyl-β,β-dimethylcyclohexaneethanol

When side chains of two or more different kinds are attached to a cyclic component, only the senior side chain is named by the conjunctive method. The remaining side chains are named as prefixes. Likewise, when there is a choice of cyclic component, the senior is chosen. Benzene derivatives may be named by the conjunctive method only when two or more identical side chains are present. Trivial names for oxo carboxylic acids may be used for the acyclic component. If the cyclic and acyclic components are joined by a double bond, the locants of this bond are placed as superscripts to a Greek capital delta that is inserted between the two names. The locant for the cyclic component precedes that for the acyclic component, e.g., indene-$\Delta^{1,\alpha}$-acetic acid.

1.1.2.3 Radicofunctional Nomenclature. The procedures of radicofunctional nomenclature are identical with those of substitutive nomenclature except that suffixes are never used. Instead, the functional class name (Table 1.9) of the compound is expressed as one word and the remainder of the molecule as another that precedes the class name. When the functional class name refers to a characteristic group that is bivalent, the two radicals attached to it are each named, and when different, they are written as separate words arranged in alphabetical order. When a compound contains more than one kind of group listed in Table 1.9, that kind is cited as the functional group or class name that occurs higher in the table, all others being expressed as prefixes.

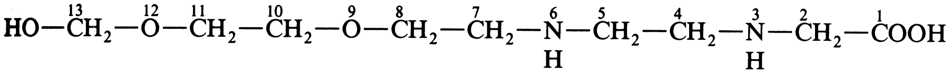
Radicofunctional nomenclature finds some use in naming ethers, sulfides, sulfoxides, sulfones, selenium analogs of the preceding three sulfur compounds, and azides.

TABLE 1.9 Functional Class Names Used in Radicofunctional Nomenclature

Groups are listed in order of decreasing priority.

Group	Functional class names
X in acid derivatives	Name of X (in priority order: fluoride, chloride, bromide, iodide, cyanide, azide; then the sulfur and selenium analogs)
—CN, —NC	Cyanide, isocyanide
$>\mathrm{CO}$	Ketone; then S and Se analogs
—OH	Alcohol; then S and Se analogs
—O—OH	Hydroperoxide
$>\mathrm{O}$	Ether or oxide
$>\mathrm{S}$, $>\mathrm{SO}$, $>\mathrm{SO_2}$	Sulfide, sulfoxide, sulfone
$>\mathrm{Se}$, $>\mathrm{SeO}$, $>\mathrm{SeO_2}$	Selenide, selenoxide, selenone
—F, —Cl, —Br, —I	Fluoride, chloride, bromide, iodide
—$\mathrm{N_3}$	Azide

1.1.2.4 Replacement Nomenclature. Replacement nomenclature is intended for use only when other nomenclature systems are difficult to apply in the naming of chains containing heteroatoms. When no group is present that can be named as a principal group, the longest chain of carbon and heteroatoms terminating with carbon is chosen and named as though the entire chain were that of an acyclic hydrocarbon. The heteroatoms within this chain are identified by means of prefixes aza-, oxa-, thia-, etc., in the order of priority stated in Table 1.3. Locants indicate the positions of the heteroatoms in the chain. Lowest-numbered locants are assigned to the principal group when such is present. Otherwise, lowest-numbered locants are assigned to the heteroatoms considered together and, if there is a choice, to the heteroatoms cited earliest in Table 1.3. An example is



$$HO{-}\overset{13}{C}H_2{-}\overset{12}{O}{-}\overset{11}{C}H_2{-}\overset{10}{C}H_2{-}\overset{9}{O}{-}\overset{8}{C}H_2{-}\overset{7}{C}H_2{-}\underset{H}{\overset{6}{N}}{-}\overset{5}{C}H_2{-}\overset{4}{C}H_2{-}\underset{H}{\overset{3}{N}}{-}\overset{2}{C}H_2{-}\overset{1}{C}OOH$$

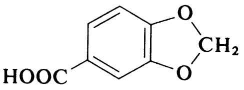
13-Hydroxy-9,12-dioxa-3,6-diazatridecanoic acid

1.1.3 Specific Functional Groups

Characteristic groups will now be treated briefly in order to expand the terse outline of substitutive nomenclature presented in Table 1.7. Alternative nomenclature will be indicated whenever desirable.

1.1.3.1 Acetals and Acylals. Acetals, which contain the group $>C(OR)_2$, where R may be different, are named (1) as dialkoxy compounds or (2) by the name of the corresponding aldehyde or ketone followed by the name of the hydrocarbon radical(s) followed by the word *acetal.* For example, $CH_3{-}CH(OCH_3)_2$ is named either (1) 1,1-dimethoxyethane or (2) acetaldehyde dimethyl acetal.

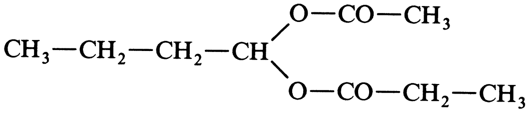
A cyclic acetal in which the two acetal oxygen atoms form part of a ring may be named (1) as a heterocyclic compound or (2) by use of the prefix methylenedioxy for the group $-O-CH_2-O-$ as a substituent in the remainder of the molecule. For example,



(1) 1,3-Benzo[*d*]dioxole-5-carboxylic acid

(2) 3,4-Methylenedioxybenzoic acid

Acylals, $R^1R^2C(OCOR^3)_2$, are named as acid esters;

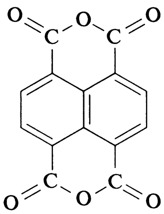


Butylidene acetate propionate

α-Hydroxy ketones, formerly called acyloins, had been named by changing the ending -ic acid or -oic acid of the corresponding acid to -oin. They are preferably named by substitutive nomenclature; thus

$CH_3{-}CH(OH){-}CO{-}CH_3$ 3-Hydroxy-2-butanone (formerly acetoin)

1.1.3.2 Acid Anhydrides. Symmetrical anhydrides of monocarboxylic acids, when unsubstituted, are named by replacing the word *acid* by *anhydride.* Anhydrides of substituted monocarboxylic acids, if symmetrically substituted, are named by prefixing bis- to the name of the acid and replacing the word *acid* by *anhydride.* Mixed anhydrides are named by giving in alphabetical order the first part of the names of the two acids followed by the word *anhydride,* e.g., acetic propionic anhydride or acetic propanoic anhydride. Cyclic anhydrides of polycarboxylic acids, although possessing a heterocyclic structure, are preferably named as acid anhydrides. For example,



1,8;4,5-Napthalenetetracarboxylic dianhydride (note the use of a semicolon to distinguish the pairs of locants)

1.1.3.3 Acyl Halides. Acyl halides, in which the hydroxyl portion of a carboxyl group is replaced by a halogen, are named by placing the name of the corresponding halide after that of the acyl radical. When another group is present that has priority for citation as principal group or when the acyl halide is attached to a side chain, the prefix haloformyl- is used as, for example, in fluoroformyl-.

1.1.3.4 Alcohols and Phenols. The hydroxyl group is indicated by a suffix -ol when it is the principal group attached to the parent compound and by the prefix hydroxy- when another group with higher priority for citation is present or when the hydroxy group is present in a side chain. When confusion may arise in employing the suffix -ol, the hydroxy group is indicated as a prefix; this terminology is also used when the hydroxyl group is attached to a heterocycle, as, for example, in the name 3-hydroxythiophene to avoid confusion with thiophenol (C_6H_5SH). Designations such as isopropanol, *sec*-butanol, and *tert*-butanol are incorrect because no hydrocarbon exists to which the suffix can be added. Many trivial names are retained. These structures are shown in Table 1.10. The radicals (RO—) are named by adding -oxy as a suffix to the name of the R radical, e.g., pentyloxy for $CH_3CH_2CH_2CH_2CH_2O$—. These contractions are exceptions: methoxy (CH_3O—), ethoxy (C_2H_5O—), propoxy (C_3H_7O—), butoxy (C_4H_9O—), and phenoxy (C_6H_5O—). For unsubstituted radicals only, one may use isopropoxy [$(CH_3)_2CH$—O—], isobutoxy [$(CH_3)_2CH_2CH$—O—], *sec*-butoxy [$CH_3CH_2CH(CH_3)$—O—], and *tert*-butoxy [$(CH_3)_3C$—O—].

TABLE 1.10 Retained Trivial Names of Alcohols and Phenols with Structures

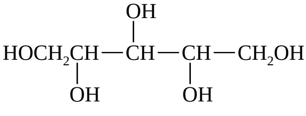
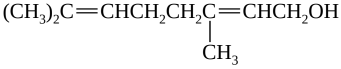
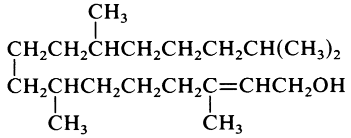
Ally alcohol	$CH_2{=}CHCH_2OH$
tert-Butyl alcohol	$(CH_3)_3COH$
Benzyl alcohol	$C_6H_5CH_2OH$
Phenethyl alcohol	$C_6H_5CH_2CH_2OH$
Ethylene glycol	$HOCH_2CH_2OH$
1,2-Propylene glycol	$CH_3CHOHCH_2OH$
Glycerol	$HOCH_2CHOHCH_2OH$
Pentaerythritol	$C(CH_2OH)_4$
Pinacol	$(CH_3)_2COHCOH(CH_3)_2$
Phenol	C_6H_5OH
Xylitol	 $HOCH_2\underset{OH}{CH}{-}\overset{OH}{CH}{-}\underset{OH}{CH}{-}CH_2OH$
Geraniol	 $(CH_3)_2C{=}CHCH_2CH_2\underset{CH_3}{C}{=}CHCH_2OH$

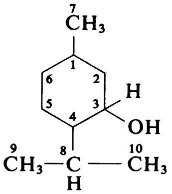
TABLE 1.10 Retained Trivial Names of Alcohols and Phenols with Structures (*Continued*)

Phytol

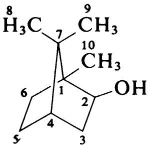


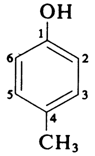
$$\begin{array}{l} CH_2CH_2\overset{CH_3}{\overset{|}{C}}HCH_2CH_2CH_2CH(CH_3)_2 \\ | \\ CH_2\underset{CH_3}{\underset{|}{C}}HCH_2CH_2CH_2\underset{CH_3}{\underset{|}{C}}{=}CHCH_2OH \end{array}$$

Menthol

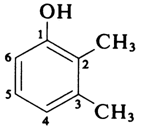


Borneol

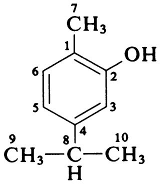




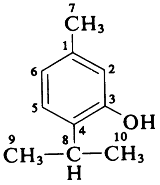
Cresol (1,4-isomer shown)



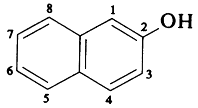
Xylenol (2,3-isomer shown)



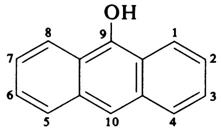
Carvacrol



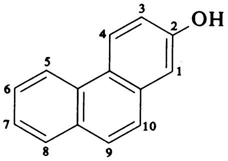
Thymol



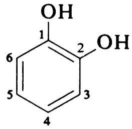
Naphthol (2-isomer shown)
2-Hydroxynaphthalene



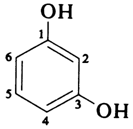
Anthrol (9-isomer shown)
9-Hydroxyanthracene



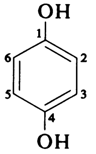
Phenanthrol (2-isomer shown)
2-Hydroxyphenanthrene



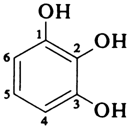
Pyrocatechol
1,2-Dihydroxybenzene



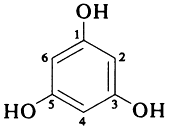
Resorcinol
1,3-Dihydroxybenzene



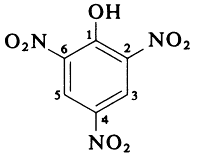
Hydroquinone
1,4-Dihydroxybenzene



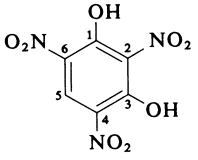
Pyrogallol
1,2,3-Trihydroxybenzene



Phloroglucinol
1,3,5-Trihydroxybenzene



Picric acid
2,4,6-Trinitrophenol



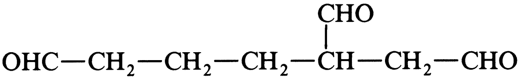
Styphnic acid
1,3-Dihydroxy-2,4,6-trinitrobenzene

Bivalent radicals of the form O—Y—O are named by adding -dioxy to the name of the bivalent radicals except when forming part of a ring system. Examples are —O—CH_2—O— (methylenedioxy), —O—CO—O— (carbonyldioxy), and —O—SO_2—O— (sulfonyldioxy). Anions derived from alcohols or phenols are named by changing the final -ol to -olate.

Salts composed of an anion, RO—, and a cation, usually a metal, can be named by citing first the cation and then the RO anion (with its ending changed to -yl oxide), e.g., sodium benzyl oxide for $C_6H_5CH_2ONa$. However, when the radical has an abbreviated name, such as methoxy, the ending -oxy is changed to -oxide. For example, CH_3ONa is named sodium methoxide (not sodium methylate).

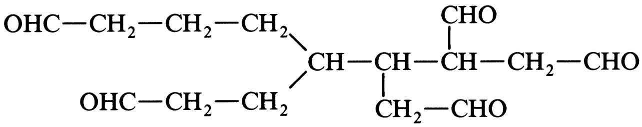
1.1.3.5 Aldehydes. When the group —C(═O)H, usually written —CHO, is attached to carbon at one (or both) end(s) of a linear acyclic chain the name is formed by adding the suffix -al (or -dial) to the name of the hydrocarbon containing the same number of carbon atoms. Examples are butanal for $CH_3CH_2CH_2CHO$ and propanedial for, $OHCCH_2CHO$.

Naming an acyclic polyaldehyde can be handled in two ways. First, when more than two aldehyde groups are attached to an unbranched chain, the proper affix is added to -carbaldehyde, which becomes the suffix to the name of the longest chain carrying the maximum number of aldehyde groups. The name and numbering of the main chain do not include the carbon atoms of the aldehyde groups. Second, the name is formed by adding the prefix formyl- to the name of the -dial that incorporates the principal chain. Any other chains carrying aldehyde groups are named by the use of formylalkyl- prefixes. Examples are



$$OHC-CH_2-CH_2-CH_2-\overset{\overset{\displaystyle CHO}{|}}{CH}-CH_2-CHO$$

(1) 1,2,5-Pentanetricarbaldehyde
(2) 3-Formylheptanedial



(1) 4-(2-Formylethyl)-3-(formylmethyl)-1,2,7-heptanetricarbaldehyde
(2) 3-Formyl-5-(2-formylethyl)-4-(formylmethyl)nonanedial

When the aldehyde group is directly attached to a carbon atom of a ring system, the suffix -carbaldehyde is added to the name of the ring system, e.g., 2-naphthalenecarbaldehyde. When the aldehyde group is separated from the ring by a chain of carbon atoms, the compound is named (1) as a derivative of the acyclic system or (2) by conjunctive nomenclature, for example, (1) (2-naphthyl)propionaldehyde or (2) 2-naphthalenepropionaldehyde.

An aldehyde group is denoted by the prefix formyl- when it is attached to a nitrogen atom in a ring system or when a group having priority for citation as principal group is present and part of a cyclic system.

When the corresponding monobasic acid has a trivial name, the name of the aldehyde may be formed by changing the ending -ic acid or -oic acid to -aldehyde. Examples are

Formaldehyde
Acetaldehyde
Propionaldehyde
Butyraldehyde
Acrylaldehyde (not acrolein)
Benzaldehyde
Cinnamaldehyde
2-Furaldehyde (not furfural)

The same is true for polybasic acids, with the proviso that all the carboxyl groups must be changed to aldehyde; then it is not necessary to introduce affixes. Examples are

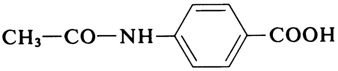
Glyceraldehyde
Glycolaldehyde
Malonaldehyde
Succinaldehyde
Phthalaldehyde (*o*-, *m*-, *p*-)

These trivial names may be retained: citral (3,7-dimethyl-2,6-octadienal), vanillin (4-hydroxy-3-methoxybenzaldehyde), and piperonal (3,4-methylenedioxybenzaldehyde).

1.1.3.6 Amides. For primary amides the suffix -amide is added to the systematic name of the parent acid. For example, $CH_3—CO—NH_2$ is acetamide. Oxamide is retained for $H_2N—CO—CO—NH_2$. The name -carboxylic acid is replaced by -carboxamide.

For amino acids having trivial names ending in -ine, the suffix -amide is added after the name of the acid (with elision of *e* for monoamides). For example, $H_2N—CH_2—CO—NH_2$ is glycinamide.

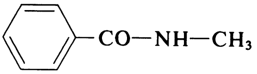
In naming the radical R—CO—NH—, either (1) the -yl ending of RCO— is changed to -amido or (2) the radicals are named as acylamino radicals. For example,



(1) 4-Acetamidobenzoic acid
(2) 4-Acetylaminobenzoic acid

The latter nomenclature is always used for amino acids with trivial names.

N-substituted primary amides are named either (1) by citing the substituents as *N* prefixes or (2) by naming the acyl group as an *N* substituent of the parent compound. For example,

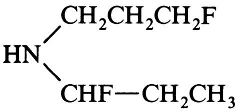


(1) *N*-Methylbenzamide
(2) Benzoylaminomethane

1.1.3.7 Amines. Amines are preferably named by adding the suffix -amine (and any multiplying affix) to the name of the parent radical. Examples are

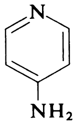
$CH_3CH_2CH_2CH_2CH_2NH_2$	Pentylamine
$H_2NCH_2CH_2CH_2CH_2CH_2NH_2$	1,5-Pentyldiamine or pentamethylenediamine

Locants of substituents of symmetrically substituted derivatives of symmetrical amines are distinguished by primes or else the names of the complete substituted radicals are enclosed in parentheses. Unsymmetrically substituted derivatives are named similarly or as *N*-substituted products of a primary amine (after choosing the most senior of the radicals to be the parent amine). For example,



(1) 1,3′-Difluorodipropylamine
(2) 1-Fluoro-*N*-(3-fluoropropyl)propylamine
(3) (1-Fluoropropyl)(3-fluoropropyl)amine

Complex cyclic compounds may be named by adding the suffix -amine or the prefix amino- (or aminoalkyl-) to the name of the parent compound. Thus three names are permissible for



(1) 4-Pyridylamine
(2) 4-Pyridinamine
(3) 4-Aminopyridine

Complex linear polyamines are best designated by replacement nomenclature. These trivial names are retained: aniline, benzidene, phenetidine, toluidine, and xylidine.

The bivalent radical —NH— linked to two identical radicals can be denoted by the prefix imino-, as well as when it forms a bridge between two carbon ring atoms. A trivalent nitrogen atom linked to three identical radicals is denoted by the prefix nitrilo-. Thus ethylenediaminetetraacetic acid (an allowed exception) should be named ethylenedinitrilotetraacetic acid.

1.1.3.8 Ammonium Compounds. Salts and hydroxides containing quadricovalent nitrogen are named as a substituted ammonium salt or hydroxide. The names of the substituting radicals precede the word *ammonium,* and then the name of the anion is added as a separate word. For example, $(CH_3)_4N^+I^-$ is tetramethylammonium iodide.

When the compound can be considered as derived from a base whose name does not end in -amine, its quaternary nature is denoted by adding ium to the name of that base (with elision of *e*), substituent groups are cited as prefixes, and the name of the anion is added separately at the end. Examples are

$C_6H_5NH_3^+HSO_4^-$	Anilinium hydrogen sulfate
$[(C_6H_5NH_3)^+]_2PtCl_6^{2-}$	Dianilinium hexachloroplatinate

The names *choline* and *betaine* are retained for unsubstituted compounds.

In complex cases, the prefixes amino- and imino- may be changed to ammonio- and iminio- and are followed by the name of the molecule representing the most complex group attached to this nitrogen atom and are preceded by the names of the other radicals attached to this nitrogen. Finally the name of the anion is added separately. For example, the name might be 1-trimethylammonio-acridine chloride or 1-acridinyltrimethylammonium chloride.

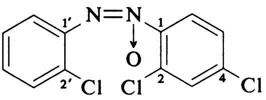
When the preceding rules lead to inconvenient names, then (1) the unaltered name of the base may be used followed by the name of the anion or (2) for salts of hydrohalogen acids only the unaltered name of the base is used followed by the name of the hydrohalide. An example of the latter would be 2-ethyl-*p*-phenylenediamine monohydrochloride.

1.1.3.9 Azo Compounds. When the azo group (—N═N—) connects radicals derived from identical unsubstituted molecules, the name is formed by adding the prefix azo- to the name of the parent unsubstituted molecules. Substituents are denoted by prefixes and suffixes. The azo group has priority for lowest-numbered locant. Examples are azobenzene for $C_6H_5—N═N—C_6H_5$, azobenzene-4-sulfonic acid for $C_6H_5—N═N—C_6H_5SO_3H$, and 2′,4-dichloroazobenzene-4′-sulfonic acid for $ClC_6H_4—N═N—C_6H_3ClSO_3H$.

When the parent molecules connected by the azo group are different, azo is placed between the complete names of the parent molecules, substituted or unsubstituted. Locants are placed between the affix azo and the names of the molecules to which each refers. Preference is given to the more complex parent molecule for citation as the first component, e.g., 2-aminonaphthalene-1-azo-(4′-chloro-2′-methylbenzene).

In an alternative method, the senior component is regarded as substituted by RN═N—, this group R being named as a radical. Thus 2-(7-phenylazo-2-naphthylazo)anthracene is the name by this alternative method for the compound named anthracene-2-azo-2′-naphthalene-7′-azobenzene.

1.1.3.10 Azoxy Compounds. Where the position of the azoxy oxygen atom is unknown or immaterial, the compound is named in accordance with azo rules, with the affix azo replaced by azoxy. When the position of the azoxy oxygen atom in an unsymmetrical compound is designated, a prefix *NNO*- or *ONN*- is used. When both the groups attached to the azoxy radical are cited in the name of the compound, the prefix *NNO*- specifies that the second of these two groups is attached directly to —N(O)—; the prefix *ONN*- specifies that the first of these two groups is attached directly to —N(O)—. When only one parent compound is cited in the name, the prefixed *ONN*- and *NNO*-specify that the group carrying the primed and unprimed substituents is connected, respectively, to the —N(O)— group. The prefix *NON*- signifies that the position of the oxygen atom is unknown; the azoxy group is then written as —N_2O—. For example,



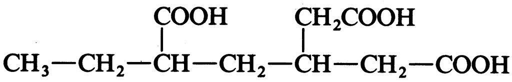
2,2′,4-Trichloro-*NNO*-azoxybenzene

1.1.3.11 Boron Compounds. Molecular hydrides of boron are called boranes. They are named by using a multiplying affix to designate the number of boron atoms and adding an Arabic numeral within parentheses as a suffix to denote the number of hydrogen atoms present. Examples are pentaborane(9) for B_5H_9 and pentaborane(11) for B_5H_{11}.

Organic ring systems are named by replacement nomenclature. Three- to ten-membered monocyclic ring systems containing uncharged boron atoms may be named by the specialist nomenclature for heterocyclic systems. Organic derivatives are named as outlined for substitutive nomenclature. The complexity of boron nomenclature precludes additional details; the text by Rigaudy and Klesney should be consulted.

1.1.3.12 Carboxylic Acids. Carboxylic acids may be named in several ways. First, —COOH groups replacing CH_3— at the end of the main chain of an acyclic hydrocarbon are denoted by adding -oic acid to the name of the hydrocarbon. Second, when the —COOH group is the principal group, the suffix -carboxylic acid can be added to the name of the parent chain whose name and chain numbering *does not include* the carbon atom of the —COOH group. The former nomenclature is preferred unless use of the ending -carboxylic acid leads to citation of a larger number of carboxyl groups as suffix. Third, carboxyl groups are designated by the prefix carboxy- when attached to a group named as a substituent or when another group is present that has higher priority for citation as principal group. In all cases, the principal chain should be linked to as many carboxyl groups as possible even though it might not be the longest chain present. Examples are

$CH_3CH_2CH_2CH_2CH_2CH_2COOH$	(1) Heptanoic acid (2) 1-Hexanecarboxylic acid
$C_6H_{11}COOH$	(2) Cyclohexanecarboxylic acid



$$\begin{array}{ccccccccccccc} & & & & COOH & & & & CH_2COOH & & & & \\ & & & & | & & & & | & & & & \\ CH_3 & - & CH_2 & - & CH & - & CH_2 & - & CH & - & CH_2 & - & COOH \end{array}$$

(3) 2-(Carboxymethyl)-1,4-hexanedicarboxylic acid

Removal of the OH from the —COOH group to form the acyl radical results in changing the ending -oic acid to -oyl or the ending -carboxylic acid to -carbonyl. Thus the radical $CH_3CH_2CH_2CH_2CO$— is named either pentanoyl or butanecarbonyl. When the hydroxyl has not been removed from all carboxyl groups present in an acid, the remaining carboxyl groups are denoted by the prefix carboxy-. For example, $HOOCCH_2CH_2CH_2CH_2CH_2CO$— is named 6-carboxyhexanoyl.

TABLE 1.11 Names of Some Carboxylic Acids

Systematic name	Trivial name	Systematic name	Trivial name
Methanoic	Formic	*trans*-Methylbutenedioic	Mesaconic*
Ethanoic	Acetic		
Propanoic	Propionic	1,2,2-Trimethyl-1,3-cyclopentanedicarboxylic acid	Camphoric
Butanoic	Butyric		
2-Methylpropanoic	Isobutyric*		
Pentanoic	Valeric	Benzenecarboxylic	Benzoic
3-Methylbutanoic	Isovaleric*	1,2-Benzenedicarboxylic	Phthalic
2,2-Dimethylpropanoic	Pivalic*	1,3-Benzenedicarboxylic	Isophthalic
Hexanoic	(Caproic)	1,4-Benzenedicarboxylic	Terephthalic
Heptanoic	(Enanthic)	Naphthalenecarboxylic	Naphthoic
Octanoic	(Caprylic)	Methylbenzenecarboxylic	Toluic
Decanoic	(Capric)	2-Phenylpropanoic	Hydratropic
Dodecanoic	Lauric*	2-Phenylpropenoic	Atropic
Tetradecanoic	Myristic*	*trans*-3-Phenylpropenoic	Cinnamic
Hexadecanoic	Palmitic*	Furancarboxylic	Furoic
Octadecanoic	Stearic*	Thiophenecarboxylic	Thenoic
		3-Pyridinecarboxylic	Nicotinic
Ethanedioic	Oxalic	4-Pyridinecarboxylic	Isonicotinic
Propanedioic	Malonic		
Butanedioic	Succinic	Hydroxyethanoic	Glycolic
Pentanedioic	Glutaric	2-Hydroxypropanoic	Lactic
Hexanedioic	Adipic	2,3-Dihydroxypropanoic	Glyceric
Heptanedioic	Pimelic*	Hydroxypropanedioic	Tartronic
Octanedioic	Suberic*	Hydroxybutanedioic	Malic
Nonanedioic	Azelaic*	2,3-Dihydroxybutanedioic	Tartaric
Decanedioic	Sebacic*	3-Hydroxy-2-phenylpropanoic	Tropic
Propenoic	Acrylic	2-Hydroxy-2,2-diphenylethanoic	Benzilic
Propynoic	Propiolic		
2-Methylpropenoic	Methacrylic	2-Hydroxybenzoic	Salicylic
trans-2-Butenoic	Crotonic	Methoxybenzoic	Anisic
cis-2-Butenoic	Isocrotonic	4-Hydroxy-3-methoxybenzoic	Vanillic
cis-9-Octadecenoic	Oleic		
trans-9-Octadecenoic	Elaidic	3,4-Dimethoxybenzoic	Veratric
cis-Butenedioic	Maleic	3,4-Methylenedioxybenzoic	Piperonylic
trans-Butenedioic	Fumaric	3,4-Dihydroxybenzoic	Protocatechuic
cis-Methylbutenedioic	Citraconic*	3,4,5-Trihydroxybenzoic	Gallic

* Systematic names should be used in derivatives formed by substitution on a carbon atom.
Note: The names in parentheses are abandoned but are listed for reference to older literature.

Many trivial names exist for acids; these are listed in Table 1.11. Generally, radicals are formed by replacing -ic acid by -oyl.* When a trivial name is given to an acyclic monoacid or diacid, the numeral 1 is always given as locant to the carbon atom of a carboxyl group in the acid or to the carbon atom with a free valence in the radical RCO—.

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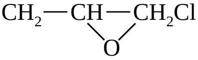
* Exceptions: formyl, acetyl, propionyl, butyryl, isobutyryl, valeryl, isovaleryl, oxalyl, malonyl, succinyl, glutaryl, furoyl, and thenoyl.

1.1.3.13 Ethers ($R^1—O—R^2$). In substitutive nomenclature, one of the possible radicals, R—O—, is stated as the prefix to the parent compound that is senior from among R^1 or R^2. Examples are methoxyethane for $CH_3OCH_2CH_3$ and butoxyethanol for $C_4H_9OCH_2CH_2OH$.

When another principal group has precedence and oxygen is linking two identical parent compounds, the prefix oxy- may be used, as with 2,2′-oxydiethanol for $HOCH_2CH_2OCH_2CH_2OH$.

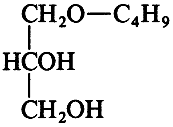
Compounds of the type RO—Y—OR, where the two parent compounds are identical and contain a group having priority over ethers for citation as suffix, are named as assemblies of identical units. For example, $HOOC—CH_2—O—CH_2CH_2—O—CH_2—COOH$ is named 2,2′-(ethylenedioxy)diacetic acid.

Linear polyethers derived from three or more molecules of aliphatic dihydroxy compounds, particularly when the chain length exceeds ten units, are most conveniently named by open-chain replacement nomenclature. For example, $CH_3CH_2—O—CH_2CH_2—O—CH_2CH_3$ could be 3,6-dioxaoctane or (2-ethoxy)ethoxyethane.

An oxygen atom directly attached to two carbon atoms already forming part of a ring system or to two carbon atoms of a chain may be indicated by the prefix epoxy-. For example,  $\mathrm{CH_2{-}CH}\underset{\diagdown\mathrm{O}\diagup}{-}\mathrm{CH_2Cl}$ is named 1-chloro-2,3-epoxypropane.

Symmetrical linear polyethers may be named (1) in terms of the central oxygen atom when there is an odd number of ether oxygen atoms or (2) in terms of the central hydrocarbon group when there is an even number of ether oxygen atoms. For example, $C_2H_5—O—C_4H_8—O—C_4H_8—O—C_2H_5$ is bis-(4-ethoxybutyl)ether, and 3,6-dioxaoctane (earlier example) could be named 1,2-bis(ethoxy)ethane.

Partial ethers of polyhydroxy compounds may be named (1) by substitutive nomenclature or (2) by stating the name of the polyhydroxy compound followed by the name of the etherifying radical(s) followed by the word *ether*. For example,



$$\begin{array}{l}\mathrm{CH_2O{-}C_4H_9}\\ \;|\\ \mathrm{HCOH}\\ \;|\\ \mathrm{CH_2OH}\end{array}$$

(1) 3-Butoxy-1,2-propanediol
(2) Glycerol 1-butyl ether; also, 1-*O*-butylglycerol

Cyclic ethers are named either as heterocyclic compounds or by specialist rules of heterocyclic nomenclature. Radicofunctional names are formed by citing the names of the radicals R^1 and R^2 followed by the word *ether*. Thus methoxyethane becomes ethyl methyl ether and ethoxyethane becomes diethyl ether.

1.1.3.14 Halogen Derivatives. Using substitutive nomenclature, names are formed by adding prefixes listed in Table 1.8 to the name of the parent compound. The prefix perhalo- implies the replacement of all hydrogen atoms by the particular halogen atoms.

Cations of the type $R^1R^2X^+$ are given names derived from the halonium ion, H_2X^+, by substitution, e.g., diethyliodonium chloride for $(C_2H_5)_2I^+Cl^-$.

Retained are these trivial names; bromoform ($CHBr_3$), chloroform ($CHCl_3$), fluoroform (CHF_3), iodoform (CHI_3), phosgene ($COCl_2$), thiophosgene ($CSCl_2$), and dichlorocarbene radical ($>CCl_2$). Inorganic nomenclature leads to such names as carbonyl and thiocarbonyl halides (COX_2 and CSX_2) and carbon tetrahalides (CX_4).

1.1.3.15 Hydroxylamines and Oximes. For RNH—OH compounds, prefix the name of the radical R to hydroxylamine. If another substituent has priority as principal group, attach the prefix hydroxyamino- to the parent name. For example, C_6H_5NHOH would be named *N*-phenylhydroxylamine, but HOC_6H_4NHOH would be (hydroxyamino)phenol, with the point of attachment indicated by a locant preceding the parentheses.

Compounds of the type R^1NH—OR^2 are named (1) as alkoxyamino derivatives of compound R^1H, (2) as *N,O*-substituted hydroxylamines, (3) as alkoxyamines (even if R^1 is hydrogen), or (4) by the prefix aminooxy- when another substituent has priority for parent name. Examples of each type are

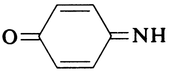
1. 2-(Methoxyamino)-8-naphthalenecarboxylic acid for CH_3ONH—$C_{10}H_6COOH$
2. *O*-Phenylhydroxylamine for H_2N—O—C_6H_5 or *N*-phenylhydroxylamine for C_6H_5NH—OH
3. Phenoxyamine for H_2N—O—C_6H_5 (not preferred to *O*-phenylhydroxylamine)
4. Ethyl (aminooxy)acetate for H_2N—O—CH_2CO—OC_2H_5

Acyl derivatives, RCO—NH—OH and H_2N—O—CO—R, are named as *N*-hydroxy derivatives of amides and as *O*-acylhydroxylamines, respectively. The former may also be named as hydroxamic acids. Examples are *N*-hydroxyacetamide for CH_3CO—NH—OH and *O*-acetylhydroxylamine for H_2N—O—CO—CH_3. Further substituents are denoted by prefixes with *O*- and/or *N*-locants. For example, C_6H_5NH—O—C_2H_5 would be *O*-ethyl-*N*-phenylhydroxylamine or *N*-ethoxylaniline.

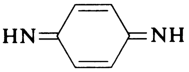
For oximes, the word *oxime* is placed after the name of the aldehyde or ketone. If the carbonyl group is not the principal group, use the prefix hydroxyimino-. Compounds with the group $>$N—OR are named by a prefix alkyloxyimino- as oxime *O*-ethers or as *O*-substituted oximes. Compounds with the group $>C{=}N(O)R$ are named by adding *N*-oxide after the name of the alkylideneaminc compound. For amine oxides, add the word *oxide* after the name of the base, with locants. For example, C_5H_5N—O is named pyridine *N*-oxide or pyridine 1-oxide.

1.1.3.16 ***Imines.*** The group $>C{=}NH$ is named either by the suffix -imine or by citing the name of the bivalent radical $R^1R^2C<$ as a prefix to amine. For example, $CH_3CH_2CH_2CH{=}NH$ could be named 1-butanimine or butylideneamine. When the nitrogen is substituted, as in $CH_2{=}N$—CH_2CH_3, the name is *N*-(methylidene)ethylamine.

Quinones are exceptions. When one or more atoms of quinonoid oxygen have been replaced by $>$NH or $>$NR, they are named by using the name of the quinone followed by the word *imine* (and preceded by proper affixes). Substituents on the nitrogen atom are named as prefixes. Examples are



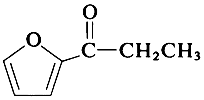
p-Benzoquinone monoimine



p-Benzoquinone diimine

1.1.3.17 ***Ketenes.*** Derivatives of the compound ketene, $CH_2{=}C{=}O$, are named by substitutive nomenclature. For example, $C_4H_9CH{=}C{=}O$ is butyl ketene. An acyl derivative, such as CH_3CH_2—CO—$CH_2CH{=}C{=}O$, may be named as a polyketone, 1-hexene-1,4-dione. Bisketene is used for two to avoid ambiguity with diketene (dimeric ketene).

1.1.3.18 ***Ketones.*** Acyclic ketones are named (1) by adding the suffix -one to the name of the hydrocarbon forming the principal chain or (2) by citing the names of the radicals R^1 and R^2 followed by the word *ketone.* In addition to the preceding nomenclature, acyclic monoacyl derivatives of cyclic compounds may be named (3) by prefixing the name of the acyl group to the name of the cyclic compound. For example, the three possible names of

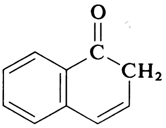


(1) 1-(2-Furyl)-1-propanone
(2) Ethyl 2-furyl ketone
(3) 2-Propionylfuran

When the cyclic component is benzene or naphthalene, the -ic acid or -oic acid of the acid corresponding to the acyl group is changed to -ophenone or -onaphthone, respectively. For example, C_6H_5—CO—$CH_2CH_2CH_3$ can be named either butyrophenone (or butanophenone) or phenyl propyl ketone.

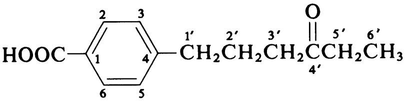
Radicofunctional nomenclature can be used when a carbonyl group is attached directly to carbon atoms in two ring systems and no other substituent is present having priority for citation.

When the methylene group in polycarbocyclic and heterocyclic ketones is replaced by a keto group, the change may be denoted by attaching the suffix -one to the name of the ring system. However, when $\geq$CH in an unsaturated or aromatic system is replaced by a keto group, two alternative names become possible. First, the maximum number of noncumulative double bonds is added after introduction of the carbonyl group(s), and any hydrogen that remains to be added is denoted as indicated hydrogen with the carbonyl group having priority over the indicated hydrogen for lower-numbered locant. Second, the prefix oxo- is used, with the hydrogenation indicated by hydro prefixes; hydrogenation is considered to have occurred before the introduction of the carbonyl group. For example,

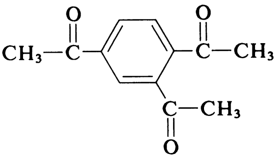


(1) 1-(2*H*)-Naphthalenone
(2) 1-Oxo-1,2-dihydronaphthalene

When another group having higher priority for citation as principal group is also present, the ketonic oxygen may be expressed by the prefix oxo-, or one can use the name of the carbonyl-containing radical, as, for example, acyl radicals and oxo-substituted radicals. Examples are



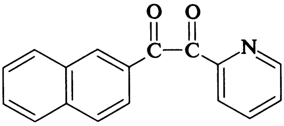
4-(4′-Oxohexyl)-1-benzoic acid



1,2,4-Triacetylbenzene

Diketones and tetraketones derived from aromatic compounds by conversion of two or four $\geqq$CH groups into keto groups, with any necessary rearrangement of double bonds to a quinonoid structure, are named by adding the suffix -quinone and any necessary affixes.

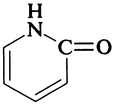
Polyketones in which two or more contiguous carbonyl groups have rings attached at each end may be named (1) by the radicofunctional method or (2) by substitutive nomenclature. For example,



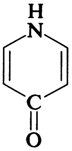
(1) 2-Naphthyl 2-pyridyl diketone
(2) 1-(2-Naphthyl)-2-(2-pyridyl)ethanedione

Some trivial names are retained: acetone (2-propanone), biacetyl (2,3-butanedione), propiophenone ($C_6H_5—CO—CH_2CH_3$), chalcone ($C_6H_5—CH{=}CH—CO—C_6H_5$), and deoxybenzoin ($C_6H_5—CH_2—CO—C_6H_5$).

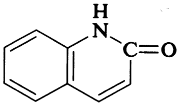
These contracted names of heterocyclic nitrogen compounds are retained as alternatives for systematic names, sometimes with indicated hydrogen. In addition, names of oxo derivatives of fully saturated nitrogen heterocycles that systematically end in -idinone are often contracted to end in -idone when no ambiguity might result. For example,



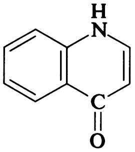
2-Pyridone
2(1*H*)-Pyridone



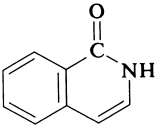
4-Pyridone
4(1*H*)-Pyridone



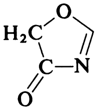
2-Quinolone
2(1*H*)-Quinolone



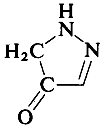
4-Quinolone
4(1*H*)-Quinolone



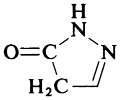
1-Isoquinolone
1(2*H*)-Isoquinolone



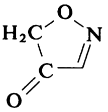
4-Oxazolone
4(5*H*)-Oxazolone



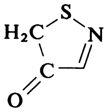
4-Pyrazolone
4(5*H*)-Pyrazolone



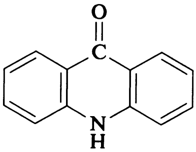
5-Pyrazolone
5(4*H*)-Pyrazolone



4-Isoxazoline
4(5*H*)-Isoxazolone

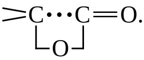


4-Thiazolone
4(5*H*)-Thiazolone



9-Acridone
9(10*H*)-Acridone

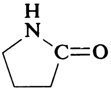
1.1.3.19 Lactones, Lactides, Lactams, and Lactims. When the hydroxy acid from which water may be considered to have been eliminated has a trivial name, the lactone is designated by substituting -olactone for -ic acid. Locants for a carbonyl group are numbered as low as possible, even before that of a hydroxyl group.

Lactones formed from aliphatic acids are named by adding -olide to the name of the nonhydroxylated hydrocarbon with the same number of carbon atoms. The suffix -olide signifies the change of $>CH\cdots CH_3$ into  $\underbrace{>C\cdots C}_{O}{=}O$.

Structures in which one or more (but not all) rings of an aggregate are lactone rings are named by placing -carbolactone (denoting the —O—CO— bridge) after the names of the structures that remain when each bridge is replaced by two hydrogen atoms. The locant for —CO— is cited before that for the ester oxygen atom. An additional carbon atom is incorporated into this structure as compared to the -olide.

These trivial names are permitted: γ-butyrolactone, γ-valerolactone, and δ-valerolactone. Names based on heterocycles may be used for all lactones. Thus, γ-butyrolactone is also tetrahydro-2-furanone or dihydro-2(3*H*)-furanone.

Lactides, intermolecular cyclic esters, are named as heterocycles. *Lactams* and *lactims,* containing a —CO—NH— and —C(OH)═N— group, respectively, are named as heterocycles, but they may also be named with -lactam or -lactim in place of -olide. For example,



(1) 2-Pyrrolidinone
(2) 4-Butanelactam

1.1.3.20 ***Nitriles and Related Compounds.*** For acids whose systematic names end in -carboxylic acid, nitriles are named by adding the suffix -carbonitrile when the —CN group replaces the —COOH group. The carbon atom of the —CN group is excluded from the numbering of a chain to which it is attached. However, when the triple-bonded nitrogen atom is considered to replace three hydrogen atoms at the end of the main chain of an acyclic hydrocarbon, the suffix -nitrile is added to the name of the hydrocarbon. Numbering begins with the carbon attached to the nitrogen. For example, $CH_3CH_2CH_2CH_2CH_2CN$ is named (1) pentanecarbonitrile or (2) hexanenitrile.

Trivial acid names are formed by changing the endings -oic acid or -ic acid to -onitrile. For example, CH_3CN is acetonitrile. When the —CN group is not the highest priority group, the —CN group is denoted by the prefix cyano-.

In order of decreasing priority for citation of a functional class name, and the prefix for substitutive nomenclature, are the following related compounds:

Functional group	Prefix	Radicofunctional ending
—NC	Isocyano-	Isocyanide
—OCN	Cyanato-	Cyanate
—NCO	Isocyanato-	Isocyanate
—ONC	—	Fulminate
—SCN	Thiocyanato-	Thiocyanate
—NCS	Isothiocyanato-	Isothiocyanate
—SeCN	Selenocyanato-	Selenocyanate
—NCSe	Isoselenocyanato-	Isoselenocyanate

1.1.3.21 ***Peroxides.*** Compounds of the type R—O—OH are named (1) by placing the name of the radical R before the word *hydroperoxide* or (2) by use of the prefix hydroperoxy- when another parent name has higher priority. For example, C_2H_5OOH is ethyl hydroperoxide.

Compounds of the type $R^1O—OR^2$ are named (1) by placing the names of the radicals in alphabetical order before the word *peroxide* when the group —O—O— links two chains, two rings, or a ring and a chain, (2) by use of the affix dioxy to denote the bivalent group —O—O— for naming assemblies of identical units or to form part of a prefix, or (3) by use of the prefix epidioxy- when the peroxide group forms a bridge between two carbon atoms, a ring, or a ring system.

Examples are methyl propyl peroxide for $CH_3—O—O—C_3H_7$ and 2,2′-dioxydiacetic acid for $HOOC—CH_2—O—O—CH_2—COOH$.

1.1.3.22 Phosphorus Compounds. Acyclic phosphorus compounds containing only one phosphorus atom, as well as compounds in which only a single phosphorus atom is in each of several functional groups, are named as derivatives of the parent structures listed in Table 1.12. Often these are purely hypothetical parent structures. When hydrogen attached to phosphorus is replaced by a hydrocarbon group, the derivative is named by substitution nomenclature. When hydrogen of an —OH group is replaced, the derivative is named by radicofunctional nomenclature. For example, $C_2H_5PH_2$ is ethylphosphine; $(C_2H_5)_2PH$, diethylphosphine; $CH_3P(OH)_2$, dihydroxy-methyl-phosphine or methylphosphonous acid; $C_2H_5—PO(Cl)(OH)$, ethylchlorophosphonic acid or ethylphosphonochloridic acid or hydrogen chlorodioxoethylphosphate(V); $CH_3CH(PH_2)COOH$, 2-phosphinopropionic acid; $HP(CH_2COOH)_2$, phosphinediyldiacetic acid; $(CH_3)HP(O)OH$, methylphosphinic acid or hydrogen hydridomethyldioxophosphate(V); $(CH_3O)_3PO$, trimethyl phosphate; and $(CH_3O)_3P$, trimethyl phosphite.

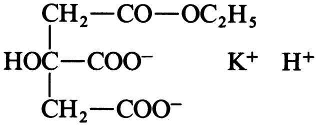
TABLE 1.12 Parent Structures of Phosphorus-Containing Compounds

Formula	Parent name	Substitutive prefix	Radicofunctional ending
H_3P	Phosphine	$H_2P—$ Phosphino-	Phosphide
H_5P	Phosphorane	$H_4P—$ Phosphoranyl-	
		$H_3P<$ Phosphoroanediyl-	
		$H_2P\leqq$ Phosphoranetriyl-	
H_3PO	Phosphine oxide		
H_3PS	Phosphine sulfide		
H_3PNH	Phosphine imide		
$P(OH)_3$	Phosphorous acid		Phosphite
$HP(OH)_2$	Phosphonous acid		Phosphonite
H_2POH	Phosphinous acid		Phosphinite
$P(O)(OH)_3$	Phosphoric acid	$P(O)\leqq$ Phosphoryl-	Phosphate(V)
$HP(O)(OH)_2$	Phosphonic acid	$HP(O)<$ Phosphonoyl-	Phosphonate
		$—P(O)OH_2$ Phosphono-	
$H_2P(O)OH$	Phosphinic acid	$H_2P(O)—$ Phosphinoyl-	Phosphinate
		$>P(O)OH$ Phosphinoco-	
		Phosphinato-	

1.1.3.23 Salts and Esters of Acids. Neutral salts of acids are named by citing the cation(s) and then the anion, whose ending is changed from -oic to -oate or from -ic to -ate. When different acidic residues are present in one structure, prefixes are formed by changing the anion ending -ate to -ato- or -ide to -ido-. The prefix carboxylato- denotes the ionic group $—COO^-$. The phrase (metal) salt of (the acid) is permissible when the carboxyl groups are not all named as affixes.

Acid salts include the word *hydrogen* (with affixes, if appropriate) inserted between the name of the cation and the name of the anion (or word *salt*).

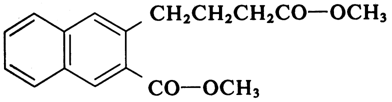
Esters are named similarly, with the name of the alkyl or aryl radical replacing the name of the cation. Acid esters of acids and their salts are named as neutral esters, but the components are cited in the order: cation, alkyl or aryl radical, hydrogen, and anion. Locants are added if necessary. For example,



$$\begin{array}{l} CH_2{-}CO{-}OC_2H_5 \\ HOC{-}COO^- \quad K^+ \quad H^+ \\ CH_2{-}COO^- \end{array}$$

Potassium 1-ethyl hydrogen citrate

Ester groups in $R^1{-}CO{-}OR^2$ compounds are named (1) by the prefix alkoxycarbonyl- or aryloxycarbonyl- for $-CO{-}OR^2$ when the radical R^1 contains a substituent with priority for citation as principal group or (2) by the prefix acyloxy- for $R^1{-}CO{-}O-$ when the radical R^2 contains a substituent with priority for citation as principal group. Examples are



Methyl 3-methoxycarbonyl-2-naphthalenebutyrate

$[CH_3O{-}CO{-}CH_2CH_2\overset{+}{N}(CH_3)_3]Cl^-$ [(2-Methoxycarbonyl)ethyl]trimethylammonium chloride

$C_6H_5{-}CO{-}OCH_2CH_2COOH$ 3-Benzoyloxypropionic acid

The trivial name *acetoxy* is retained for the $CH_3{-}CO{-}O-$ group. Compounds of the type $R^2C(OR^2)_3$ are named as R^2 esters of the hypothetical ortho acids. For example, $CH_3C(OCH_3)_3$ is trimethyl orthoacetate.

1.1.3.24 Silicon Compounds.

SiH_4 is called silane; its acyclic homologs are called disilane, trisilane, and so on, according to the number of silicon atoms present. The chain is numbered from one end to the other so as to give the lowest-numbered locant in radicals to the free valence or to substituents on a chain. The abbreviated form silyl is used for the radical SiH_3-. Numbering and citation of side chains proceed according to the principles set forth for hydrocarbon chains. Cyclic nonaromatic structures are designated by the prefix cyclo-.

When a chain or ring system is composed entirely of alternating silicon and oxygen atoms, the parent name *siloxane* is used with a multiplying affix to denote the number of silicon atoms present. The parent name *silazane* implies alternating silicon and nitrogen atoms; multiplying affixes denote the number of silicon atoms present.

The prefix sila- designates replacement of carbon by silicon in replacement nomenclature. Prefix names for radicals are formed analogously to those for the corresponding carbon-containing compounds. Thus silyl is used for SiH_3-, silyene for $-SiH_2-$, silylidyne for $-SiH<$, as well as trily, tetrayl, and so on for free valences(s) on ring structures.

1.1.3.25 Sulfur Compounds

Bivalent Sulfur. The prefix thio, placed before an affix that denotes the oxygen-containing group or an oxygen atom, implies the replacement of that oxygen by sulfur. Thus the suffix -thiol denotes $-SH$, -thione denotes $-(C){=}S$ and implies the presence of an $=S$ at a nonterminal carbon atom, -thioic acid denotes $[(C){=}S]OH \rightleftharpoons [(C){=}O]SH$ (that is, the *O*-substituted acid and the *S*-substituted acid, respectively), -dithioc acid denotes [—C(S)]SH, and -thial denotes —(C)HS (or -carbothialdehyde denotes —CHS). When -carboxylic acid has been used for acids, the sulfur analog is named -carbothioic acid or -carbodithioic acid.

Prefixes for the groups HS— and RS— are mercapto- and alkylthio-, respectively; this latter name may require parentheses for distinction from the use of thio- for replacement of oxygen in a trivially named acid. Examples of this problem are 4-C_2H_5—C_6H_4—CSOH named *p*-ethyl(thio)benzoic acid and 4-C_2H_5—S—C_6H_4—COOH named *p*-(ethylthio)benzoic acid. When —SH is not the principal group, the prefix mercapto- is placed before the name of the parent compound to denote an unsubstituted —SH group.

The prefix thioxo- is used for naming ═S in a thioketone. Sulfur analogs of acetals are named as alkylthio- or arylthio-. For example, $CH_3CH(SCH_3)OCH_3$ is 1-methoxy-1-(methylthio)ethane. Prefix forms for -carbothioic acids are hydroxy(thiocarbonyl)- when referring to the *O*-substituted acid and mercapto(carbonyl)- for the *S*-substituted acid.

Salts are formed as with oxygen-containing compounds. For example, C_2H_5—S—Na is named either sodium ethanethiolate or sodium ethyl sulfide. If mercapto- has been used as a prefix, the salt is named by use of the prefix sulfido- for —S^-.

Compounds of the type R^1—S—R^2 are named alkylthio- (or arylthio-) as a prefix to the name of R^1 or R^2, whichever is the senior.

Sulfonium Compounds. Sulfonium compounds of the type $R^1R^2R^3S^+X^-$ are named by citing in alphabetical order the radical names followed by -sulfonium and the name of the anion. For heterocyclic compounds, -ium is added to the name of the ring system. Replacement of >CH by sulfonium sulfur is denoted by the prefix thionia-, and the name of the anion is added at the end.

Organosulfur Halides. When sulfur is directly linked only to an organic radical and to a halogen atom, the radical name is attached to the word *sulfur* and the name(s) and number of the halide(s) are stated as a separate word. Alternatively, the name can be formed from R—SOH, a sulfenic acid whose radical prefix is sulfenyl-. For example, CH_3CH_2—S—Br would be named either ethylsulfur monobromide or ethanesulfenyl bromide. When another principal group is present, a composite prefix is formed from the number and substitutive name(s) of the halogen atoms in front of the syllable thio. For example, BrS—COOH is (bromothio)formic acid.

Sulfoxides. Sulfoxides, R^1—SO—R^2, are named by placing the names of the radicals in alphabetical order before the word *sulfoxide.* Alternatively, the less senior radical is named followed by sulfinyl- and concluded by the name of the senior group. For example, CH_3CH_2—SO—$CH_2CH_2CH_3$ is named either ethyl propyl sulfoxide or 1-(ethylsulfinyl)propane.

When an >SO group is incorporated in a ring, the compound is named an oxide.

Sulfones. Sulfones, R^1—SO_2—R^2, are named in an analogous manner to sulfoxides, using the word *sulfone* in place of *sulfoxide.* In prefixes, the less senior radical is followed by -sulfonyl-. When the >SO_2 group is incorporated in a ring, the compound is named as a dioxide.

Sulfur Acids. Organic oxy acids of sulfur, that is, —SO_3H, —SO_2H, and —SOH, are named sulfonic acid, sulfinic acid, and sulfenic acid, respectively. In subordinate use, the respective prefixes are sulfo-, sulfino, and sulfeno-. The grouping —SO_2—O—SO_2— or —SO—O—SO is named sulfonic or sulfinic anhydride, respectively.

Inorganic nomenclature is employed in naming sulfur acids and their derivatives in which sulfur is linked only through oxygen to the organic radical. For example, $(C_2H_5O)_2SO_2$ is diethyl sulfate and C_2H_5O—SO_2—OH is ethyl hydrogen sulfate. Prefixes *O*- and *S*- are used where necessary to denote attachment to oxygen and to sulfur, respectively, in sulfur replacement compounds. For example, CH_3—S—SO_2—ONa is sodium *S*-methyl thiosulfate.

When sulfur is linked only through nitrogen, or through nitrogen and oxygen, to the organic radical, naming is as follows: (1) *N*-substituted amides are designated as *N*-substituted derivatives of the sulfur amides and (2) compounds of the type R—NH—SO_3H may be named as *N*-substituted sulfamic acids or by the prefix sulfoamino- to denote the group $HO_3S—NH—$. The groups $—N{=}SO$ and $—N{=}SO_2$ are named sulfinylamines and sulfonylamines, respectively.

Sultones and Sultams. Compounds containing the group $—SO_2—O—$ as part of the ring are called -sultone. The $—SO_2—$ group has priority over the $—O—$ group for lowest-numbered locant.

Similarly, the $—SO_2—N{=}$ group as part of a ring is named by adding -sultam to the name of the hydrocarbon with the same number of carbon atoms. The $—SO_2—$ has priority over $—N{=}$ for lowest-numbered locant.

1.1.4 Stereochemistry

Concepts in stereochemistry, that is, chemistry in three-dimensional space, are in the process of rapid expansion. This section will deal with only the main principles. The compounds discussed will be those that have identical molecular formulas but differ in the arrangement of their atoms in space. *Stereoisomers* is the name applied to these compounds.

Stereoisomers can be grouped into three categories: (1) Conformational isomers differ from each other only in the way their atoms are oriented in space, but can be converted into one another by rotation about sigma bonds. (2) Geometric isomers are compounds in which rotation about a double bond is restricted. (3) Configurational isomers differ from one another only in configuration about a chiral center, axis, or plane. In subsequent structural representations, a broken line denotes a bond projecting behind the plane of the paper and a wedge denotes a bond projecting in front of the plane of the paper. A line of normal thickness denotes a bond lying essentially in the plane of the paper.

1.1.4.1 Conformational Isomers. A molecule in a conformation into which its atoms return spontaneously after small displacements is termed a *conformer.* Different arrangements of atoms that can be converted into one another by rotation about single bonds are called *conformational isomers* (see Fig. 1.1). A pair of conformational isomers can be but do not have to be mirror images of each other. When they are not mirror images, they are called *diastereomers.*

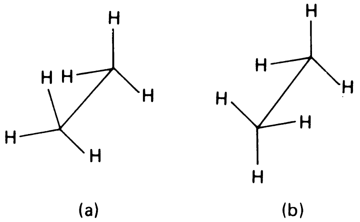


FIGURE 1.1 Conformations of ethane. (*a*) Eclipsed; (*b*) staggered.

Acyclic Compounds. Different conformations of acyclic compounds are best viewed by construction of ball-and-stick molecules or by use of Newman projections (see Fig. 1.2). Both types of representations are shown for ethane. Atoms or groups that are attached at opposite ends of a single bond should be viewed along the bond axis. If two atoms or groups attached at opposite ends of the bond appear one directly behind the other, these atoms or groups are described as eclipsed. That portion of the molecule is described as being in the eclipsed conformation. If not eclipsed, the atoms

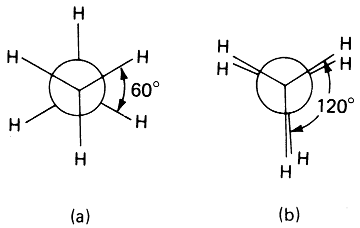


FIGURE 1.2 Newman projections for ethane. (*a*) Staggered; (*b*) eclipsed.

or groups and the conformation may be described as staggered. Newman projections show these conformations clearly.

Certain physical properties show that rotation about the single bond is not quite free. For ethane there is an energy barrier of about 3 kcal · mol^{-1} (12 kJ · mol^{-1}). The potential energy of the molecule is at a minimum for the staggered conformation, increases with rotation, and reaches a maximum at the eclipsed conformation. The energy required to rotate the atoms or groups about the carbon-carbon bond is called *torsional energy*. Torsional strain is the cause of the relative instability of the eclipsed conformation or any intermediate skew conformations.

In butane, with a methyl group replacing one hydrogen on each carbon of ethane, there are several different staggered conformations (see Fig. 1.3). There is the *anti*-conformation in which the methyl groups are as far apart as they can be (dihedral angle of 180°). There are two *gauche* conformations in which the methyl groups are only 60° apart; these are two nonsuperimposable mirror images of each other. The *anti*-conformation is more stable than the *gauche* by about 0.9 kcal · mol^{-1} (4 kJ · mol^{-1}). Both are free of torsional strain. However, in a *gauche* conformation the methyl groups are closer together than the sum of their van der Waals' radii. Under these conditions van der Waals' forces are repulsive and raise the energy of conformation. This strain can affect not only the relative stabilities of various staggered conformations but also the heights of the energy barriers

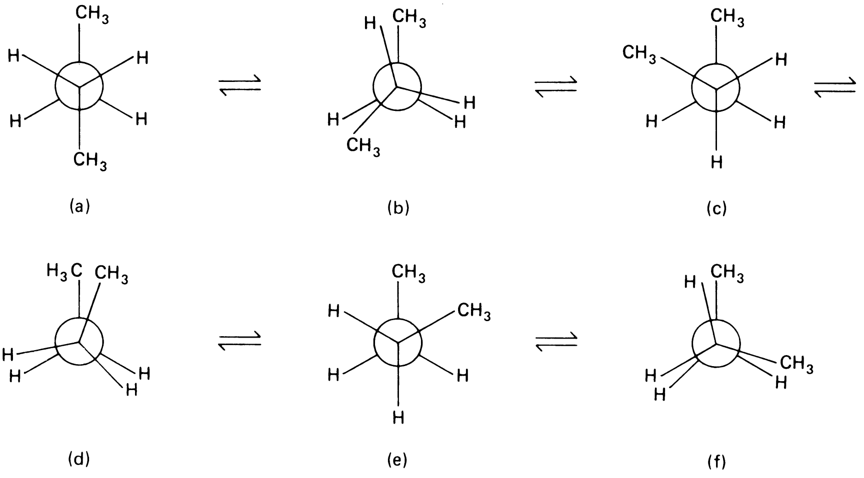


FIGURE 1.3 Conformations of butane. (*a*) *Anti*-staggered; (*b*) eclipsed; (*c*) *gauche*-staggered; (*d*) eclipsed; (*e*) *gauche*-staggered; (*f*) eclipsed. (Eclipsed conformations are slightly staggered for convenience in drawing; actually they are superimposed.)

between them. The energy maximum (estimated at 4.8 to 6.1 kcal · mol^{-1} or 20 to 25 kJ · mol^{-1})is reached when two methyl groups swing past each other (the eclipsed conformation) rather than past hydrogen atoms.

Cyclic Compounds. Although cyclic aliphatic compounds are often drawn as if they were planar geometric figures (a triangle for cyclopropane, a square for cyclobutane, and so on), their structures are not that simple. Cyclopropane does possess the maximum angle strain if one considers the difference between a tetrahedral angle (109.5°) and the 60° angle of the cyclopropane structure. Nevertheless the cyclopropane structure is thermally quite stable. The highest electron density of the carbon-carbon bonds does not lie along the lines connecting the carbon atoms. Bonding electrons lie principally outside the triangular internuclear lines and result in what is known as *bent bonds* (see Fig. 1.4).

Cyclobutane has less angle strain than cyclopropane (only 19.5°). It is also believed to have some bent-bond character associated with the carbon-carbon bonds. The molecule exists in a nonplanar conformation in order to minimize hydrogen-hydrogen eclipsing strain.

Cyclopentane is nonplanar, with a structure that resembles an envelope (see Fig. 1.5). Four of the carbon atoms are in one plane, and the fifth is out of that plane. The molecule is in continual motion so that the out-of-plane carbon moves rapidly around the ring.

The 12 hydrogen atoms of cyclohexane do not occupy equivalent positions. In the chair conformation six hydrogen atoms are perpendicular to the average plane of the molecule and six are directed outward from the ring, slightly above or below the molecular plane (see Fig. 1.6). Bonds which are perpendicular to the molecular plane are known as *axial bonds,* and those which extend outward

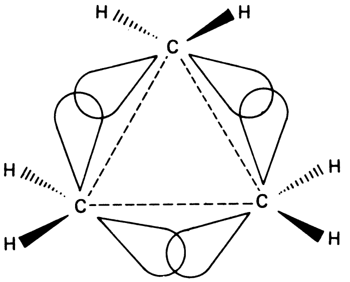


FIGURE 1.4 The bent bonds (“tear drops”) of cyclopropane.

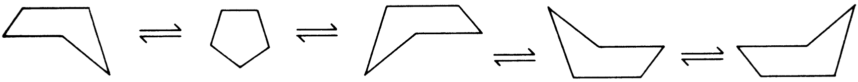


FIGURE 1.5 The conformations of cyclopentane.

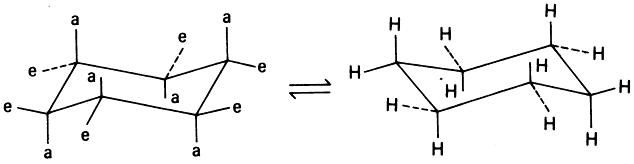


FIGURE 1.6 The two chair conformations of cyclohexane; *a* = axial hydrogen atom and *e* = equatorial hydrogen atom.

from the ring are known as *equatorial bonds.* The three axial bonds directed upward originate from alternate carbon atoms and are parallel with each other; a similar situation exists for the three axial bonds directed downward. Each equatorial bond is drawn so as to be parallel with the ring carbon-carbon bond once removed from the point of attachment to that equatorial bond. At room temperature, cyclohexane is interconverting rapidly between two chair conformations. As one chair form converts to the other, all the equatorial hydrogen atoms become axial and all the axial hydrogens become equatorial. The interconversion is so rapid that all hydrogen atoms on cyclohexane can be considered equivalent. Interconversion is believed to take place by movement of one side of the chair structure to produce the twist boat, and then movement of the other side of the twist boat to give the other chair form. The chair conformation is the most favored structure for cyclohexane. No angle strain is encountered since all bond angles remain tetrahedral. Torsional strain is minimal because all groups are staggered.

In the boat conformation of cyclohexane (Fig. 1.7) eclipsing torsional strain is significant, although no angle strain is encountered. Nonbonded interaction between the two hydrogen atoms across the ring from each other (the “flagpole” hydrogens) is unfavorable. The boat conformation is about 6.5 kcal · mol^{-1} (27 kJ · mol^{-1}) higher in energy than the chair form at 25°C.

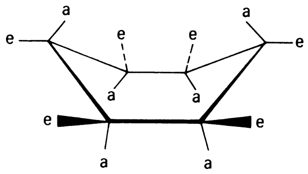


FIGURE 1.7 The boat conformation of cyclohexane. *a* = axial hydrogen atom and *e* = equatorial hydrogen atom.

FIGURE 1.8 Twist-boat conformation of cyclohexane.

A modified boat conformation of cyclohexane, known as the twist boat (Fig. 1.8), or skew boat, has been suggested to minimize torsional and nonbounded interactions. This particular conformation is estimated to be about 1.5 kcal · mol^{-1} (6 kJ · mol^{-1}) lower in energy than the boat form at room temperature.

The medium-size rings (7 to 12 ring atoms) are relatively free of angle strain and can easily take a variety of spatial arrangements. They are not large enough to avoid all nonbonded interactions between atoms.

Disubstituted cyclohexanes can exist as *cis-trans* isomers as well as axial-equatorial conformers. Two isomers are predicted for 1,4-dimethylcyclohexane (see Fig. 1.9). For the *trans* isomer the diequatorial conformer is the energetically favorable form. Only one *cis* isomer is observed, since the two conformers of the *cis* compound are identical. Interconversion takes place between the conformational (equatorial-axial) isomers but not configurational (*cis-trans*) isomers.

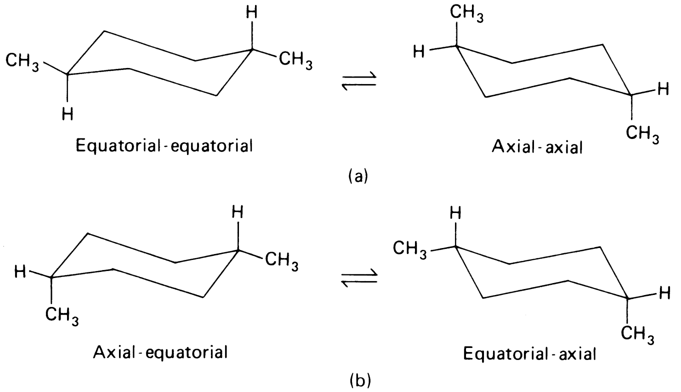


FIGURE 1.9 Two isomers of 1,4-dimethylcyclohexane. (*a*) *Trans* isomer; (*b*) *cis* isomer.

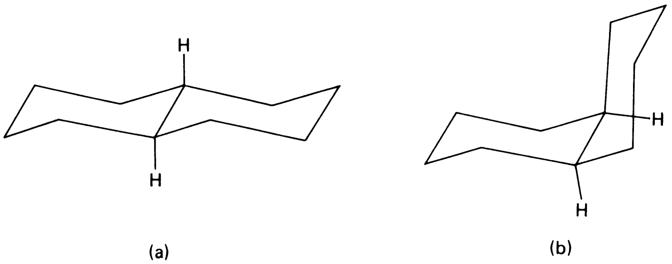


FIGURE 1.10 Two isomers of decahydronaphthalene, or bicyclo[4.4.0]decane. (*a*) *Trans* isomer; (*b*) *cis* isomer.

The bicyclic compound decahydronaphthalene, or bicyclo[4.4.0]decane, has two fused six-membered rings. It exists in *cis* and *trans* forms (see Fig. 1.10), as determined by the configurations at the bridgehead carbon atoms. Both *cis*- and *trans*-decahydronaphthalene can be constructed with two chair conformations.

1.1.4.2 Geometrical Isomerism. Rotation about a carbon-carbon double bond is restricted because of interaction between the *p* orbitals which make up the pi bond. Isomerism due to such restricted rotation about a bond is known as *geometric isomerism.* Parallel overlap of the *p* orbitals of each carbon atom of the double bond forms the molecular orbital of the pi bond. The relatively large barrier to rotation about the pi bond is estimated to be nearly 63 $\mathrm{kcal \cdot mol^{-1}}$ (263 $\mathrm{kJ \cdot mol^{-1}}$).

When two different substituents are attached to each carbon atom of the double bond, *cis-trans* isomers can exist. In the case of *cis*-2-butene (Fig. 1.11*a*), both methyl groups are on the same side of the double bond. The other isomer has the methyl groups on opposite sides and is designated as *trans*-2-butene (Fig. 1.11*b*). Their physical properties are quite different. Geometric isomerism can also exist in ring systems; examples were cited in the previous discussion on conformational isomers.

For compounds containing only double-bonded atoms, the reference plane contains the double-bonded atoms and is perpendicular to the plane containing these atoms and those directly attached to them. It is customary to draw the formulas so that the reference plane is perpendicular to that of

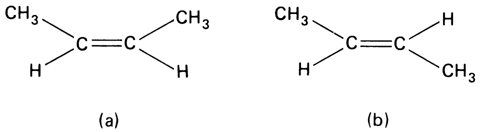


FIGURE 1.11 Two isomers of 2-butene. (*a*) *Cis* isomer, bp 3.8°C, mp −138.9°C, dipole moment 0.33 D; (*b*) *trans* isomer, bp 0.88°C, mp −105.6°C, dipole moment 0 D.

the paper. For cyclic compounds the reference plane is that in which the ring skeleton lies or to which it approximates. Cyclic structures are commonly drawn with the ring atoms in the plane of the paper.

1.1.4.3 Sequence Rules for Geometric Isomers and Chiral Compounds. Although *cis* and *trans* designations have been used for many years, this approach becomes useless in complex systems. To eliminate confusion when each carbon of a double bond or a chiral center is connected to different groups, the Cahn, Ingold, and Prelog system for designating configuration about a double bond or a chiral center has been adopted by IUPAC. Groups on each carbon atom of the double bond are assigned a first (1) or second (2) priority. Priority is then compared at one carbon relative to the other. When both first priority groups are on the *same side* of the double bond, the configuration is designated as *Z* (from the German *zusammen,* "together"), which was formerly *cis.* If the first priority groups are on *opposite sides* of the double bond, the designation is *E* (from the German *entgegen,* "in opposition to"), which was formerly *trans.* (See Fig. 1.12.)

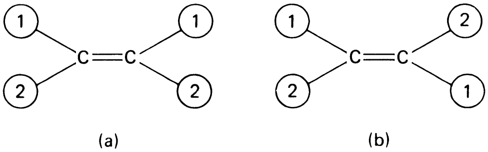
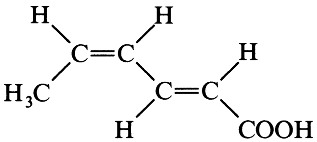


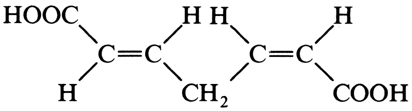
FIGURE 1.12 Configurations designated by priority groups. (*a*) *Z* (*cis*); (*b*) *E* (*trans*).

When a molecule contains more than one double bond, each *E* or *Z* prefix has associated with it the lower-numbered locant of the double bond concerned. Thus (see also the rules that follow)



(2*E*,4*Z*)-2,4-Hexadienoic acid

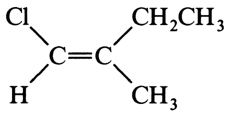
When the sequence rules permit alternatives, preference for lower-numbered locants and for inclusion in the principal chain is allotted as follows in the order stated: *Z* over *E* groups and *cis* over *trans* cyclic groups. If a choice is still not attained, then the lower-numbered locant for such a preferred group at the first point of difference is the determining factor. For example,



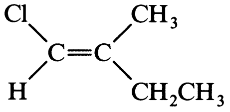
(2*Z*,5*E*)-2,5-Heptadienedioic acid

Rule 1. Priority is assigned to atoms on the basis of atomic number. Higher priority is assigned to atoms of higher atomic number. If two atoms are isotopes of the same element, the atom of higher mass number has the higher priority. For example, in 2-butene, the carbon atom of each methyl group receives first priority over the hydrogen atom connected to the same carbon atom. Around the asymmetric carbon atom in chloroiodomethanesulfonic acid, the priority sequence is I, Cl, S, H. In 1-bromo-1-deuteroethane, the priority sequence is Cl, C, D, H.

Rule 2. When atoms attached directly to a double-bonded carbon have the same priority, the second atoms are considered and so on, if necessary, working outward once again from the double bond or chiral center. For example, in 1-chloro-2-methylbutene, in CH_3 the second atoms are H, H, H and in CH_2CH_3 they are C, H, H. Since carbon has a higher atomic number than hydrogen, the ethyl group has the next highest priority after the chlorine atom.

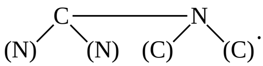


(*Z*)-1-Chloro-2-methylbutene

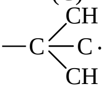


(*E*)-1-Chloro-2-methylbutene

Rule 3. When groups under consideration have double or triple bonds, the multiple-bonded atom is replaced conceptually by two or three single bonds to that same kind of atom. Thus, $=A$ is considered to be equivalent to two A's, or $<^{A}_{A}$ and $\equiv A$ equals $\overset{\diagup A}{\underset{\diagdown A}{-A}}$. However, a real $<^{A}_{A}$ has priority over $=A$; likewise a real $\overset{\diagup A}{\underset{\diagdown A}{-A}}$ has priority over $\equiv A$. Actually, both atoms of a multiple bond are duplicated, or triplicated, so that $C{=}O$ is treated as $\begin{array}{ccc}C&-&O\\|&&|\\O&&C\end{array}$, that is $\begin{array}{l}C-O\\|\\(O)\end{array}$ and $\begin{array}{l}O-C\\|\\(C)\end{array}$, and $C{\equiv}N$ is treated as



. A phenyl carbon becomes



. Only the double-bonded atoms themselves are duplicated, not the atoms or groups attached to them. The duplicated atoms (or phantom atoms) may be considered as carrying atomic number zero. For example, among the groups OH, CHO, CH_2OH, and H, the OH group has the highest priority, and the C(O, O, H) of CHO takes priority over the C(O, H, H) of CH_2OH.

1.1.4.4 Chirality and Optical Activity. A compound is chiral (the term *dissymmetric* was formerly used) if it is not superimposable on its mirror image. A chiral compound does not have a plane of symmetry. Each chiral compound possesses one (or more) of three types of chiral element, namely, a chiral center, a chiral axis, or a chiral plane.

Chiral Center. The chiral center, which is the chiral element most commonly met, is exemplified by an asymmetric carbon with a tetrahedral arrangement of ligands about the carbon. The ligands comprise four different atoms or groups. One "ligand" may be a lone pair of electrons; another, a phantom atom of atomic number zero. This situation is encountered in sulfoxides or with a nitrogen atom. Lactic acid is an example of a molecule with an asymmetric (chiral) carbon. (See Fig. 1.13b.)

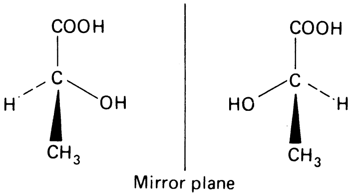
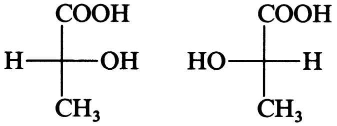


FIGURE 1.13 Asymmetric (chiral) carbon in the lactic acid molecule.

A simpler representation of molecules containing asymmetric carbon atoms is the Fischer projection, which is shown here for the same lactic acid configurations. A Fischer projection involves drawing a cross and attaching to the four ends the four groups that are attached to the asymmetric carbon atom. The asymmetric carbon atom is understood to be located where the lines cross. The horizontal lines are understood to represent bonds coming toward the viewer out of the plane of the paper. The vertical lines represent bonds going away from the viewer behind the plane of the paper as if the vertical line were the side of a circle. The principal chain is depicted in the vertical direction; the lowest-numbered (locant) chain member is placed at the top position. These formulas may be moved sideways or rotated through 180° in the plane of the paper, but they may not be removed from the plane of the paper (i.e., rotated through 90°). In the latter orientation it is essential to use thickened lines (for bonds coming toward the viewer) and dashed lines (for bonds receding from the viewer) to avoid confusion.



$$\begin{array}{ccc} & \mathrm{COOH} & \\ \mathrm{H} & + & \mathrm{OH} \\ & \mathrm{CH_3} & \end{array} \qquad \begin{array}{ccc} & \mathrm{COOH} & \\ \mathrm{HO} & + & \mathrm{H} \\ & \mathrm{CH_3} & \end{array}$$

Enantiomers. Two nonsuperimposable structures that are mirror images of each other are known as *enantiomers.* Enantiomers are related to each other in the same way that a right hand is related to a left hand. Except for the direction in which they rotate the plane of polarized light, enantiomers are identical in all physical properties. Enantiomers have identical chemical properties except in their reactivity toward optically active reagents.

Enantiomers rotate the plane of polarized light in opposite directions but with equal magnitude. If the light is rotated in a clockwise direction, the sample is said to be dextrorotatory and is designed as (+). When a sample rotates the plane of polarized light in a counterclockwise direction, it is said to be levorotatory and is designed as (−). Use of the designations *d* and *l* is discouraged.

Specific Rotation. Optical rotation is caused by individual molecules of the optically active compound. The amount of rotation depends upon how many molecules the light beam encounters in passing through the tube. When allowances are made for the length of the tube that contains the sample and the sample concentration, it is found that the amount of rotation, as well as its direction, is a characteristic of each individual optically active compound.

Specific rotation is the number of degrees of rotation observed if a 1-dm tube is used and the compound being examined is present to the extent of 1 g per 100 mL. The density for a pure liquid replaces the solution concentration.

$$\text{Specific rotation} = [\alpha] = \frac{\text{observed rotation (degrees)}}{\text{length (dm)} \times \text{(g/100 mL)}}$$

The temperature of the measurement is indicated by a superscript and the wavelength of the light employed by a subscript written after the bracket; for example, $[\alpha]_{590}^{20}$ implies that the measurement was made at 20°C using 590-nm radiation.

Optically Inactive Chiral Compounds. Although chirality is a necessary prerequisite for optical activity, chiral compounds are not necessarily optically active. With an equal mixture of two enantiomers, no net optical rotation is observed. Such a mixture of enantiomers is said to be *racemic* and is designated as (±) and not as *dl*. Racemic mixtures usually have melting points higher than the melting point of either pure enantiomer.

A second type of optically inactive chiral compounds, *meso* compounds, will be discussed in the next section.

Multiple Chiral Centers. The number of stereoisomers increases rapidly with an increase in the number of chiral centers in a molecule. A molecule possessing two chiral atoms should have four optical isomers, that is, four structures consisting of two pairs of enantiomers. However, if a compound has two chiral centers but both centers have the same four substituents attached, the total number of isomers is three rather than four. One isomer of such a compound is not chiral because it is identical with its mirror image; it has an internal mirror plane. This is an example of a diastereomer. The achiral structure is denoted as a *meso* compound. Diastereomers have different physical and chemical properties from the optically active enantiomers. Recognition of a plane of symmetry is usually the easiest way to detect a *meso* compound. The stereoisomers of tartaric acid are examples of compounds with multiple chiral centers (see Fig. 1.14), and one of its isomers is a *meso* compound.

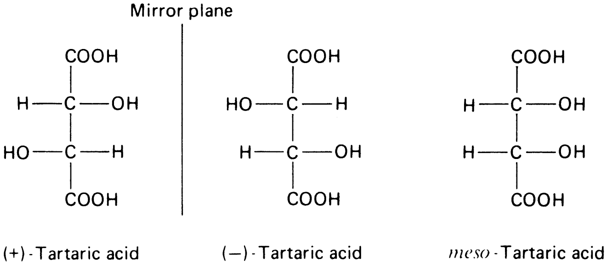


FIGURE 1.14 Isomers of tartaric acid.

When the asymmetric carbon atoms in a chiral compound are part of a ring, the isomerism is more complex than in acyclic compounds. A cyclic compound which has two different asymmetric carbons with different sets of substituent groups attached has a total of $2^2 = 4$ optical isomers: an enantiometric pair of *cis* isomers and an enantiometric pair of *trans* isomers. However, when the two asymmetric centers have the same set of substituent groups attached, the *cis* isomer is a *meso* compound and only the *trans* isomer is chiral. (See Fig. 1.15.)

Torsional Asymmetry. Rotation about single bonds of most acyclic compounds is relatively free at ordinary temperatures. There are, however, some examples of compounds in which nonbonded

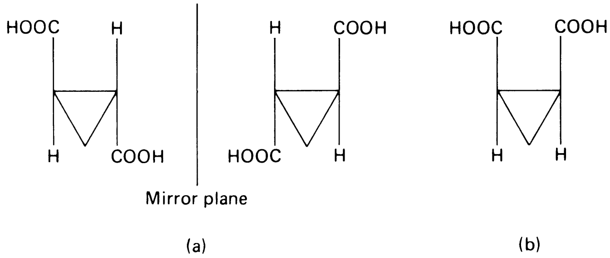


FIGURE 1.15 Isomers of cyclopropane-1,2-dicarboxylic acid. (*a*) *Trans* isomer; (*b*) *meso* isomer.

interactions between large substituent groups inhibit free rotation about a sigma bond. In some cases these compounds can be separated into pairs of enantiomers.

A *chiral axis* is present in chiral biaryl derivatives. When bulky groups are located at the *ortho* positions of each aromatic ring in biphenyl, free rotation about the single bond connecting the two rings is inhibited because of torsional strain associated with twisting rotation about the central single bond. Interconversion of enantiomers is prevented (see Fig. 1.16).

For compounds possessing a chiral axis, the structure can be regarded as an elongated tetrahedron to be viewed along the axis. In deciding upon the absolute configuration it does not matter from which end it is viewed; the nearer pair of ligands receives the first two positions in the order of precedence (see Fig. 1.17). For the meaning of (*S*), see the discussion under Absolute Configuration on p. 1.49.

A *chiral plane* is exemplified by the plane containing the benzene ring and the bromine and oxygen atoms in the chiral compound shown in Fig. 1.18. Rotation of the benzene ring around the oxygen-to-ring single bonds is inhibited when *x* is small (although no critical size can be reasonably established).

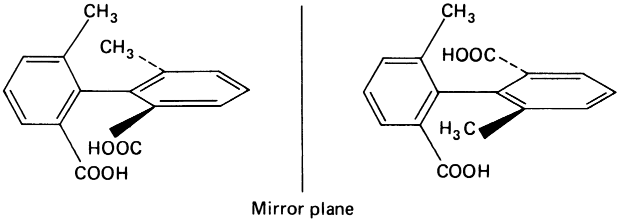


FIGURE 1.16 Isomers of biphenyl compounds with bulky groups attached at the *ortho* positions.

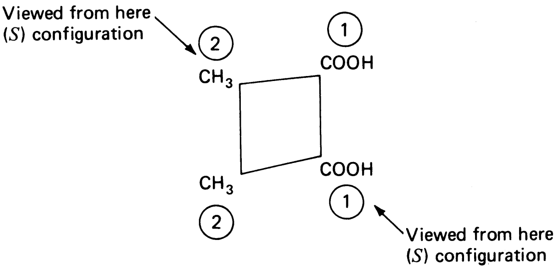


FIGURE 1.17 Example of a chiral axis.

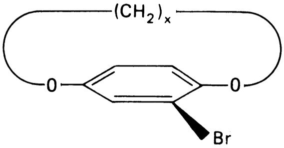


FIGURE 1.18 Example of a chiral plane.

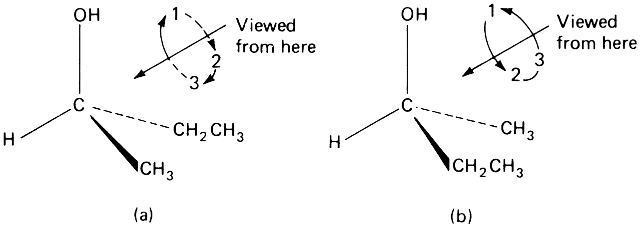


FIGURE 1.19 Viewing angle as a means of designating the absolute configuration of compounds with a chiral axis. (*a*) (*R*)-2-Butanol (sequence clockwise); (*b*) (*S*)-2-butanol (sequence counterclockwise).

Absolute Configuration. The terms absolute stereochemistry and absolute configuration are used to describe the three-dimensional arrangement of substituents around a chiral element. A general system for designating absolute configuration is based upon the priority system and sequence rules. Each group attached to a chiral center is assigned a number, with number one the highest-priority group. For example, the groups attached to the chiral center of 2-butanol (see Fig. 1.19) are assigned these priorities: 1 for OH, 2 for CH_2CH_3, 3 for CH_3, and 4 for H. The molecule is then viewed from the side opposite the group of lowest priority (the hydrogen atom), and the arrangement of the remaining groups is noted. If, in proceeding from the group of highest priority to the group of second priority and thence to the third, the eye travels in a clockwise direction, the configuration is specified *R* (from the Latin *rectus,* “right”); if the eye travels in a counterclockwise direction, the configuration is specified *S* (from the Latin *sinister,* “left”). The complete name includes both configuration and direction of optical rotation, as for example, (*S*)-(+)-2-butanol.

The relative configurations around the chiral centers of many compounds have been established. One optically active compound is converted to another by a sequence of chemical reactions which are stereospecific; that is, each reaction is known to proceed spatially in a specific way. The configuration of one chiral compound can then be related to the configuration of the next in sequence. In order to establish absolute configuration, one must carry out sufficient stereospecific reactions to relate a new compound to another of known absolute configuration. Historically the configuration of D-(+)-2,3-dihydroxypropanal has served as the standard to which all configuration has been compared. The absolute configuration assigned to this compound has been confirmed by an X-ray crystallographic technique.

1.1.5 *Chemical Abstracts* Indexing System

When compounds of complex structure are considered, the number of name possibilities grows rapidly. To avoid having index entries for all possible names, Chemical Abstracts Service has developed what might be called the principle of inversion. The indexing system employs inverted entries to bring together related compounds in an alphabetically arranged index. The *index heading parent* from the Chemical Substance Index appears in the Formula Index in lightface before the "comma of inversion." The *substituents* follow the "comma of inversion" in alphabetical order. Any *name modification* appears on a separate line. If necessary, the chemical description is completed by citation of an associated ion, a functional derivative, a "salt with" or "compound with" term, and/or a stereochemical descriptor.

Quite naturally there is a certain amount of arbitrariness in this system, although the IUPAC nomenclature is followed. The preferred *Chemical Abstracts* index names for chemical substances have been, with very few exceptions, continued unchanged (since 1972) as set forth in the *Ninth Collective Index Guide* and in a journal article.* Any revisions appear in the updated *Index Guide;* new editions appear at 18-month intervals. Appendix VI is of particular interest to chemists. Reprints of the Appendix may be purchased from Chemical Abstracts Service, Marketing Division, P.O. Box 3012, Columbus, Ohio 43210.

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* *J. Chem. Doc.* **14**(1):3–15 (1974).

TABLE 1.13 Names and Formulas of Organic Radicals

For more comprehensive lists, see the various lists of radicals given in the subject indexes of the annual and decennial indexes of Chemical Abstracts.

Name	Formula
Acenaphthenyl	$C_{12}H_9$—
Acenaphthenylene	—$C_{12}H_8$—
Acenaphthenylidene	$C_{12}H_8$=
Acetamido	CH_3—CO—NH—
Acetimidoyl	CH_3C(=NH)—
Acetoacetyl	CH_3—CO—CH_2—CO—
Acetohydrazonoyl	CH_3—C(=NNH_2)—
Acetohydroximoyl	CH_3—C(=NOH)—
Acetonyl	CH_3—CO—CH_2—
Acetonylidene	CH_3—CO—CH=
Acetoxy	CH_3—CO—O—
Acetyl (*not ethanoyl*)	CH_3—CO—
Acetylamino	CH_3—CO—NH—
Acetylhydrazino	CH_3—CO—NH—NH—
Acetylimino	CH_3—CO—N=
Acridinyl (*from acridine*)	$NC_{13}H_8$—
Acroyloyl (*or propenoyl*)	CH_2=CH—CO—
Adipoyl (*or hexanedioyl*)	—CO—$[CH_2]_4$—CO—
Alanyl	CH_3—CH(NH_2)—CO—
β-Alanyl	H_2N—CH_2—CH_2—CO—
Allyl (*or 2-propenyl*)	CH_2=CH—CH_2—
Allylidene	CH_2=CH—CH=
Allyloxy	CH_2=CH—CH_2—O—
Amidino	H_2N—C(=NH)—
Amino	H_2N—
Aminomethyleneamino	H_2N—CH=N—
Aminooxy	H_2N—O—
Ammonio	$^{+}H_3N$—
Amyl, *see* Pentyl	
Anilino	C_6H_5—NH—
Anisidino (*o-, m-, or p-*)	CH_3O—C_6H_4—NH—
Anisoyl (*o-, m-, or p-; or methoxybenzoyl*)	CH_3O—C_6H_4—CO—
Anthraniloyl	*o*-NH_2—C_6H_4—CO—
Anthryl (*from anthracene*)	$C_{14}H_9$—
Anthrylene	—$C_{14}H_8$—
Arginyl	H_2N—C(=NH)—NH—$[CH_2]_3$—CH(NH)—CO—
Asparaginyl	H_2N—CO—CH_2—CH(NH_2)—CO—
Aspartoyl	—CO—CH_2—CH(NH_2)—CO—
α-Aspartyl	HO_2C—$CH_2CH(NH_2)$—
Atropoyl (*or 2-phenylpropenoyl*)	C_6H_5—C(=CH_2)—CO—
Azelaoyl, *see* Nonanedioyl	
Azido	N_3—
Azino	=N—N=
Azo	—N=N—
Azoxy	—N(O)—N—
Azulenyl	$C_{10}H_7$—
Benzamido	C_6H_5—CO—NH—
Benzeneazo	C_6H_5—N=N—
Benzeneazoxy	C_6H_5—N_2O—
1,2-Benzenedicarbonyl, *see* Phthaloyl	
1,3-Benzenedicarbonyl (*or isophthaloyl*)	—CO—C_6H_4—CO— (*m*-)
1,4-Benzenedicarbonyl (*or terephthaloyl*)	—CO—C_6H_4—CO— (*p*-)
Benzenesulfinyl	C_6H_5—SO—
Benzenesulfonamido	C_6H_5—SO_2—NH—
Benzenesulfonyl	C_6H_5—SO_2—
Benzenesulfonylamino	C_6H_5—SO_2—NH—
Benzenetriyl	C_6H_3—
Benzhydryl (*or diphenylmethyl*)	$(C_6H_5)_2CH$—
Benzidino	*p*-H_2N—C_6H_4—C_6H_4—NH—
Benziloyl (*or 2-hydroxy-2,2-diphenylethanoyl*)	$(C_6H_5)_2C(OH)$—CO—
Benzimidazolyl	$N_2C_7H_5$—
Benzimidoyl	C_6H_5—C(=NH)—
Benzofuranyl	OC_8H_5—
Benzopyranyl	OC_9H_7—
Benzoquinonyl (1,2- or 1,4-)	$(O{=})_2C_6H_3$—
Benzo[*b*]thienyl	SC_8H_5—
Benzoyl	C_6H_5—CO—
Benzoylamino	C_6H_5—CO—NH—
Benzoylhydrazino	C_6H_5—CO—NH—NH—
Benzoylimino	C_6H_5—CO—N=
Benzoyloxy	C_6H_5—CO—O—
Benzyl	C_6H_5—CH_2—
Benzylidene	C_6H_5—CH=
Benzylidyne	C_6H_5—C≡
Benzyloxy	C_6H_5—CH_2—O—
Benzyloxycarbonyl	C_6H_5—CH_2—O—CO—
Benzylthio	C_6H_5—CH_2—S—
Biphenylenyl	$C_{12}H_7$—
Biphenylyl	C_6H_5—C_6H_4—
Bornenyl	$C_{10}H_{15}$—
Bornyl (*not camphyl or bornylyl*)	$C_{10}H_{17}$—
Bromo	Br—
Bromoformyl	Br—CO—

TABLE 1.13 Names and Formulas of Organic Radicals (*Continued*)

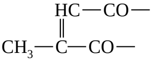
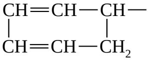
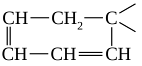
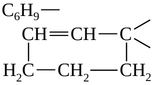
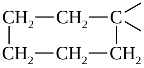
Name	Formula	Name	Formula
Bromonio	$^{+}HBr-$	Cinnamoyl (*or 3-phenylpropenoyl*)	$C_6H_5-CH=CH-CO$
Butadienyl (1,3- shown)	$CH_2=CH-CH=CH-$	Cinnamyl	$C_6H_5-CH=CH-CH_2-$
Butanedioyl, *see* Succinyl		Cinnamylidene	$C_6H_5-CH=CH-CH=$
Butanediylidene	$=CH-CH_2-CH_2-CH=$	Citraconoyl (*unsubstituted only*)	 $CH_3-\overset{\overset{\displaystyle HC-CO-}{\Vert}}{C}-CO-$
Butanediylidyne	$\equiv C-CH_2-CH_2-C\equiv$	Crotonoyl	$CH_3-CH=CH-CO-$ (*trans*)
Butanoyl, *see* Butyryl		Crotyl, *see* 2-Butenyl	
cis-Butenedioyl, *see* Maleoyl		Cumenyl (*o-, m-, or p-*)	$(CH_3)_2CH-C_6H_4-$
trans-Butenedioyl, *see* Fumaroyl Butenoyl, *see* Crotonoyl and Isocrotonoyl		Cyanato	$NCO-$
1-Butenyl	$CH_3-CH_2-CH=CH-$	Cyano	$NC-$
2-Butenyl (*not crotyl*)	$CH_3-CH=CH-CH_2-$	Cyclobutyl	C_4H_7-
2-Butenylene	$-CH_2-CH=CH-CH_2-$	Cycloheptyl	$C_7H_{13}-$
Butenylidene (*2- shown*)	$CH_3CH=CH-CH=$	Cyclohexadienyl (2,4- shown)	
Butenylidyne (*2- shown*)	$CH_3-CH=CH-C\equiv$	Cyclohexadienylidene (2,4- shown)	
Butoxy	$CH_3-[CH_2]_3-O-$	Cyclohexanecarbonyl	$C_6H_{11}-CO-$
sec-Butoxy (*unsubstituted only*)	$C_2H_5-CH(CH_3)-O-$	Cyclohexanecarbothioyl	$C_6H_{11}-CS-$
tert-Butoxy (*unsubstituted only*)	$(CH_3)_3C-O-$	Cyclohexanecarboxamido	$C_6H_{11}-CO-NH-$
Butyl	$CH_3-[CH_2]_3-$ or C_4H_9-	Cyclohexanecarboximidoyl	$C_6H_{11}-C(=NH)-$
sec-Butyl (*unsubstituted only*)	$C_2H_5-CH(CH_3)-$	Cyclohexenyl	C_6H_9-
tert-Butyl (*unsubstituted only*)	$(CH_3)_3C-$	2-Cyclohexenylidene	
Butylidene	$CH_3-CH_2-CH_2-CH=$	Cyclohexyl	$C_6H_{11}-$
sec-Butylidene (*unsubstituted only*)	$C_2H_5C(CH_3)=$	Cyclohexylcarbonyl	$C_6H_{11}-CO-$
Butylidyne	$CH_3-[CH_2]_2-C\equiv$	Cyclohexylene	$-C_6H_{10}-$
Butyryl (*or butanoyl*)	$CH_3-CH_2-CH_2-CO-$	Cyclohexylidene	
Camphoroyl	$C_{10}H_{14}O_2-$	Cyclohexylthiocarbonyl	$C_6H_{11}-CS-$
Carbamoyl	H_2N-CO-	Cyclopentadienyl	C_5H_5-
Carbazolyl	$NC_{12}H_8-$	Cyclopentadienylidene	$CH=CH-CH=CH-C=$
Carbazoyl	$H_2N-NH-CO-$	Cyclopenta[*a*]phenanthryl	$C_{17}H_{17}-$
Carbonimidoyl	$-C(=NH)-$	1,2-Cyclopentenophenanthryl	$C_{17}H_{11}-$
Carbonohydrazido (*preferred to carbohydazido or carbazido*)	$H_2N-NH-CO-NH-NH-$	Cyclopentenyl	C_5H_7-
Carbonyl	$-CO-$ or $=C(O)$	Cyclopentyl	C_5H_9-
Carbonyldioxy	$-O-CO-O-$	Cyclopentylene	$-C_5H_8-$
Carboxy	HO_2C-	Cyclopropyl	C_3H_5-
Carboxylato	$-O_2C-$	Cysteinyl	$HS-CH_2-CH(NH_2)-CO-$
Chloro	$Cl-$	Cystyl	$-CO-CH(NH_2)-CH_2-S-S-CH_2-CH(NH_2)-CO-$
Chlorocarbonyl, *see* Chloroformyl		Decanedioyl	$-CO-[CH_2]_8-CO-$
Chloroformyl	$Cl-C(O)-$	Decanoyl	$CH_3-[CH_2]_8-CO-$
Chlorosyl	$OCl-$	Decyl	$CH_3-[CH_2]_9-$
Chlorothio	$ClS-$	Diacetoxyiodo	$(CH_3-CO-O)_2I-$
Chloryl	O_2Cl-	Diacetylamino	$(CH_3-CO)_2N-$
		Diaminomethyleneamino	$(NH_2)_2C=N-$

TABLE 1.13 Names and Formulas of Organic Radicals (*Continued*)

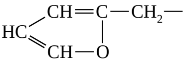
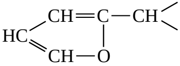
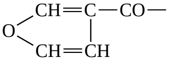
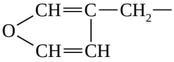
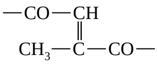
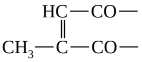
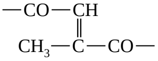
Name	Formula	Name	Formula
Diazo	$=N_2$	Fluorenyl	$C_{13}H_9{-}$
Diazoamino	${-}N{=}N{-}NH{-}$	Fluoro	$F{-}$
Dibenzoylamino	$(C_6H_5{-}CO)_2N{-}$	Fluoroformyl	$F{-}CO{-}$
Dichloroiodo	$Cl_2I{-}$	Formamido	$OCH{-}NH{-}$
Diethylamino	$(C_2H_5)_2N{-}$	Formimidoyl	$CH({=}NH){-}$
3,4-Dihydroxybenzoyl, *see* Protocatechuoyl		Formyl (*not methanoyl*)	$OCH{-}$ or ${-}C(O)H$
		Formylamino	$H{-}CO{-}NH{-}$
2,3-Dihydroxybutanedioyl, *see* Tartaroyl		Formylimino	$H{-}CO{-}N{=}$
		Formyloxy	$H{-}CO{-}O{-}$
Dihydroxyiodo	$(HO)_2I{-}$	Fumaroyl (*or* trans-*butenedioyl*)	${-}CO{-}CH{=}CH{-}CO{-}$ (*trans*)
2,3-Dihydroxypropanoyl, *see* Glyceroyl			
		Furancarbonyl, *see* Furoyl	
3,4-Dimethoxybenzoyl, *see* Veratroyl		Furfuryl (*2- only; preferred to 2-furylmethyl*)	
3,4-Dimethoxyphenethyl	3,4-$(CH_3O)_2C_6H_3CH_2CH{-}$	Furfurylidene (*2- only*)	
3,4-Dimethoxyphenylacetyl	3,4-$(CH_3O)_2C_6H_3CH_2CO{-}$		
Dimethylamino	$(CH_3)_2N{-}$	Furoyl (*3- shown; preferred to furancarbonyl*)	
Dimethylbenzoyl	$(CH_3)_2C_6H_6H_3{-}CO{-}$	Furyl	$OC_4H_3{-}$
Dioxy	${-}O{-}O{-}$	3-Furylmethyl	
Diphenylamino	$(C_6H_5)_2N{-}$		
Diphenylmethylene	$(C_6H_5)_2C{=}$		
Dithio	${-}S{-}S{-}$		
Diethiocarboxy	$HSSC{-}$	Galloyl (*or 3,4,5-trihydroxybenzoyl*)	3,4,5-$(HO)_3C_6H_2{-}CO{-}$
Dithiosulfo	$HOS_2{-}$		
Dodecanoyl	$CH_3[CH_2]_{10}{-}CO{-}$	Geranyl (*from geraniol*)	$C_{10}H_{17}{-}$
Dodecyl	$CH_3[CH_2]_{11}{-}$	Glutaminyl	$H_2N{-}CO{-}CH_2{-}CH_2{-}CH(NH_2){-}CO{-}$
Elaidoyl (*or* trans-*9-octadecenoyl*)	$CH_3[CH_2]_7CH{=}CH{-}[CH_2]_7{-}CO{-}$		
Epidioxy (as a bridge)	${-}O{-}O{-}$	Glutamoyl	${-}CO{-}CH_2{-}CH_2{-}CH(NH_2){-}CO{-}$
Epidiseleno (as bridge)	${-}Se{-}Se{-}$	α-Glutamyl	$HOOC[CH_2]_2CH(NH_2){-}CO{-}$
Epidithio (as a bridge)	${-}S{-}S{-}$		
Epimino (as a bridge)	${-}NH{-}$	γ-Glutamyl	$HOOC{-}CH(NH_2){-}[CH_2]_2{-}CO{-}$
Episeleno (as a bridge)	${-}Se{-}$		
Epithio (as a bridge)	${-}S{-}$	Glutaryl (*or pentanedioyl*)	${-}CO{-}[CH_2]_3{-}CO{-}$
Epoxy (as a bridge)	${-}O{-}$	Glyceroyl (*or 2,3-dihydroxypropanoyl*)	$HO{-}CH_2{-}CH(OH){-}CO{-}$
Ethanesulfonamide	$C_2H_5{-}SO_2{-}NH{-}$		
Ethanoyl, *see* Acetyl		Glycoloyl (*or hydroxyethanoyl*)	$HO{-}CH_2{-}CO{-}$
Ethenyl, *see* Vinyl			
Ethoxalyl	$C_2H_5{-}OOC{-}CO{-}$	Glycyl	$H_2N{-}CH_2{-}CO{-}$
Ethoxy	$C_2H_5{-}O{-}$	Glycylamino	$H_2N{-}CH_2{-}CO{-}NH{-}$
Ethoxycarbonyl	$C_2H_5{-}O{-}CO{-}$	Glyoxyloyl	$OHC{-}CO{-}$
Ethyl	$C_2H_5{-}$ or $CH_3{-}CH_2{-}$	Guanidino	$H_2N{-}C({=}NH){-}NH{-}$
Ethylamino	$C_2H_5{-}NH{-}$	Guanyl, *see* Amidino	
Ethylene	${-}CH_2{-}CH_2{-}$	Heptanamido	$CH_3{-}[CH_2]_5{-}CO{-}NH{-}$
Ethylenedioxy	${-}O{-}CH_2{-}CH_2{-}O{-}$	Heptanedioyl	${-}CO{-}[CH_2]_5{-}CO{-}$
Ethylidene	$CH_3{-}CH{=}$	Heptanoyl	$CH_3{-}[CH_2]_5{-}CO{-}$
Ethylidyne	$CH_3{-}C{\equiv}$	Heptyl	$CH_3{-}[CH_2]_5{-}CH_2{-}$
Ethylsulfonylamino	$C_2H_5{-}SO_2{-}NH{-}$	Hexadecanoyl	$CH_3{-}[CH_2]_{14}{-}CO{-}$
Ethylthio	$C_2H_5{-}S{-}$	Hexadecyl	$CH_3{-}[CH_2]_{14}{-}CH_2{-}$
Ethynyl	$HC{\equiv}C{-}$	Hexamethylene	${-}[CH_2]_6{-}$
Ethynylene	${-}C{\equiv}C{-}$	Hexanamido	$CH_3{-}[CH_2]_4{-}CO{-}NH{-}$
Fluoranthenyl	$C_{16}H_9{-}$	Hexanedioyl (*or adipoyl*)	${-}CO{-}[CH_2]_4{-}CO{-}$

TABLE 1.13 Names and Formulas of Organic Radicals (*Continued*)

Name	Formula
Hexanimidoyl	$CH_3-[CH_2]_4-C(=NH)-$
Hexanoyl	$CH_3-[CH_2]_4-CO-$
Hexanoylamino	$CH_3-[CH_2]_4-CO-NH-$
Hexyl	$CH_3-[CH_2]_4-CH_2-$
Hexylidene	$CH_3-[CH_2]_4-CH=$
Hexyloxy	$CH_3[CH_2]_5-O-$
Hippuroyl	$C_6H_5-CO-NH-CH_2-CO-$
Histidyl	$N_2C_3H_3-CH_2-CH(NH_2)-CO-$
Homocysteinyl	$HS-CH_2-CH_2-CH(NH_2)-CO-$
Homoseryl	$HO-CH_2-CH_2-CH(NH_2)-CO-$
Hydantoyl	$H_2N-CO-NH-CH_2-CO-$
Hydratropoyl (*or 2-phenylpropanoyl*)	$C_6H_5-CH(CH_3)-CO-$
Hydrazi	$-NH-NH-$ (to single atom)
Hydrazino	H_2N-NH-
Hydrazo	$-NH-NH-$ (to different atoms)
Hydrazono	$H_2N-N=$
Hydroperoxy	$HO-O-$
Hydroseleno	$HSe-$
Hydroxy	$HO-$
Hydroxyamino	$HO-NH-$
o-Hydroxybenzoyl (*or salicyloyl*)	*o*-$HO-C_6H_4-CO-$
m-Hydroxybenzoyl	*m*-$HO-C_6H_4-CO-$
p-Hydroxybenzoyl	*p*-$HO-C_6H_4-CO-$
Hydroxybutanedioyl, *see* Maloyl	
2-Hydroxy-2,2-diphenyl ethanoyl, *see* Benziloyl	
Hydroxyethanoyl, *see* Glycoloyl	
Hydroxyimino	$HO-N=$
4-Hydroxy-3-methoxybenzoyl (*or vanilloyl*)	$4\text{-}HO,3\text{-}CH_3O-C_6H_3-CO-$
3-Hydroxy-2-phenylpropanoyl (*or tropoyl*)	$C_6H_5-CH(CH_2OH)-CO-$
Hydroxypropanedioyl (*or tartronoyl*)	$-CO-CH(OH)-CO-$
2-Hydroxypropanoyl (*or lactoyl*)	$CH_3-CH(OH)-CO-$
Icosyl	$CH_3-[CH_2]_{18}-CH_2-$
Imino	$-NH-$, $HN=$
Iminomethylamino	$HN=CH-NH-$
Iodo	$I-$
Iodoformyl	$I-CO-$

Name	Formula
Iodonio	$^+HI-$
Iodosyl	$OI-$
Iodyl	O_2I-
Isobutoxy (*unsubstituted only*)	$(CH_3)_2CH-CH_2-O-$
Isobutyl (*unsubstituted only*)	$(CH_3)_2CH-CH_2-$
Isobutylidene (*unsubstituted only*)	$(CH_3)_2CH-CH=$
Isobutylidyne (*unsubstituted only*)	$(CH_3)_2CH-C\equiv$
Isobutyryl (*unsubstituted only; or 2-methylpropanoyl*)	$(CH_3)_2CH-CO-$
Isocarbonohydrazido	$H_2N-N=C(OH)-NH-NH-$
Isocrotonoyl	$CH_3-CH=CH-CO-$ (*cis*)
Isocyanato	$OCN-$
Isocyano	$CN-$
Isohexyl (*unsubstituted only*)	$(CH_3)_2CH-[CH_2]_3-$
Isoleucyl	$C_2H_5-CH(CH_3)-CH(NH_2)-CO$
Isonicotinoyl (*or 4-pyridinecarbonyl*)	NC_5H_4-CO- (4-)
Isopentyl (*unsubstituted only*)	$(CH_3)_2CH-CH_2-CH_2-$
Isophthaloyl (*or 1,3-benzenedicarbonyl*)	$-CO-C_6H_4-CO-$ (*m*-)
Isopropenyl (*unsubstituted only; or 1-methylvinyl*)	$CH_2=C(CH_3)-$
Isopropoxy (*unsubstituted only*)	$(CH_3)_2CH-O-$
Isopropyl (*unsubstituted only*)	$(CH_3)_2CH-$
p-Isopropylbenzoyl	*p*-$(CH_3)_2CH-C_6H_4-CO-$
Isopropylbenzyl	$(CH_3)_2CH-C_6H_4-CH_2-$
Isopropylidene	$(CH_3)_2C=$
Isoselenocyanato	$SeCN-$
Isosemicarbazido	$H_2N-NH-C(OH)=N-$
Isothiocyanato	$SCN-$
Isothioureido	$HN=C(SH)-NH-$, $H_2N-C(SH)=N-$
Isoureido	$HN=C(OH)-NH-$, $H_2N-C(OH)=N-$
Isovaleryl (*unsubstituted only; or 3-methylbutanoyl*)	$(CH_3)_2CH-CH_2-CO-$
Lactoyl	$CH_3-CH(OH)-CO-$
Lauroyl (*unsubstituted only*)	$CH_3-[CH_2]_{10}-CO-$

TABLE 1.13 Names and Formulas of Organic Radicals (*Continued*)

Name	Formula
Leucyl	$(CH_3)_2CH-CH_2-CH(NH_2)-CO-$
Lysyl	$H_2N-[CH_2]_4-CH(NH_2)-CO-$
Maleoyl	$-CO-CH=CH-CO-$
Malonyl	$-CO-CH_2-CO-$
Maloyl	$-CO-CH(OH)-CH_2-CO-$
Mercapto-	$HS-$
Mesaconoyl (*unsubstituted only*)	 $\begin{array}{l} -CO-CH \\ \qquad\quad \Vert \\ CH_3-C-CO- \end{array}$
Mesityl	$2,4,6\text{-}(CH_3)_3C_6H_2-$
Mesoxalo	$HOOC-CO-CO-$
Mesoxalyl	$-CO-CO-CO-$
Mesyl	CH_3-SO_2-
Methacryloyl (*or 2-methylpropenoyl*)	$CH_2=C(CH_3)-CO-$
Methaneazo	$CH_3-N=N-$
Methaneazoxy	CH_3-N_2O-
Methanesulfinamido	$CH_3-SO-NH-$
Methanesulfinyl	CH_3-SO-
Methanesulfonamido	CH_3-SO_2-NH-
Methanesulfonyl, *see* Mesyl	
Methanoyl, *see* Formyl	
Methionyl	$CH_3-S-CH_2-CH_2-CH(NH_2)-CO-$
Methoxalyl	$CH_3OOC-CO-$
Methoxy	CH_3O-
Methoxybenzoyl (*o-, m-, or p-*)	$CH_3O-C_6H_4-CO-$
Methoxycarbonyl	CH_3O-CO-
Methoxyimino	$CH_3O-N=$
Methoxyphenyl	$CH_3O-C_6H_4-$
Methoxysulfinyl	CH_3O-SO-
Methoxysulfonyl	CH_3O-SO_2-
Methoxy(thiosulfonyl)	CH_3O-S_2O-
Methyl	CH_3-
Methylallyl	$CH_2=C(CH_3)-CH_2-$
Methylamino	CH_3-NH-
Methylazo	$CH_3-N=N-$
Methylazoxy	CH_3-N_2O-
α-Methylbenzyl	$C_6H_5-CH(CH_3)-$
Methylbenzyl	$CH_3-C_6H_4-CH_2-$
3-Methylbutanoyl	$(CH_3)_2CH-CH_2-CO-$
cis-Methylbutenedioyl	 $\begin{array}{l} \qquad\ HC-CO- \\ \qquad\quad \Vert \\ CH_3-C-CO- \end{array}$
trans-Methylbutenedioyl	 $\begin{array}{l} -CO-CH \\ \qquad\quad \Vert \\ CH_3-C-CO- \end{array}$
Methyldithio	CH_3-S-S-
Methylene	$-CH_2-$, $H_2C=$
Methylenedioxy	$-O-CH_2-O-$
3,4-Methylenedioxybenzoyl	$3,4\text{-}CH_2O_2{:}C_6H_3-CO-$

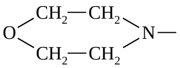
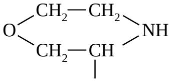
Name	Formula
5-Methylhexyl	$(CH_3)_2CH-[CH_2]_4-$
Methylidyne	$HC\equiv$
Methylsulfinimidoyl	$CH_3-S(=NH)-$
Methylsulfinohydrazonoyl	$CH_3-S(=NNH_2)-$
Methylsulfinohydroximoyl	$CH_3-S(=N-OH)-$
Methylsulfinyl	CH_3-SO-
Methylsulfinylamino	$CH_3-SO-NH-$
Methylsulfonohydrazonoyl	$CH_3-S(O)(NNH_2)-$
Methylsulfonimidoyl	$CH_3-S(O)(=NH)-$
Methylsulfonohydroxamoyl	$CH_3-S(O)(N-OH)-$
Methylsulfonyl	CH_3-SO_2-
Methylthio	CH_3S-
(Methylthio)sulfonyl	CH_3S-SO_2-
1-Methylvinyl, *see* Isopropenyl	
Morpholino (*4- only*)	
Morpholinyl (*3- shown*)	
Myristoyl (*unsubstituted only*)	$CH_3-[CH_2]_{12}-CO-$
Naphthalenazo	$C_{10}H_7-N=N-$
Naphthalenecarbonyl, *see* Naphthoyl	
Naphthoyl	$C_{10}H_7-CO-$
Naphthoyloxy	$C_{10}H_7-CO-O-$
Naphthyl	$C_{10}H_7-$
Naphthylazo	$C_{10}H_7-N=N-$
Naphthylene	$-C_{10}H_6-$
Naphthylenebisazo	$-N=N-C_{10}H_6-N=N-$
Naphthyloxy	$C_{10}H_7-O-$
Neopentyl (*unsubstituted only*)	$(CH_3)_3C-CH_2-$
Nicotinoyl	NC_5H_4-CO- (3-)
Nitrilo	$N\equiv$
Nitro	O_2N-
aci-Nitro	$HO-(O=)N=$
Nitroso	$ON-$
Nonanedioyl	$-CO-[CH_2]_7-CO-$
Nonanoyl	$CH_3-[CH_2]_7-CO-$
Nonyl	$CH_3-[CH_2]_7-CH_2-$
Norbornyl	$C_7H_{11}-$
Norbornylyl, *see* Norbornyl	
Norcamphyl, *see* Norbornyl	
Norleucyl	$CH_3-[CH_2]_3-CH(NH_2)-CO-$
Norvalyl	$CH_3-CH_2-CH_2-CH(NH_2)-CO-$
Octadecanoyl	$CH_3-[CH_2]_{16}-CO-$

TABLE 1.13 Names and Formulas of Organic Radicals (*Continued*)

Name	Formula
cis-9-Octadecenoyl	H$[CH_2]_8$—CH═CH—$[CH_2]_7$—CO—
Octadecyl	CH_3—$[CH_2]_{16}$—CH_2—
Octanedioyl	—CO—$[CH_2]_6$—CO—
Octanoyl	CH_3—$[CH_2]_6$—CO—
Octyl	CH_3—$[CH_2]_6$—CH_2—
Oleoyl	H$[CH_2]_8$—CH═CH—$[CH_2]_7$—CO—
Ornithyl	H_2N—$[CH_2]_3$—CH(NH_2)—CO—
Oxalacetyl	—CO—CH_2—CO—CO—
Oxalaceto	HOOC—CO—CH_2—CO—
Oxalo	HOOC—CO—
Oxalyl	—CO—CO—
Oxamoyl	H_2N—CO—CO—
Oxido	$^-$O— (ion)
Oxo	O═
Oxonio	^+H_2O—
Oxy	—O—
Palmitoyl (*unsubstituted only*)	CH_3—$[CH_2]_{14}$—CO—
Pentafluorothio	F_5S—
Pentamethylene	—CH_2—CH_2—CH_2—CH_2—CH_2—
Pentanedioyl, *see* Glutaryl	
Pentanoyl, *see* Valeryl	
Pentenyl (*2- shown*)	CH_3—CH_2—CH═CH—CH_2—
Pentyl	CH_3—CH_2—CH_2—CH_2—CH_2—
Pentyloxy	CH_3—$[CH_2]_4$—O—
Perchloryl	O_3Cl—
Phenacyl	C_6H_5—CO—CH_2—
Phenacylidene	C_6H_5—CO—CH═
Phenanthryl	$C_{14}H_9$—
Phenethyl	C_6H_5—CH_2—CH_2—
Phenetidino (*o-, m-, or p-*)	C_2H_5O—C_6H_4—NH—
Phenoxy	C_6H_5—O—
Phenyl	C_6H_5—
Phenylacetyl	C_6H_5—CH_2—CO—
Phenylazo	C_6H_5—N═N—
Phenylazoxy	C_6H_5—N_2O—
Phenylcarbamoyl	C_6H_5—NH—CO
Phenylene	—C_6H_4—
Phenylenebisazo	—N═N—C_6H_4—N═N—
Phenylimino	C_6H_5—N═
2-Phenylpropanoyl	C_6H_5—CH(CH_3)—CO—
3-Phenylpropenoyl, *see* Cinnamoyl	
3-Phenylpropyl	C_6H_5—CH_2—CH_2—CH_2—
Phenylsulfamoyl	C_6H_5—NH—SO_2
Phenylsulfinyl	C_6H_5—SO—
Phenylsulfonyl	C_6H_5—SO_2—
Phenylsulfonylamino	C_6H_5—SO_2—NH—
Phenylthio	C_6H_5—S—
3-Phenylureido	C_6H_5—NH—CO—NH—
Phthalamoyl	H_2N—CO—C_6H_4—CO— (*o*-)
Phthalidyl	C_6H_4—CO—O—CH—
Phthalimido	CO—C_6H_4—CO—N—
Phthaloyl	—CO—C_6H_4—CO— (*o*-)
Picryl	2,4,6-$(NO_2)_3C_6H_2$—
Pimeloyl (*unsubstituted only*)	—CO—$[CH_2]_5$—CO—
Piperidino (*1- only*)	$C_5H_{10}N$—
Piperidyl (*2-, 3-, 4-*)	NC_5H_{10}—
Piperonyl	3,4-CH_2O_2:C_6H_3—CH_2—
Pivaloyl (*unsubstituted only*)	$(CH_3)_3C$—CO—
Polythio	—S_4—
Propanedioyl, *see* Malonyl	
Propanoyl, *see* Propionyl	
Propargyl, *see* 2-Propynyl	
Propenoyl, *see* Acryloyl	
1-Propenyl	CH_3—CH═CH—
2-Propenyl, *see* Allyl	
Propenylene	—CH_2—CH═CH—
Propioloyl	CH≡C—CO—
Propionamido	CH_3—CH_2—CO—NH—
Propionyl	CH_3—CH_2—CO—
Propionylamino	CH_3—CH_2—CO—NH—
Propionyloxy	CH_3—CH_2—CO—O—
Propoxy	CH_3—CH_2—CH_2—O
Propyl	CH_3—CH_2—CH_2—
Propylene	—CH(CH_3)—CH_2—
Propylidene	CH_3—CH_2—CH═
Propylidyne	CH_3—CH_2—C≡
Propynoyl, *see* Propiolyl	
1-Propynyl	CH_3—C≡C—
2-Propynyl	HC≡C—CH_2—
Protocatechuoyl	3,4-$(HO)_2C_6H_3$—CO—
3-Pyridinecarbonyl	NC_5H_4—CO— (3-)
4-Pyridinecarbonyl	NC_5H_4—CO— (4-)
Pyridinio	$^+NC_5H_5$— (ion)
Pyridyl	NC_5H_4—
2-Pyridylcarbonyl	NC_5H_4—CO— (2-)
Pyridyloxy	NC_5H_4—O—
Pyruvoyl	CH_3—CO—CO—
Salicyl	*o*-HO—C_6H_4—CH_2—
Salicylidene	*o*-HO—C_6H_4—CH═
Salicyloyl	*o*-HO—C_6H_4—CO—
Sarcosyl	CH_3—NH—CH_2—CO—

TABLE 1.13 Names and Formulas of Organic Radicals (*Continued*)

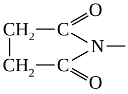
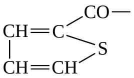
Name	Formula
Sebacoyl (*unsubstituted only*)	$-CO-[CH_2]_8-CO-$
Seleneno	$HOSe-$
Selenino	HO_2Se-
Seleninyl	$OSe=$
Seleno	$-Se-$
Selenocyanato	$NC-Se-$
Selenoformyl	$HSeC-$
Selenonio	$^+H_2Se-$ (ion)
Selenono	HO_3Se-
Selenonyl	O_2Se-
Selenoureido	$H_2N-CSe-NH-$
Selenoxo	$(C)=Se$
Semicarbazido	$H_2N-CO-NH-NH-$
Semicarbazono	$H_2N-CO-NH-N=$
Seryl	$HO-CH_2-CH(NH_2)-CO-$
Stearoyl (*unsubstituted only*)	$CH_3-[CH_2]_{16}-CO-$
Styryl	$C_6H_5-CH=CH-$
Suberoyl (*unsubstituted only*)	$-CO-[CH_2]_6-CO-$
Succinamoyl	$H_2N-CO-CH_2-CH_2-CO-$
Succinimido	
Succinimidoyl	$-C(=NH)-CH_2-CH_2C(=NH)-$
Succinyl	$-CO-CH_2-CH_2-CO-$
Sulfamoyl	H_2N-SO_2-
Sulfanilamido	p-$H_2N-C_6H_4-SO_2-NH-$
Sulfanilyl	p-$H_2N-C_6H_4-SO_2-$
Sulfenamoyl	H_2N-S-
Sulfeno	$HO-S-$
Sulfido	$^-S-$ (ion)
Sulfinamoyl	H_2N-SO-
Sulfino	HO_2S-
Sulfinyl	$-SO-$
Sulfo	$HO-SO_2-$
Sulfoamino	HO_2S-NH-
Sulfonato	$^-O_3S-$ (ion)
Sulfonio	$^+H_2S-$ (ion)
Sulfonyl	$-SO_2-$
Sulfonyldioxy	$-O-SO_2-O-$
Tartaroyl	$-CO-CH(OH)-CH(OH)-CO-$
Tartronoyl	$-CO-CH(OH)-CO-$
Tauryl	$H_2N-CH_2-CH_2-SO_2-$
Telluro	Te replacing O
Terephthaloyl	$-CO-C_6H_4-CO-$ (*p*-)
Terphenylyl	$C_6H_5-C_6H_4-C_6H_4-$
(Terthiophen)yl	$SC_4H_3-SC_4H_2-SC_4H_2-$
Tetradecanoyl	$CH_3-[CH_2]_{12}-CO-$
Tetradecyl	$CH_3-[CH_2]_{12}-CH_2-$
Tetramethylene	$-CH_2-CH_2-CH_2-CH_2-$
Thenoyl (*2- shown*)	
Thenyl	$SC_4H_3-CH_2-$
Thienyl	SC_4H_3-
Thio	$-S-$
Thioacetyl	CH_3-CS-
Thiobenzoyl	C_6H_5-CS-
Thiocarbamoyl	H_2N-CS-
Thiocarbazono	$HN=N-CS-NH-NH-$
Thiocarbodiazono	$HN=N-CS-N=N-$
Thiocarbonohydrazido	$H_2N-NH-CS-NH-NH-$
Thiocarbonyl	$-CS-$, $SC=$
Thiocarboxy	$HSOC-$, $HS-CO-$
Thiocyanato	$NCS-$
Thioformyl	$SHC-$, $HCS-$
Thiophenecarbonyl, *see* Thenoyl	
Thiosemicarbazido	$H_2N-CS-NH-NH-$
Thiosulfino	HOS_2-
Thiosulfo	HO_2S_2-
Thioreido	$H_2N-CS-NH-$
Thioxo	$S=$
Threonyl	$CH_3-CH(OH)-CH(NH_2)-CO-$
Toluenesulfonyl (*o*-, *m*-)	$CH_3-C_6H_4-SO_2-$
Toluidino (*o*-, *m*-, *or p*-)	$CH_3-C_6H_4-NH-$
Toluoyl (*o*-, *m*-, *or p*-)	$CH_3-C_6H_4-CO-$
Tolyl (*o*-, *m*-, *or p*-)	$CH_3-C_6H_4-$
Tolylsulfonyl	$CH_3-C_6H_4-SO_2-$
Tosyl (*p- only*)	p-$CH_3-C_6H_4-SO_2-$
Triazano	$H_2N-NH-NH-$
Triazeno	$H_2N-N=N-$
Trichlorothio	Cl_3S-
Tridecanoyl	$CH_3-[CH_2]_{11}-CO-$
Tridecyl	$CH_3-[CH_2]_{12}-$
Trifluorothio	F_3S-
3,4,5-Trihydroxybenzoyl	3,4,5-$(HO)_3C_6H_2-CO-$
Trimethylammonio	$(CH_3)_3N^+-$ (ion)
Trimethylanilino (*all isomers*)	$(CH_3)_3C_6H_2-NH-$
Trimethylene	$-CH_2-CH_2-CH_2-$
Trimethylenedioxy	$-O-CH_2-CH_2-CH_2-O-$
Triphenylmethyl	$(C_6H_5)_3C-$
Trithio	$-S_3-$
Trithiosulfo	$HS-S_3-$

TABLE 1.13 Names and Formulas of Organic Radicals (*Continued*)

Name	Formula	Name	Formula
Trityl	$(C_6H_5)_3C$—	Vanilloyl	3,4-$CH_3O(HO)C_6H_3$—CO—
Tropoyl	C_6H_5—CH(CH_2OH)—CO—	Vanillyl	3,4-$CH_3O(HO)C_6H_3$—CH_2—
Tyrosyl	*p*-HO—C_6H_4—CH_2—CH(NH_2)—CO—	Veratroyl	3,4-$(CH_3O)_2C_6H_3$—CO—
Undecanoyl	CH_3—$[CH_2]_9$—CO—	Veratryl	3,4-$(CH_3O)_2C_6H_2$—CH_2—
Undecyl	CH_3—$[CH_2]_9$—CH_2—	Vinyl	$CH_2{=}CH$—
Ureido	H_2N—CO—NH—	Vinylene	—$CH{=}CH$—
Ureylene	—NH—CO—NH—	Xylidino (*all isomers*)	$(CH_3)_2C_6H_3$—NH—
Valeryl	CH_3—$[CH_2]_3$—CO—	Xylyl (*all isomers*)	$(CH_3)_2C_6H_3$—
Valyl	$(CH_3)_2CH$—CH(NH_2)—CO—		

1.2 PHYSICAL PROPERTIES OF PURE SUBSTANCES

TABLE 1.14 Empirical Formula Index of Organic Compounds

The alphanumeric designations are keyed to Table 1.15.

Br_2OS: t149
$ClHO_3S$: c248
ClH_4NO: h139
Cl_2OS: t150
Cl_2H_2Si: d270a
Cl_3HSi: t249
Cl_3PS: t158
H_3NO_3S: s23
H_4N_2: h85
H_6Si_2: d791

C_1

CBr_4: c13
$CBrClF_2$: b301
$CBrCl_3$: b432
$CBrF_3$: b434
CBrN: c325
CBr_2F_2: d93
CBr_4: c13
$CClF_3$: c264
$CClNO_3S$: c249
CCl_2F_2: d218
CCl_3D: c146
CCl_3F: t237
CCl_4: c14
CCl_4S: t240
CD_2Cl_2: d236
CD_4O: m36
CD_7O: m40
$CFCl_3$: f30
CF_4: c15
$CHBrCl_2$: b316
$CHBr_2Cl$: d88
$CHBr_2F$: d104a
$CHBr_3$: t204
$CHClF_2$: c101
$CHCl_2F$: d233
$CHCl_3$: c145
CHF_3: t307
CHF_3O_3S: t308
CHI_3: i33
CH_2BrCl: b305
CH_2Br_2: d110
CH_2Cl_2: d235
CH_2F_2: d409
CH_2I_2: d452
CH_2N_2: c318, d63
CH_2N_4: t131
CH_2O: f32
$(CH_2O)_x$: p1
CH_2O_2: f36
CH_2O_3: g29
CH_2S_3: t451
CH_3Br: b354
CH_3Br_3Ge: m260
CH_3Cl: c157
CH_3ClO_2S: m36
CH_3Cl_3Si: m450, t242
CH_3DO: m39
CH_3F: f18
CH_3I: i37
CH_3NO: f33
CH_3NO_2: m325, n56
CH_3NO_3: m324
CH_3N_5: a294
CH_4: m33
CH_4Cl_2Si: d240
CH_4N_2O: f38, u16
CH_4N_2S: t161
$CH_4N_4O_2$: n54
CH_4O: m38
$^{13}CH_4O$: m41
CH_4O_2: m279
CH_4O_3S: m34
CH_4S: m37
CH_5AsO_3: m137
CH_5N: m127
CH_5NO_3S: a201
CH_5N_3: g30
CH_5N_3S: t160
CH_6ClN_3O: s3
CH_6N_2: m274
CH_6N_4: a180
CH_6N_4O: c9
CI_4: c16
CN_4O_8: t123
CS_2: c10
CO: c11
COS: c12

C_2

$C_2Br_2ClF_3$: d90
$C_2Br_2Cl_4$: d129
$C_2Br_2F_4$: d130
$C_2Br_2O_2$: o54
C_2ClF_3: c263
$C_2Cl_2F_4$: d270b, d271
$C_2Cl_2O_2$: o55
$C_2Cl_3F_3$: t256, t257
C_2Cl_3N: t222

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

C_2Cl_4: t38
$C_2Cl_4F_2$: d411, d412, t36
C_2Cl_4O: t224
C_2Cl_6: h27
C_2D_3N: a30
$C_2D_4O_2$: a21
C_2D_6OS: d698
C_2F_4: t65
C_2F_6: h42
$C_2F_6O_5S_2$: t309
$C_2HBrClF_3$: b308
$C_2HBr_2F_3$: d133
C_2HBr_2N: d77
C_2HBr_3: t203
C_2HBr_3O: t199
$C_2HBr_3O_2$: t200
C_2HClF_2: c100a
$C_2HClF_2O_2$: c98
C_2HCl_3: t235
C_2HCl_3O: d186, t218
$C_2HCl_3O_2$: t219
C_2HCl_5: p7
$C_2HF_3O_2$: t300
C_2H_2: a41
C_2H_2BrClO: b255
$C_2H_2Br_2$: d99, d100
$C_2H_2Br_2F_2$: d92
$C_2H_2Br_2O$: b254
$C_2H_2Br_2O_2$: d76
$C_2H_2Br_4$: t16
$C_2H_2ClF_3$: c262
C_2H_2ClN: c30
$C_2H_2Cl_2$: d227, d228, d229
$C_2H_2Cl_2O$: c34
$C_2H_2Cl_2O_2$: d182
$C_2H_2Cl_3NO$: t217
$C_2H_2Cl_4$: t36a, t37
$C_2H_2F_2$: d408
$C_2H_2F_3NO$: t299
$C_2H_2F_4$: t64
$C_2H_2N_2S_3$: d488
C_2H_2O: k1
$C_2H_2O_2$: g28
$C_2H_2O_3$: g29
$C_2H_2O_4$: o52, o53
C_2H_3Br: b336
C_2H_3BrO: a35
$C_2H_3BrO_2$: b249
$C_2H_3Br_2Cl_3Si$: d101
$C_2H_3Br_3O$: t202
C_2H_3Cl: c129
$C_2H_3ClF_2$: c100
C_2H_3ClO: a37, c23a
$C_2H_3ClO_2$: c27, m194
$C_2H_3Cl_3$: t231, t232
$C_2H_3Cl_3O$: t233
$C_2H_3Cl_3Si$: t258
$C_2H_3DO_2$: a20
C_2H_3FO: a43
$C_2H_3FO_2$: f5
$C_2H_3F_3O$: t305
$C_2H_3F_3O_3S$: m453
C_2H_3IO: a48
$C_2H_3IO_2$: i21
C_2H_3N: a29
C_2H_3NO: m288
C_2H_3NS: m294, m440
$C_2H_3N_3$: t197
$C_2H_3N_3S_2$: a284
C_2H_4: e131
C_2H_4BrCl: b303
C_2H_4BrNO: b247
$C_2H_4Br_2$: d96, d97
C_2H_4ClNO: c24
C_2H_4ClO: b165a
$C_2H_4Cl_2$: d225, d226
$C_2H_4Cl_2O$: d237
$C_2H_4Cl_6Si_2$: b227
$C_2H_4F_2$: d407
C_2H_4INO: i20
$C_2H_4I_2$: d451
$C_2H_4N_2$: a109
$C_2H_4N_2O_2$: o58
$C_2H_4N_2S_2$: d795
$C_2H_4N_4$: a289, d281
$C_2H_4N_4O_2$: a314
C_2H_4O: e147
C_2H_4OS: t147
$C_2H_4O_2$: a19, h87, m257
$C_2H_4O_2S$: m16
$C_2H_4O_3$: h88, p60
$C_2H_4O_5S$: s26
C_2H_4S: e148
$C_2H_5AlCl_2$: e61
C_2H_5Br: b329
$C_2H_5BrNaO_2S$: b330
C_2H_5BrO: b331, b369
C_2H_5Cl: c121
C_2H_5ClHg: e198
C_2H_5ClO: c122, c156, c173
C_2H_5ClS: c174
$C_2H_5Cl_2OPS$: e124
$C_2H_5Cl_2O_2P$: e123
$C_2H_5Cl_3Si$: c171, e269, t236
C_2H_5DO: e28
C_2H_5F: f17
C_2H_5I: i31
C_2H_5IO: i32
C_2H_5N: e146
C_2H_5NO: a5, a6, m255, m291
$C_2H_5NO_2$: e225, g26, m187, n52
$C_2H_5NO_3$: e224
C_2H_5NS: t138
$C_2H_5N_3O_2$: b238, o57
C_2H_6: e20
C_2H_6AlCl: d533
C_2H_6BrN: b333
C_2H_6Cd: d578
C_2H_6ClN: c126
$C_2H_6ClNO_2S$: d692
$C_2H_6ClO_2PS$: d582
$C_2H_6Cl_2Si$: d222
C_2H_6Hg: d631
$C_2H_6N_2$: a8
$C_2H_6N_2O$: m460, n78
$C_2H_6N_2O_2$: m275
$C_2H_6N_2S$: m444
$C_2H_6N_4O$: o56
C_2H_6O: d603, e27
C_2H_6OS: d697, m20
$C_2H_6O_2$: e21a, e135
$C_2H_6O_2S$: d696
$C_2H_6O_3S$: d695, e25, m301
$C_2H_6O_4S$: d693
$C_2H_6O_5S_2$: m35
C_2H_6S: d694, e26a
$C_2H_6S_2$: d600, e24
C_2H_6Te: d700
C_2H_6Zn: d709
$C_2H_7AsO_2$: d560
C_2H_7ClSi: c111
C_2H_7N: d534, e63
C_2H_7NO: a162, a163, e29
$C_2H_7NO_3S$: a160
$C_2H_7NO_4S$: a169
C_2H_7NS: a161
$C_2H_7N_5$: b137
$C_2H_7O_3P$: d625
$C_2H_8N_2$: d623, d624, e21, e133
$C_2H_8N_2O$: h125
C_2H_9BD: b243
$C_2H_{10}BN$: b242

C_3

$C_3Br_2F_5$: d105
$C_3Cl_3N_3$: t255
$C_3Cl_3N_3O_3$: t239
C_3Cl_6: h30
C_3Cl_6O: a27, h2
C_3F_6: h44
C_3HCl_5O: p5
C_3H_2ClN: c35
$C_3H_2Cl_2O_2$: m6

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_3H_2Cl_4O$: t31
$C_3H_2Cl_4O_2$: t234
$C_3H_2F_6O$: h43
$C_3H_2N_2$: m5
$C_3H_2O_2$: p248
C_3H_3Br: b415
$C_3H_3Br_2N$: d126
C_3H_3Cl: c241
C_3H_3ClO: a63a
$C_3H_3Cl_3O$: e18, t221
$C_3H_3Cl_3O_2$: m449
$C_3H_3F_3O$: t302
$C_3H_3F_3O_2$: m452
C_3H_3N: a63
$C_3H_3NOS_2$: r7
$C_3H_3NO_2$: c320
C_3H_3NS: t136
$C_3H_3N_3O_2S$: a244
$C_3H_3N_3O_3$: a289, c332
C_3H_4: a72, p246
C_3H_4BrClO: b410, b411
C_3H_4BrN: b408
$C_3H_4Br_2$: d124
$C_3H_4Br_2O$: b409
$C_3H_4Br_2O_2$: d125
C_3H_4ClN: c233
$C_3H_4Cl_2$: d265, d266
$C_3H_4Cl_2O$: c235, c236, d183, d184
$C_3H_4Cl_2O_2$: m227
$C_3H_4F_4O$: t66
$C_3H_4N_2$: i3, m241, p254
$C_3H_4N_2O$: c287
$C_3H_4N_2O_2$: h84
$C_3H_4N_2S$: a285
$C_3H_4N_3NaS$: c326
C_3H_4O: p203, p249
$C_3H_4O_2$: a62, o64
$C_3H_4O_3$: e132, o65, p210
$C_3H_4O_4$: m3
C_3H_5Br: b314, b404, b405
C_3H_5BrO: b328, b403
$C_3H_5BrO_2$: b406, b407, m143
$C_3H_5Br_3$: t206
C_3H_5Cl: c236a
C_3H_5ClO: c120, c232, p216
$C_3H_5ClO_2$: c228, c229, e109, m188
$C_3H_5Cl_3$: t247
$C_3H_5Cl_3Si$: a98
$C_3H_5F_3O_3S$: m453
C_3H_5I: a87, i50
C_3H_5N: p215
C_3H_5NO: c323, h172, h173, v11
$C_3H_5NO_2$: o59
C_3H_5NS: e193, m435
$C_3H_5NS_2$: m26
$C_3H_5N_3O$: c321
$C_3H_5N_3O_9$: g22
$C_3H_5N_3S$: c293
C_3H_6: c406, p204
C_3H_6BrCl: b307
$C_3H_6BrNO_3$: b381
$C_3H_6Br_2$: d120, d121
$C_3H_6Br_2O$: d122, d123
C_3H_6ClI: c155
C_3H_6ClNO: d578
$C_3H_6Cl_2$: d262, d263
$C_3H_6Cl_2N_2O_2$: d173
$C_3H_6Cl_2O$: d231, d264
$C_3H_6Cl_2Si$: d241
$C_3H_6Cl_4Si$: t230
$C_3H_6I_2$: d454
C_3H_6NO: a61
$C_3H_6N_2$: d583
$C_3H_6N_2O$: i5
$C_3H_6N_2O_3$: m4
$C_3H_6N_2OS$: a58
$C_3H_6N_2O_2$: m4, m270
$C_3H_6N_2S$: a286, i4
C_3H_6O: a26, a78, e15, m462, p211, p232
C_3H_6OS: t159
$C_3H_6O_2$: d734, e16, e154, h90, m122, p213
$C_3H_6O_2S$: m22, m23, m298
$C_3H_6O_3$: d445, d580, L1, L2, m43, m265, t407
$C_3H_6O_3S$: p197
C_3H_6S: p205, p233
$C_3H_6S_3$: t450
C_3H_7Br: b400, b401
C_3H_7BrO: b402
C_3H_7Cl: c172, c225, c226
C_3H_7ClO: c132, c153, c230, c231
C_3H_7ClOS: c156
$C_3H_7ClO_2$: c227
$C_3H_7ClO_2S$: p196
$C_3H_7Cl_2OP$: p241
$C_3H_7Cl_3Si$: d214, p242
C_3H_7I: i48, i49
C_3H_7N: a76, p231
C_3H_7NO: a28, d606, m120, p212
$C_3H_7NO_2$: a68, a69, a70, e102, i125, m264, n73, n74
$C_3H_7NO_2S$: c411
$C_3H_7NO_3$: i124, n75, p238, s4
C_3H_7NS: d704
C_3H_8: p188
$C_3H_8BrClSi$: b366
C_3H_8ClN: c225
$C_3H_8Cl_2Si$: c88, d232
$C_3H_8N_2O$: d708, e274
$C_3H_8N_2O_2$: e103
$C_3H_8N_2S$: d705
C_3H_8O: e10, e210, p201, p202
$C_3H_8OS_2$: d485, m315
$C_3H_8O_2$: d507, m71, p191, p192
$C_3H_8O_2S$: m21
$C_3H_8O_3$: g19
C_3H_8S: e221, p198, p199
$C_3H_8S_2$: p195
C_3H_9Al: t352
$C_3H_9BO_3$: t338
$C_3H_9B_3O_6$: t339
C_3H_9BrGe: b437
C_3H_9BrSi: b438
C_3H_9ClGe: c265
C_3H_9ClSi: c266
C_3H_9IOS: t400
C_3H_9IS: t399
C_3H_9ISi: i56
C_3H_9N: i100, p223, t354
C_3H_9NO: a263, a264, a265, a266, m77, m131
$C_3H_9NO_2$: a262
$C_3H_9N_3Si$: a309
$C_3H_9O_3P$: d635, t390
$C_3H_9O_4P$: t389
$C_3H_{10}N_2$: d54, d55, m254, p189, p190
$C_3H_{10}N_2O$: d56
$C_3H_{10}O_3Si$: t343
$C_3H_{11}Br_2N_3S$: a171

C_4

C_4Cl_6: h23
$C_4Cl_6O_3$: t220
$C_4D_6O_3$: a23
$C_4F_6O_3$: t301
C_4HBrO_3: b352
$C_4HCl_3N_2$: t248
$C_4HF_7O_2$: h2
C_4H_2: b452
$C_4H_2Br_2S$: d131
$C_4H_2Cl_2N_2$: d267
$C_4H_2Cl_2O_2$: f43
$C_4H_2Cl_2S$: d272
$C_4H_2F_6O_2$: t306
$C_4H_2O_3$: m2

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_4H_2O_4$: q42
C_4H_3IS: i52
$C_4H_3N_3O_4$: n88
C_4H_4: b489
$C_4H_4BrNO_2$: b422
$C_4H_4Br_2O_2$: d86
$C_4H_4Br_2O_4$: d128
$C_4H_4ClNO_2$: c247
$C_4H_4ClO_3$: c28
$C_4H_4Cl_2$: d213
$C_4H_4Cl_2O_2$: s19
$C_4H_4Cl_2O_3$: c25
$C_4H_4N_2$: b456, p251, p256, p277, s18
$C_4H_4N_2O_2$: d448, p278
$C_4H_4N_2O_2S$: d437
$C_4H_4N_2O_3$: b1
$C_4H_4N_2O_5$: a73
$C_4H_4N_4$: d50
C_4H_4O: f45
$C_4H_4O_2$: d483
$C_4H_4O_3$: s16
$C_4H_4O_4$: f42, m1
C_4H_4S: t151
$C_4H_5BrO_2$: b283
$C_4H_5BrO_4$: b421
C_4H_5Cl: c74, c74a, c83
$C_4H_5ClN_2O_2$: c184
C_4H_5ClO: c310, c408, m31
$C_4H_5ClO_2$: a82
$C_4H_5ClO_3$: c194, e232
$C_4H_5Cl_3O_2$: e268
C_4H_5N: b482, c309, c407, m30a, p279
C_4H_5NO: m47, m295
$C_4H_5NO_2$: m201, s17
$C_4H_5NO_2S$: e39
$C_4H_5NO_3$: h183
C_4H_5NS: a88, m432
$C_4H_5N_3$: a278, i8
$C_4H_5N_3O$: a194
$C_4H_5N_3OS$: a187
$C_4H_5N_3O_2$: a152, a153, c322, m338
$C_4H_5N_4O$: d49
C_4H_6: b448, b449, b610a, b610b
$C_4H_6Br_2O$: b374
$C_4H_6Br_2N_2O_2$: d95
$C_4H_6Br_2O_2$: d87
C_4H_6ClN: c86
$C_4H_6Cl_2$: c89, d211, d212
$C_4H_6Cl_2O$: c87
$C_4H_6Cl_2O_2$: m229
$C_4H_6Cl_3NSi$: t250
$C_4H_6N_2$: a149, m284, m285, m286
$C_4H_6N_2O_2$: e121, m273
$C_4H_6N_2S$: a225
$C_4H_6N_2S_2$: d584
$C_4H_6N_4O$: d39
$C_4H_6N_4O_3$: a71
C_4H_6O: b488, c306, d421, m27, m407
$C_4H_6O_2$: b466, b483, b484, b485, b611, b616, b617, c307, c409, m29, m126, v5
$C_4H_6O_2S$: b450
$C_4H_6O_3$: a22, a24, m355, o60, p230
$C_4H_6O_4$: d652, s15
$C_4H_6O_4S$: m25, t143
$C_4H_6O_5$: d690, h186, h187, o67
$C_4H_6O_6$: t1, t2, t3, t4
C_4H_7Br: b276, b277, b278
$C_4H_7BrO_2$: b282, b332, b368, b373, e83, m156
C_4H_7Cl: c79, c80, c81, c181, c182, c312
C_4H_7ClO: b620, c78, c136, i85
$C_4H_7ClO_2$: c84, c85, e105, m196, p228
$C_4H_7Cl_3O$: t241
$C_4H_7FO_2$: e153
C_4H_7N: b618, i83
C_4H_7NO: h153, i115, m28, m99a, m352, p236, p285
$C_4H_7NO_2$: b467, h146, m351
$C_4H_7NO_3$: a46, e233, s13
$C_4H_7NO_4$: a304, i7
C_4H_7NS: m434
$C_4H_7N_3O$: c302
C_4H_8: b477, b478, b479, c333, m399
C_4H_8BrCl: b298, b306
$C_4H_8Br_2$: d81, d82, d83, d84
$C_4H_8Br_2O$: b148
$C_4H_8Br_2O_2$: d85
$C_4H_8Cl_2$: d210
$C_4H_8Cl_2O$: b163, d230
$C_4H_8I_2$: d450
$C_4H_8N_2$: d535
$C_4H_8N_2O$: a102
$C_4H_8N_2O_2$: d610, s14
$C_4H_8N_2O_3$: a313, g27
$C_4H_8N_2S$: a97, t85
C_4H_8O: b475, b486, b487, b612, c311, e3, e276, i79, m106, m389, m400, t69
$C_4H_8O_2$: b480, b481, b614, d732, d733, e57, h107, h108, i81. m64, m401, p234
$C_4H_8O_2S$: e196, m299, t107
$C_4H_8O_3$: e24, e153, h120, h138, m70, m296, m302
C_4H_8S: a90, t87
$C_4H_8S_2$: d792
C_4H_9Br: b274, b275, b371, b372
C_4H_9BrO: b337
$C_4H_9BrO_2$: b319
C_4H_9Cl: c75, c76, c179, c180
C_4H_9ClO: a64, c77, c131, m74
$C_4H_9ClO_2$: c105, c123, m67
C_4H_9ClSi: c112
$C_4H_9Cl_3Si$: b604, b603, d215
$C_4H_9Cl_3Sn$: b600
C_4H_9F: f21
C_4H_9I: i26, i27, i38, i39
C_4H_9N: e53, p280
C_4H_9NO: a311, b476, b613, d526, i80, m110, m463
$C_4H_9NO_2$: a133, a133a, a134, b578, b579, h119, i73, n48
$C_4H_9NO_2S$: a200
$C_4H_9NO_3$: a185, a186, i72, m341, n49
$C_4H_9NO_5$: t442
C_4H_9NSi: c331
$C_4H_9N_3O_2$: c301
C_4H_{10}: b454, m390
$C_4H_{10}AlCl$: d320, e62
$C_4H_{10}ClO_2PS$: d351
$C_4H_{10}ClO_3P$: d350
$C_4H_{10}Cl_2Si$: b165
$C_4H_{10}Cl_4Si_2$: b174
$C_4H_{10}N_2$: p178
$C_4H_{10}N_2O$: a227
$C_4H_{10}N_2O_4S$: a8
$C_4H_{10}O$: b473, b474, d365, m397, m398, m404
$C_4H_{10}OS$: e180
$C_4H_{10}OS_2$: b208
$C_4H_{10}O_2$: b457, b457a, b457b, b458, b563, d504, d505, e40, e141, m105, m393
$C_4H_{10}O_2S$: t144
$C_4H_{10}O_2S_2$: d484, h123
$C_4H_{10}O_3$: b198, b472, d361, o62, t378
$C_4H_{10}O_3S$: d399
$C_4H_{10}O_4$: e19
$C_4H_{10}O_4S$: d397

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_4H_{10}S$: b470, b471, d398, i104, m394, m395, m396, m406
$C_4H_{10}S_2$: b468, d356
$C_4H_{10}S_3$: b209
$C_4H_{10}Zn$: d405
$C_4H_{11}ClSi$: c183
$C_4H_{11}N$: b453, b509, b510, b511, d323, d604, i66, m293
$C_4H_{11}NO$: a135, a164, a203, a216, d376, d539, e44, e67, m112
$C_4H_{11}NO_2$: a215, d297, d506
$C_4H_{11}NO_3$: t439
$C_4H_{11}OP$: d390
$C_4H_{11}O_2PS_2$: d358
$C_4H_{11}O_3P$: d375
$C_4H_{12}BrN$: t93
$C_4H_{12}ClN$: d324, t94
$C_4H_{12}Ge$: t109
$C_4H_{12}IN$: t95
$C_4H_{12}N_2$: b455, b560, b562, d41, d605, m391, m392
$C_4H_{12}N_2O$: a165
$C_4H_{12}N_2S_4$: b183
$C_4H_{12}OSi$: m119
$C_4H_{12}O_2Si$: d502
$C_4H_{12}O_3Si$: m455
$C_4H_{12}Pb$: t112
$C_4H_{12}Si$: t118
$C_4H_{12}Sn$: t121
$C_4H_{13}N_3$: d362
$C_4H_{14}BN$: b239
$C_4H_{14}OSi_2$: t106
$C_4H_{16}O_4Si_4$: t104

C_5

C_5Cl_5N: p10
C_5Cl_6: h25
C_5D_5N: p258
C_5H_3BrS: b426, b427
$C_5H_3Br_2N$: d127
C_5H_3ClOS: t153
$C_5H_3ClO_2$: f55
C_5H_3ClS: c251
$C_5H_3Cl_2N$: d268, d269
$C_5H_3N_3$: p252
C_5H_4BrN: b416, b417
C_5H_4ClN: c242
C_5H_4FN: f26
$C_5H_4F_8O$: o20
$C_5H_4N_2O_2$: p253
$C_5H_4N_2O_3$: n76
$C_5H_4N_4O_3$: u17
C_5H_4OS: t154
$C_5H_4O_2$: f44
$C_5H_4O_2S$: t155
$C_5H_4O_3$: c285, f54
$C_5H_5ClN_2$: a148
$C_5H_5ClN_2O_2$: c168
C_5H_5N: p257
C_5H_5NO: h179, h180, h181, p271
$C_5H_5NO_2$: d448, h183
$C_5H_5N_3O_2$: a243
$C_5H_5N_3O_4$: a158
$C_5H_5N_5$: a61
C_5H_6: c395, m174
$C_5H_6BrClN_2O_2$: b302
$C_5H_6Br_2N_2O_2$: d76
$C_5H_6Cl_2NO_2$: d220
$C_5H_6Cl_2O_2$: g18
$C_5H_6N_2$: a275, a276, a277, g17, m408, v12
$C_5H_6N_2O$: a47, a193
$C_5H_6N_2OS$: h140, h141
C_5H_6O: m259
C_5H_6OS: f48, m443
$C_5H_6O_2$: f50
$C_5H_6O_3$: g15, h156
$C_5H_6O_4$: c284, m253
$C_5H_6O_4S_3$: b156
C_5H_6S: m441, m442
C_5H_7BN: b244
$C_5H_7BrO_3$: e91
$C_5H_7ClO_2$: c205, d581
$C_5H_7ClO_3$: m189, m190, m195
C_5H_7N: m417, p51, p52
C_5H_7NO: e31, f51
$C_5H_7NO_2$: c324, e115
$C_5H_7N_3$: a224, d58
$C_5H_7N_3O$: a188
C_5H_8: c401, d424, m157, m178, p15, p16, p17, p18, p58
$C_5H_8Br_2O_2$: e122
$C_5H_8N_2$: d626, d684, e191, p283
$C_5H_8N_2O_2$: d622
$C_5H_8N_4O_{12}$: p22
C_5H_8O: c399, c410, d364, e6, m179
$C_5H_8O_2$: a74, c334, d532, e60, g16, i95, m65, m168, m169, m170, m200, m225, m300, p33, p34, p207, v2, v3, v10, v14
$C_5H_8O_3$: e237, h121, m123, o63
$C_5H_8O_4$: d547, g14, m278
C_5H_9Br: b313, b365
$C_5H_9BrO_2$: b364, e93, e94, m155
C_5H_9Cl: c93
C_5H_9ClO: c206, d681, m186, p45, t75, t351
C_5H_9ClOS: c238
$C_5H_9ClO_2$: b538, c237, e110, e111, i68, i107, m193
C_5H_9N: d683, m185, p35
C_5H_9NO: b565, b566, c400, d531, e53, e234, m419, m461
$C_5H_9NO_2$: d523, f39, m130, p187
$C_5H_9NO_4$: g12
C_5H_{10}: c396, m165a, m166, m167, p48, p49, p50
$C_5H_{10}Br_2$: d117, d118
$C_5H_{10}ClNO$: d348
$C_5H_{10}Cl_2$: d209
$C_5H_{10}Cl_2$: d251
$C_5H_{10}I_2$: d453
$C_5H_{10}NO_3P$: d293a
$C_5H_{10}N_2$: d548
$C_5H_{10}N_2O$: d627
$C_5H_{10}N_2O_3$: g13
$C_5H_{10}N_2O_4S_2$: c412
$C_5H_{10}O$: a85, c398, d653, d677, e252, m165, m171, m172, m173, m180, m181, m429, p28, p42, p43, t83
$C_5H_{10}OS$: m439
$C_5H_{10}O_2$: b557, c398, d521, d679, e252, h147, h164, i69, i99, m86, m182, m183, m184, m237, m290, m353, p38, p222, t71, t349
$C_5H_{10}O_2S$: e197, e222, m316, m431
$C_5H_{10}O_3$: d349, d520, e194, m75, m282, m307
$C_5H_{10}O_4$: b201, m72
$C_5H_{10}O_5$: a300, r9, x8
$C_5H_{11}Br$: b362, b363, b387, b388
$C_5H_{11}BrO$: b322
$C_5H_{11}BrO_2$: b320
$C_5H_{11}Br_2O$: b148
$C_5H_{11}Br_2O_2$: b150
$C_5H_{11}Cl$: c109, c150, c169a, c170, c204a
$C_5H_{11}ClO$: c110
$C_5H_{11}Cl_2N$: b164
$C_5H_{11}I$: i47

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_5H_{11}N$: a85, c404, m418, p180
$C_5H_{11}NO$: b558, d369, d678, m317, t72
$C_5H_{11}NO_2$: a248, a249, b133, b532, e275, i92, m310a, v4
$C_5H_{11}NO_2S$: m42
$C_5H_{11}NO_3$: n58
$C_5H_{11}NS_2$: d357
$C_5H_{11}O_5P$: t391
C_5H_{12}: d673, m155, p29
$C_5H_{12}Cl_2O_2Si$: b162
$C_5H_{12}N_2$: a261, m381, m382
$C_5H_{12}N_2O$: b608, d702, t122
$C_5H_{12}N_2O_2$: b533, o46
$C_5H_{12}N_2S$: t119
$C_5H_{12}N_2S_2$: p282
$C_5H_{12}O$: b572, d676, e254, m161, m162, m163, m164, p31, p32, p39, p40, p41
$C_5H_{12}O_2$: b504, d307, d518, d519, d675, i97, m64, p218
$C_5H_{12}O_2Si$: d509, t395, v18
$C_5H_{12}O_3$: m73, t340, t377, t440
$C_5H_{12}O_3S$: p36
$C_5H_{12}O_4$: p19
$C_5H_{12}O_5$: x7
$C_5H_{12}S$: b577, e255, m159, m160, p37
$C_5H_{12}Si$: t401
$C_5H_{13}ClOSi$: c125
$C_5H_{13}N$: a246, a247, d380, d628, d682, m175, m176, p54
$C_5H_{13}NO$: a209, a250, d546, d547, e54, p224
$C_5H_{13}NOSi$: t394
$C_5H_{13}NO_2$: a176, d508, d545, d607, m230
$C_5H_{13}N_3$: t110
$C_5H_{14}ClN_3O$: g5
$C_5H_{14}N_2$: d549, d674, p30, t105, t113
$C_5H_{14}N_2O$: a150, a166
$C_5H_{14}O$: b560, b561
$C_5H_{14}OSi$: e56
$C_5H_{15}NSi$: d707
$C_5H_{15}N_3$: a175

C_6

C_6BrD_5: b263
C_6BrF_5: b386
$C_6Cl_4O_2$: t34, t35
$C_6Cl_5NO_2$: p8
C_6Cl_6: h22
C_6D_6: b11
C_6D_{12}: c348
C_6F_6: h41
C_6F_{14}: t42
C_6HBr_5O: p4
$C_6HCl_4NO_2$: t39
C_6HCl_5: p6
C_6HCl_5O: p9
$C_6H_2BrFN_2O_4$: b324
$C_6H_2Br_4$: t14
$C_6H_2Cl_3NO_2$: t243
$C_6H_2Cl_4$: t32, t33
$C_6H_3Br_2F$: d103, d104
$C_6H_3Br_2NO_2$: d115
$C_6H_3Br_3O$: t211
$C_6H_3ClFNO_2$: c141
$C_6H_3ClF_2$: c99
$C_6H_3ClN_2O_4$: c114, c115
$C_6H_3ClN_2O_4S$: d712
$C_6H_3Cl_2NO_2$: d245, d246, d247, d248
$C_6H_3Cl_2NO_3$: d249
$C_6H_3Cl_3$: t227, t228, t229
$C_6H_3Cl_3O$: t244, t245
$C_6H_3Cl_3O_2S$: d201
$C_6H_3D_3$: b9
$C_6H_3FN_2O_4$: d718
$C_6H_3F_2NO_2$: d410
$C_6H_3F_3$: t303
$C_6H_3N_3O_6$: t403, t404
$C_6H_3N_3O_7$: p174
C_6H_4BrCl: b287, b288, b296
$C_6H_4BrClO_2S$: b264
C_6H_4BrF: b340, b341, b342
$C_6H_4BrNO_2$: b378
$C_6H_4BrN_3O_4$: b323
$C_6H_4Br_2$: d79, d112
$C_6H_4Br_2N_2O_2$: d114
$C_6H_4Br_2O$: d119
$C_6H_4Br_3N$: t201
C_6H_4ClF: c137, c138
C_6H_4ClFO: c142
C_6H_4ClI: c154
$C_6H_4ClNO_2$: c192, c193, c194
$C_6H_4ClNO_3$: c201
$C_6H_4ClNO_4S$: n33
$C_6H_4Cl_2$: d198, d199, d200
$C_6H_4Cl_2N_2O_2$: d244
$C_6H_4Cl_2O$: d252, d253, d254, d255
$C_6H_4Cl_2O_2S$: c50
$C_6H_4Cl_3N$: t225, t226
$C_6H_4FNO_2$: f23
$C_6H_4F_2$: d406
$C_6H_4INO_2$: i40, i41
$C_6H_4I_2$: d449
$C_6H_4N_2$: a267, c328, c329, c330
$C_6H_4N_2O_2$: b43
$C_6H_4N_2O_4$: d711
$C_6H_4N_2O_5$: d720
$C_6H_4N_4O_6$: t402
$C_6H_4O_2$: b58
$C_6H_5BO_2$: c22
C_6H_5Br: b262
C_6H_5BrO: b392, b393, b394
C_6H_5BrS: b428
C_6H_5Cl: c47
C_6H_5ClHg: p129
$C_6H_5ClN_2O_2$: c188, c189, c190, c191
$C_6H_5ClN_3O_4$: c113
C_6H_5ClO: c208, c209, c210
$C_6H_5ClO_2$: c102, c103, c244
$C_6H_5ClO_2S$: b24
$C_6H_5ClO_3S$: c49
C_6H_5ClS: c252
$C_6H_5Cl_2N$: d187, d188, d189, d190, d191, d192
$C_6H_5Cl_2OP$: p140
$C_6H_5Cl_2O_2P$: p100
$C_6H_5Cl_2P$: d260
$C_6H_5Cl_3Si$: p159
C_6H_5F: f11
$C_6H_5FN_2O_2$: f22
C_6H_5FO: f28
$C_6H_5FO_2S$: b25
C_6H_5I: b28, i23
C_6H_5NO: n77, p261, p262, p263
C_6H_5NOS: t148
$C_6H_5NO_2$: n30, n82, p265, p266, p267
$C_6H_5NO_3$: h182, n59, n60
$C_6H_5NO_4$: c288
$C_6H_5N_3$: b61
$C_6H_5N_3O$: h104
$C_6H_5N_3O_4$: d710
C_6H_6: b8
$^{13}C_6H_6$: b10
$C_6H_6AsNO_6$: h162
C_6H_6BrN: b256, b257, b258
C_6H_6ClN: c38, c39, c40
C_6H_6ClNO: a147, c162
$C_6H_6ClNO_2S$: c48
$C_6H_6Cl_6$: h24
C_6H_6FN: f7, f8
$C_6H_6F_9O_3P$: t447
C_6H_6HgO: p130

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

C_6H_6IN: i22
$C_6H_6NO_6$: n20
$C_6H_6N_2O$: e49, p259, p260, p264
$C_6H_6N_2O_2$: n23, n24, n25
$C_6H_6N_2O_3$: a238, a239, a240, m94
$C_6H_6N_4O_4$: d721, n53
C_6H_6O: p65
C_6H_6OS: a57, m443
$C_6H_6O_2$: a44, c21, d428, d429, d430, h86, m258, r2
$C_6H_6O_2S$: b21, t152
$C_6H_6O_3$: b34, m259a, t317, t318
$C_6H_6O_3S$: b23
$C_6H_6O_4$: d529
$C_6H_6O_6$: p206
C_6H_6S: t156
$C_6H_7AsO_3$: b12
$C_6H_7BO_2$: b13
$C_6H_7ClN_2$: c216, c217
C_6H_7N: a293, a294, m409, m410, m411
C_6H_7NO: a252, a253, a254, h155, m113, p273, p274
$C_6H_7NO_2$: m414
$C_6H_7NO_2S$: b22
$C_6H_7NO_3S$: a115, a116, a117, s25
C_6H_7NS: a287
$C_6H_7N_3O_2$: n65, n66, n67
$C_6H_7O_2P$: p138
$C_6H_7O_3P$: p139
$C_6H_8AsNO_3$: a113
$C_6H_8Br_2O_2$: d107
$C_6H_8Br_3O$: t205
$C_6H_8ClN_3O_4S_2$: a137
$C_6H_8Cl_2O_2$: m228
$C_6H_8N_2$: a218, a219, a220, a221, a222, a223, d284, m263, p104, p105, p106, p117
$C_6H_8N_2O$: a204, o69
$C_6H_8N_2O_2S$: b26, s24
$C_6H_8N_2O_3$: d561a
C_6H_8O: c371, d609, d620, h38
$C_6H_8O_2$: b451, c360, h40, m223
$C_6H_8O_3$: a36, a311, d599, f47
$C_6H_8O_4$: d598, d608, d629, d630
$C_6H_8O_6$: a302, g11, i61
$C_6H_8O_7$: c289
C_6H_9Br: b312
$C_6H_9BrO_3$: b285
$C_6H_9ClO_3$: e106, e107
$C_6H_9F_3O_2$: b605
C_6H_9NO: o62, v17
C_6H_9NOS: m433
$C_6H_9NO_2$: b540
$C_6H_9NO_3$: m78, n49
$C_6H_9N_3$: a156
$C_6H_9N_3O_2$: a157, c317, h83
C_6H_{10}: c368, d566, h39, h82, m356
$C_6H_{10}Br_2$: d89
$C_6H_{10}N_2$: e211, i114, p181
$C_6H_{10}N_2O_2$: c361
$C_6H_{10}N_2O_4$: d338
$C_6H_{10}N_2O_5$: a14
$C_6H_{10}N_4$: p27
$C_6H_{10}O$: c366, c370, d31, d362, e12, h77, m224, m368, m370, m372
$C_6H_{10}O_2$: a91, c397, d422, e114, e119, e142, e199, h60, h69, h74, h75, m369
$C_6H_{10}O_3$: d501, e58, e143, h126, h177, m402, p214
$C_6H_{10}O_4$: d385, d634, d691, e22, e137, h54, m276, m303
$C_6H_{10}O_4S$: t146
$C_6H_{10}O_4S_2$: d794, e136
$C_6H_{10}O_5$: d386
$C_6H_{10}O_6$: d699, g7
$C_6H_{10}S$: d34
$C_6H_{11}Br$: b311
$C_6H_{11}BrO$: b424
$C_6H_{11}BrO_2$: b279, b347, b529, e85, e86, e89
$C_6H_{11}BrO_4$: d346
$C_6H_{11}Cl$: c91
$C_6H_{11}ClO$: h72
$C_6H_{11}ClO_2$: b535, c82, e98
$C_6H_{11}I$: i28
$C_6H_{11}N$: d30, h61, m361
$C_6H_{11}NO$: c367, e260, f40, m388, o61, t379
$C_6H_{11}NO_2$: e66
C_6H_{12}: c347, d572a, d573, d574, e95a, h73, m222
$C_6H_{12}Br_2$: d94, d106
$C_6H_{12}ClNO$: c133
$C_6H_{12}Cl_2$: d217, d219, d234
$C_6H_{12}Cl_2O$: b166
$C_6H_{12}Cl_2O_2$: b161, d169
$C_6H_{12}Cl_3O_3P$: t437
$C_6H_{12}Cl_3O_4P$: t436
$C_6H_{12}F_3NOSi$: m457
$C_6H_{12}NO_3P$: d294
$C_6H_{12}N_2$: d61, d325, t279
$C_6H_{12}N_2S$: b183, t119
$C_6H_{12}N_2S_4$: t120
$C_6H_{12}N_2Si$: t396
$C_6H_{12}N_2Zn$: d601
$C_6H_{12}N_4$: h49
$C_6H_{12}O$: a96, b609, c365, d572, e11, e98, h51, h70, h71, h76, i78, m367, m430
$C_6H_{12}O_2$: b465, b501, b502, b503, c359, d576, d577, e99, e100, e192, e209, e213, h64, h150, i63, m235, m312, m362, m363, m456, p244, t84
$C_6H_{12}O_3$: d525, e42, e179, e182, i116, p2, p237, t70
$C_6H_{12}O_4$: e149
$C_6H_{12}O_4Si$: d27
$C_6H_{12}O_6$: f41, g1, g8, i19, m11, s6
$C_6H_{12}O_7$: g6
$C_6H_{12}S$: c364
$C_6H_{13}Br$: b346
$C_6H_{13}BrO_2$: b317
$C_6H_{13}Cl$: c149
$C_6H_{13}ClO$: c150
$C_6H_{13}ClO_2$: c96
$C_6H_{13}ClO_3$: c124
$C_6H_{13}I$: i36
$C_6H_{13}N$: c375, e202, h48, m383, m384, m385, m386
$C_6H_{13}NO$: d314, d637, e223, h133, h152
$C_6H_{13}NO_2$: a182, a183, h127, i88, L5, L6, m233
$C_6H_{13}NO_4$: b199
$C_6H_{13}NO_5$: t441
C_6H_{14}: d567, d568, h52, m357, m358
$C_6H_{14}ClN$: d328
$C_6H_{14}Cl_4OSi_2$: b175
$C_6H_{14}NO_2$: b213
$C_6H_{14}N_2$: a214, c354, d43, d44, d671, e245
$C_6H_{14}N_2O$: a172, h129
$C_6H_{14}N_2O_2$: L13
$C_6H_{14}N_4O_2$: a301
$C_6H_{14}O$: b554, d476, d570, d570a, d571, d786, e95, h66, h67, h68, m364, m365, m366
$C_6H_{14}OSi$: a93

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_6H_{14}O_2$: b493, d303, d304, d569, e138, e219, h55, h56, h57, m82, m360, p220
$C_6H_{14}O_2S$: d789
$C_6H_{14}O_3$: b204, b214, d305, d779, e41, e183, h63, h176, t321, t341
$C_6H_{14}O_4$: t280
$C_6H_{14}O_4S$: d788
$C_6H_{14}O_4S_2$: b459
$C_6H_{14}O_6$: d824, m10, s5
$C_6H_{14}O_6S_2$: b210
$C_6H_{14}S$: b557, h62
$C_6H_{14}Si$: a101
$C_6H_{15}Al$: t273
$C_6H_{15}AlI$: d322
$C_6H_{15}AlO$: d321
$C_6H_{15}As$: t276
$C_6H_{15}B$: t277
$C_6H_{15}ClGe$: c260
$C_6H_{15}ClO_3Si$: c240
$C_6H_{15}ClSi$: b551, c261
$C_6H_{15}Ga$: t286
$C_6H_{15}In$: t288
$C_6H_{15}N$: d468, d575, d777, e97, h81, m371, t274
$C_6H_{15}NO$: a184, a211, a212, b513, b553, d327, d364, i98
$C_6H_{15}NO_2$: d306, d540, e125
$C_6H_{15}NO_3$: t266
$C_6H_{15}N_3$: a174
$C_6H_{15}O_3B$: t268
$C_6H_{15}O_3P$: d480, t294
$C_6H_{15}O_3PS$: t298
$C_6H_{15}O_4P$: t292
$C_6H_{15}P$: t293
$C_6H_{15}Sb$: t275
$C_6H_{16}Br_2OSi_2$: b149
$C_6H_{16}Cl_2OSi_2$: b167
$C_6H_{16}N_2$: d367, h53, m359, t108
$C_6H_{16}OSi$: p221
$C_6H_{16}O_2Si$: d301
$C_6H_{16}O_3SSi$: m24
$C_6H_{16}O_3Si$: t269, t342
$C_6H_{16}Si$: t297
$C_6H_{17}NO_3Si$: a274, t344
$C_6H_{17}N_3$: i9
$C_6H_{18}ClN_3Si$: c268a
$C_6H_{18}N_2Si$: b179
$C_6H_{18}N_3OP$: h50
$C_6H_{18}N_4$: t285, t434
$C_6H_{18}OSi_2$: h47
$C_6H_{18}O_3Si_3$: h45
$C_6H_{19}NOSi_2$: b233
$C_6H_{19}NSi_2$: h46

C_7

$C_7H_3BrClF_3$: b297
$C_7H_3BrF_3NO$: b380
$C_7H_3ClF_3NO_2$: c199, c200
$C_7H_3ClN_2O_5$: d714
$C_7H_3Cl_2F_3$: d206, d207
$C_7H_3Cl_2NO$: d259
$C_7H_3Cl_3O$: d208, d209
$C_7H_4BrF_3$: b268, b269
$C_7H_4Br_4O$: t15
C_7H_4ClFO: f14, f15
$C_7H_4ClF_3$: c60, c61, c62
C_7H_4ClN: c54, c55
C_7H_4ClNO: c219, c220
$C_7H_4ClNO_3$: n39, n40
$C_7H_4ClNO_4$: c195, c196, c197
$C_7H_4Cl_2O$: c64, c65, d194, d195
$C_7H_4Cl_2O_2$: d202, d203, d204
$C_7H_4Cl_3F$: t238
$C_7H_4Cl_4$: c58, c59
$C_7H_4F_3NO_2$: n86, n87
$C_7H_4I_2O_3$: h113
$C_7H_4N_2O_2$: n38
$C_7H_4N_2O_6$: d713
$C_7H_4N_2O_7$: d722, h114
$C_7H_4O_3S$: h105
$C_7H_4O_4S$: s27
C_7H_5BrO: b65
$C_7H_5BrO_2$: b266, b265
$C_7H_5BrO_3$: b419
$C_7H_5ClF_3N$: a142, a143
C_7H_5ClO: b66, c43, c44, c45
$C_7H_5ClO_2$: c51, c52, c53, p99
$C_7H_5ClO_3$: c207, c245, c246
$C_7H_5Cl_2F$: c139
$C_7H_5Cl_2NO$: d196, d197
$C_7H_5Cl_3$: t251, t252, t253, t254
C_7H_5FO: b68, f9, f10
$C_7H_5FO_2$: f12, f13
$C_7H_5F_3$: t311
$C_7H_5F_3N_2O_2$: a237
$C_7H_5F_3O$: t304
$C_7H_5F_4N$: a179
$C_7H_5IO_2$: i25
$C_7H_5IO_3$: i51
$C_7H_5I_2NO_2$: a154
C_7H_5N: b51
C_7H_5NO: b62, p124
$C_7H_5NO_3$: n26, n27
$C_7H_5NO_3S$: s1
$C_7H_5NO_4$: n35, n36, n37, p268, p269, p270
$C_7H_5NO_5$: h163
C_7H_5NS: b59, p125
$C_7H_5NS_2$: m17, m19
$C_7H_5N_3O_2$: a234, n34, n55
$C_7H_5N_3O_2S$: a236
$C_7H_5N_3O_6$: t405
C_7H_6BrClO: b300
$C_7H_6BrNO_2$: n44
$C_7H_6BrNO_3$: h156
$C_7H_6Br_2$: b271, d132
$C_7H_6Br_2O$: d111
C_7H_6ClF: c143, c144, f16
C_7H_6ClNO: c46
$C_7H_6ClNO_2$: a138, a139, c202, c203, n45
$C_7H_6Cl_2$: c69, c70, d273, d274, d275, d276
$C_7H_6F_3N$: a126, a127, a128, t310
$C_7H_6FNO_2$: f24
$C_7H_6INO_2$: a199
$C_7H_6N_2$: a121, a122, a123, b39
$C_7H_6N_2O_3$: n28, n29
$C_7H_6N_2O_4$: a233, d723, d724
$C_7H_6N_2O_5$: d715, d716
$C_7H_6N_2S$: a125
$C_7H_6N_4O_2$: t134
C_7H_6O: b3
C_7H_6OS: t139
$C_7H_6O_2$: b44, h94, h95, h96, m251
$C_7H_6O_2S$: m18
$C_7H_6O_3$: d427, f46, h99, h100, h101
$C_7H_6O_4$: d431, d432, d433, d434
$C_7H_6O_5$: t319
$C_7H_6O_6S$: s31
C_7H_7Br: b85, b429, b430, b431
C_7H_7BrO: b259, b260, b270, b357, b358, b359
C_7H_7BrS: b425
C_7H_7Cl: b90, c255, c256, c257
$C_7H_7ClNNaO_2S$: c258
$C_7H_7ClN_4O_2$: c253
C_7H_7ClO: c66, c160, c176, c177
$C_7H_7ClO_2S$: t177
$C_7H_7ClO_3S$: m56

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

C_7H_7ClS: c73
$C_7H_7Cl_3Si$: b128
C_7H_7F: f27, f28, f29
C_7H_7FO: f19, f20
$C_7H_7FO_2S$: t178
C_7H_7I: i53, i54, i55
C_7H_7N: v15, v16
C_7H_7NO: a53, a54, a55, b4, f35
$C_7H_7NO_2$: a118, a119, a120, h97, h98, m412, m413, n83, n84, n85
$C_7H_7NO_3$: a280, a281, m92, m339, m340, n41, n42, n43
$C_7H_7NO_4S$: c17
$C_7H_7N_3$: a197, a198
C_7H_8: b134, c344, t166
C_7H_8BrN: b360
C_7H_8ClN: c37, c67, c68, c163, c164, c165, c166, c167
C_7H_8ClNO: c158, c159
$C_7H_8ClNO_2$: c19
$C_7H_8ClNO_2S$: c248
$C_7H_8Cl_2Si$: d239
$C_7H_8N_2$: h102
$C_7H_8N_2O$: a112, b71, p167
$C_7H_8N_2O_2$: d40, h149, h170, m326, m327, m328, m329, m330, m415
$C_8H_8N_2O_3$: m89, m90, m91
$C_7H_8N_2S$: p158
$C_7H_8N_4O_2$: t133
C_7H_8O: b78, c303, c304, c305, m55
$C_7H_8O_2$: d438, h106, m97, m98, m99, m280
$C_7H_8O_2S$: t172
$C_7H_8O_3$: e155, f49, m314
$C_7H_8O_3S$: m139, t176
C_7H_8S: b106, m379, t142
$C_7H_9BrO_2$: e84
C_7H_9N: b79, d685, d686, d687, d688, d689, e256, e257, e258, m134, t180, t181, t182
C_7H_9NO: a213, b101, h132, m48, m49, m50
$C_7H_9NO_2$: d524
$C_7H_9NO_2S$: t173, t174
$C_7H_9NO_3S$: a205, a206, a288
C_7H_9NS: m436
C_7H_{10}: b135
$C_7H_{10}ClN_3O$: g4
$C_7H_{10}N_2$: a177, a178, d59, d60, d287, d551, t167, t168, t169, t170
$C_7H_{10}N_2O$: o66
$C_7H_{10}N_2O_2$: e212, m242
$C_7H_{10}N_2O_2S$: t175
$C_7H_{10}O$: d294, m67, n108, t67
$C_7H_{10}O_2$: a40, c402
$C_7H_{10}O_3$: e17, e144, m354, t367
$C_7H_{10}O_4$: d29, d596, p208
$C_7H_{10}O_5$: d528
$C_7H_{11}Br$: b383
$C_7H_{11}BrO_4$: d346
$C_7H_{11}ClO$: c351
$C_7H_{11}N$: c350
$C_7H_{11}NO$: c381, h112
$C_7H_{11}NO_2$: a52, b539
$C_7H_{11}NO_3$: m83
$C_7H_{11}NO_5$: a45
$C_7H_{11}NS$: c382
C_7H_{12}: c345, h20, m215, m216, n107
$C_7H_{12}N_2O$: m464
$C_7H_{12}O$: b506, c348, c352, c369, m212, m213, m214
$C_7H_{12}O_2$: a80, b507a, b508, c353, d420, e126, i65
$C_7H_{12}O_3$: e43, e201, e226, h178, t73
$C_7H_{12}O_4$: d378, d379, d636, d656, h7, m76, m277, t125
$C_7H_{12}O_6Si$: m448
$C_7H_{13}Br$: b310, b367
$C_7H_{13}BrO_2$: b390, e92
$C_7H_{13}ClO$: h17
$C_7H_{13}N$: a245
$C_7H_{13}NO$: a307, b507, c380
$C_7H_{13}NO_2$: d541
$C_7H_{13}NO_3$: d418
C_7H_{14}: c341, e118a, h18, h18a, h18b, m202
$C_7H_{14}ClN$: c134
$C_7H_{14}N_2$: d475
$C_7H_{14}N_2O$: a272
$C_7H_{14}N_2O_2$: e246
$C_7H_{14}O$: c342, c384, d655, d658, h3, h14, h15, h16, m205, m206, m207, m208, m209, m210, m211, m271
$C_7H_{14}O_2$: b559, b593, b594, d312, e128, e207, e208, e239, h9, i74, i91, i106, m270, p53, p228
$C_7H_{14}O_2S$: b569
$C_7H_{14}O_3$: b567, e130, e151
$C_7H_{14}O_6$: m262
$C_7H_{15}Br$: b343, b344
$C_7H_{15}Cl$: c147
$C_7H_{15}ClO_2$: c97
$C_7H_{15}I$: i34
$C_7H_{15}N$: c362, d672, e247, e248, m218, m219, m220
$C_7H_{15}NO$: e186, h131, h134, m387, p182, p183
$C_7H_{15}NO_2$: p286
$C_7H_{15}NO_3$: m467
$C_7H_{15}O_5P$: t296
C_7H_{16}: d654, e238, h6, t361
$C_7H_{16}BrNO_2$: a38
$C_7H_{16}ClNO_2$: a39
$C_7H_{16}N_2$: a210, a271, m308, t392
$C_7H_{16}N_2S$: d482
$C_7H_{16}O$: d657, h10, h11, h12, t362
$C_7H_{16}O_2$: b498, b499, d311, d393, m405
$C_7H_{16}O_2Si$: d310
$C_7H_{16}O_3$: d784, t290
$C_7H_{16}O_4$: t92, t284
$C_7H_{16}S$: h8
$C_7H_{17}N$: h19, m272
$C_7H_{17}NO$: b500, d332, d333
$C_7H_{17}NO_2$: b515, d331
$C_7H_{17}NO_5$: m261
$C_7H_{18}N_2$: d334, d392, t116
$C_7H_{18}N_2O$: b180
$C_7H_{18}N_2O_2$: a270
$C_7H_{18}N_2O_4Si$: t348
$C_7H_{18}O_2Si$: b607
$C_7H_{18}O_3Si$: b606, i77, m451
$C_7H_{19}NOSi_2$: b232
$C_7H_{19}NSi$: d404
$C_7H_{19}N_3$: d52
$C_7H_{20}N_2OSi_2$: b236
$C_7H_{22}O_4Si_3$: h5

C_8

$C_8Br_4O_3$: t17
$C_8Cl_4O_3$: t40
C_8D_{10}: e73
$C_8F_{18}O_2S$: p59
$C_8HCl_4NO_2$: t39
$C_8H_3NO_5$: n72
$C_8H_4BrNO_2$: b348
$C_8H_4Cl_2O_2$: b15, b16, p172
$C_8H_4Cl_2O_4$: d261
$C_8H_4Cl_6$: b225
$C_8H_4F_6$: b229
$C_8H_4N_2$: d282, d283

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_8H_4N_2O_2$: p107
$C_8H_4O_3$: p169
C_8H_5BrN: b272
$C_8H_5ClO_2$: c224
$C_8H_5Cl_3O$: t223
$C_8H_5Cl_3O_3$: t246
$C_8H_5D_3O$: a32
$C_8H_5F_3O_2S$: t132
$C_8H_5F_6N$: b228
C_8H_5NO: b67
$C_8H_5NO_2$: i17, p171
$C_8H_5NO_3$: h171, i60
$C_8H_5NO_6$: n31, n32, n70, n71
C_8H_6: p84
C_8H_6BrClO: b286
C_8H_6BrN: b397
$C_8H_6Br_2O$: d78
$C_8H_6Br_4$: t18, t19, t20
C_8H_6ClN: c71, c72, c215
$C_8H_6ClNO_3$: c187
$C_8H_6Cl_2O$: c168, d185
$C_8H_6Cl_2O_3$: d256
$C_8H_6N_2$: q4
$C_8H_6N_2O$: q5
$C_8H_6N_2O_2$: n64
C_8H_6O: b42
$C_8H_6O_2$: b14, p170, t6
$C_8H_6O_3$: b69, f37, m250
$C_8H_6O_4$: b17, b18, p168
C_8H_6S: b60
C_8H_7Br: b420
C_8H_7BrO: b251, b253
$C_8H_7BrO_2$: b356, b396
$C_8H_7BrO_3$: b355
C_8H_7ClO: c31, c32, c33, p83, t187, t188, t189
C_8H_7ClOS: b92
$C_8H_7ClO_2$: b91, c214, m60, m191, m192, p69
$C_8H_7ClO_3$: c161, c211
C_8H_7FO: f6
C_8H_7N: i15, p82, t183, t184, t185
C_8H_7NO: m9, m147, t192
$C_8H_7NS_2$: m438
$C_8H_7NO_3$: n21, n22
$C_8H_7NO_3S$: t179
$C_8H_7NO_4$: a114, m331, m332, m333, m334, m335, m336, m337, n61, n62, n63
$C_8H_7NO_5$: m93
C_8H_7NS: b126, m146
$C_8H_7N_3O_2$: a151
C_8H_8: s11
C_8H_8BrNO: b248
$C_8H_8Br_2$: d98, d134, d135
C_8H_8ClNO: c25, c26, c26a
$C_8H_8ClNO_3$: a146
$C_8H_8ClNO_3S$: a10
$C_8H_8Cl_2$: d277, d278, d279
C_8H_8HgO: p128
$C_8H_8N_2$: a255, m140
C_8H_8O: a31, e9, m138, p77, s12
C_8H_8OS: m437
$C_8H_8O_2$: b41, b99, h91, h92, h93, m51, m52, m53, m141, m142, m143, m144, p80, p81
$C_8H_8O_2S$: p156, t157
$C_8H_8O_3$: d425, h142, h165, m8, m57, m58, m59, m281, m424, p68, r4, t81
$C_8H_8O_4$: d25, h143
$C_8H_8O_4S$: a33
$C_8H_8O_5$: m454
C_8H_9Br: b334a, b335, b443, b444, b445, b446
C_8H_9BrO: b321, b338, b361
$C_8H_9BrO_2$: b318
C_8H_9Cl: c127, c128, c269, c270, c271, c272, c273
C_8H_9ClO: c108, c218
$C_8H_9ClO_2$: c104
C_8H_9N: b104, i18
C_8H_9NO: a18, a105, a106, a107, b98, m256
$C_8H_9NO_2$: a15, a16, a17, a207, a208, b89, d638, d639, d640, d641, e226, e259, m54, m129, p114, t77
$C_8H_9NO_3$: a202, h167, h168, m95
$C_8H_9NO_4$: d511
$C_8H_9NO_4S$: m133
C_8H_{10}: e74, x4, x5, x6
$C_8H_{10}ClN$: c107
$C_8H_{10}N_2O$: d642
$C_8H_{10}N_2O_3$: m85
$C_8H_{10}N_2O_3S$: m343
$C_8H_{10}N_4O_2$: c1, d286
$C_8H_{10}O$: b136, d659, d660, d661, d662, d663, d664, e36, e240, e241, e242, m116, m117, m118, m149, m150, p109, p110
$C_8H_{10}O_2$: b19, d493, d494, d495, e51, m61, m84, p72, p108
$C_8H_{10}O_3$: c308, c356, d512, h118, h145, m30, m234
$C_8H_{10}O_3S$: e75, m447
$C_8H_{10}O_4$: d668, d669, d670
$C_8H_{10}O_8$: b469
$C_8H_{10}S$: b110
$C_8H_{11}N$: b108, d553, d554, d555, d556, d557, d558, d559, e68, e69, e70, e220, i130, m151, m152, p112, t393
$C_8H_{11}NO$: a173, a251, a256, a257, a295, d544, e32, h122, m62, m80, m81, p101, p275, p276
$C_8H_{11}NO_2$: d488, d489, d490
$C_8H_{11}NO_2S$: m446
$C_8H_{11}NO_3$: e150
C_8H_{12}: c387, c388, v9
$C_8H_{12}N_2$: d288, d665, t117, x9
$C_8H_{12}N_2O_2$: d461
$C_8H_{12}N_2O_3$: d339
$C_8H_{12}N_4$: a313
$C_8H_{12}O$: e278
$C_8H_{12}O_2$: d589, e262, n109
$C_8H_{12}O_3$: e135, t74
$C_8H_{12}O_4$: c355, d28, d370, d377, m36
$C_8H_{12}O_5$: d530
$C_8H_{12}O_6Si$: t194
$C_8H_{13}N$: e238
$C_8H_{13}NO_4$: m342
C_8H_{14}: c393, o19, o49, v8
$C_8H_{14}N_2$: p185, p281
$C_8H_{14}NO_4$: d472
$C_8H_{14}O$: b576, c392, d592, d621, m217, m269, o50
$C_8H_{14}O_2$: b464, b570, c373, c374, c405, d620, h78, i71, m203, n31
$C_8H_{14}O_3$: b505, b615, e45, e101, i64, i82
$C_8H_{14}O_4$: b197, b460, d381, d396, d617, e139, e177, o25
$C_8H_{14}O_4S$: d703
$C_8H_{14}O_4S_2$: d793
$C_8H_{14}O_6$: d400, d401
$C_8H_{15}BrO_2$: e88
$C_8H_{15}ClO$: e163, o39
$C_8H_{15}N$: o28
$C_8H_{15}NO$: p243
$C_8H_{15}NO_2$: d543, e249, e250, p184
C_8H_{16}: c389, d585, d586, d587, d587a, d588, e117, o40, t384
$C_8H_{16}Br_2$: d116
$C_8H_{16}N_2O_4S$: h130

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_8H_{16}O$: c378, c391, d500, d590, d591, e118, e158, m268, o36, o37, o38, o43
$C_8H_{16}O_2$: b531, c357, c390, e160, e161, h79, i70, m266, o30, p239
$C_8H_{16}O_3$: b497, e181
$C_8H_{16}O_4$: c313, e37, t124
$C_8H_{17}Br$: b385
$C_8H_{17}Cl$: c204
$C_8H_{17}Cl_3Si$: o48
$C_8H_{17}I$: i44
$C_8H_{17}N$: b597, c394, d593, d594
$C_8H_{17}NO_3$: e173
$C_8H_{17}O_5P$: t295
C_8H_{18}: d616a, e158a e214, e215, o23, t100, t380, t381, t382
$C_8H_{18}AlCl$: d455
$C_8H_{18}ClNO_2$: a49
$C_8H_{18}Cl_2Sn$: d177
$C_8H_{18}F_3NOSi_2$: b235
$C_8H_{18}N_2$: c349
$C_8H_{18}N_2O_4S$: h130
$C_8H_{18}N_2O_6S_2$: p179
$C_8H_{18}O$: d148, d458, e162, m267, o32, o33, o34, o35, o66a
$C_8H_{18}OSi_2$: d799
$C_8H_{18}OSn$: d180
$C_8H_{18}O_2$: b494, d159, d618, e159, o26, o27, t383
$C_8H_{18}O_2S$: d173
$C_8H_{18}O_3$: b186, b495, t289
$C_8H_{18}O_3S$: d172
$C_8H_{18}O_3Si$: t272
$C_8H_{18}O_4$: b211, t282
$C_8H_{18}O_4S$: d169
$C_8H_{18}O_5$: t51
$C_8H_{18}S$: d170, d171, o29
$C_8H_{18}S_2$: b154, b155, d146, d147
$C_8H_{18}Si_2$: b231
$C_8H_{19}Al$: d456
$C_8H_{19}N$: d139, d140, d457, d477, d619, e166, o44, t103
$C_8H_{19}NO$: d413
$C_8H_{19}NO_2$: b549, d299, d300
$C_8H_{19}O_3P$: d164
$C_8H_{20}BrN$: t49
$C_8H_{20}ClN$: t50
$C_8H_{20}Ge$: t58
$C_8H_{20}N_2$: o24, t101, t102
$C_8H_{20}N_2O_2S$: t61
$C_8H_{20}O_3Si$: e270
$C_8H_{20}O_4Si$: t48
$C_8H_{20}O_4Ti$: t163
$C_8H_{20}Pb$: t59
$C_8H_{20}Si$: t60
$C_8H_{20}Sn$: t63
$C_8H_{21}NOSi_2$: b230
$C_8H_{21}NO_2Si$: a269, d308
$C_8H_{22}B$: b241
$C_8H_{22}N_2O_3Si$: a166, t346
$C_8H_{22}N_4$: b145
$C_8H_{22}O_2Si_2$: b234
$C_8H_{23}N_5$: t56
$C_8H_{24}Cl_2O_3Si_4$: d250
$C_8H_{24}O_2Si_3$: o22
$C_8H_{24}O_4Si_4$: o21
$C_8H_{35}N$: d728

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$C_9H_2Cl_6O_3$: h28
$C_9H_3Cl_3O_3$: b33
$C_9H_4O_5$: b32
$C_9H_5BrClNO$: b304
$C_9H_5Br_2NO$: d108
C_9H_5ClINO: c152
$C_9H_5Cl_2N$: d270
C_9H_6BrN: b418
C_9H_6ClNO: c153
$C_9H_6INO_4S$: h137
$C_9H_6N_2O_2$: t171
$C_9H_6O_2$: b55, c292
$C_9H_6O_3$: h111
$C_9H_6O_4$: i13
$C_9H_6O_6$: b29, b30, b31
C_9H_7BrO: b309
C_9H_7ClO: c280
$C_9H_7ClO_2$: c90
C_9H_7N: i133, q3
C_9H_7NO: h184
$C_9H_7NO_3$: h151, m289
$C_9H_7NO_4$: n50
$C_9H_7NO_4S$: h185
$C_9H_7N_3O_4S_2$: a242
C_9H_8: i14
$C_9H_8Cl_2O_3$: d258
$C_9H_8N_2$: m423, p120
$C_9H_8N_2O_6$: e129
C_9H_8O: c278, i12
$C_9H_8O_2$: c279, d417, v6
$C_9H_8O_3$: h109
$C_9H_8O_3S$: p247
$C_9H_8O_4$: p127
C_9H_9BrO: b412
$C_9H_9BrO_2$: b86
C_9H_9Cl: v7
C_9H_9ClO: c234
$C_9H_9ClO_3$: c213, d498
C_9H_9N: d564, m287
C_9H_9NO: m103, m104, p134
$C_9H_9NO_2$: a9
$C_9H_9NO_3$: a11, a12, b70
$C_9H_9NO_4$: e227
$C_9H_9N_3O$: a260
$C_9H_9N_3O_2S_2$: t137
$C_9H_9N_5$: d53
C_9H_{10}: a78, i10, m425, m426
$C_9H_{10}Br_2$: d109
$C_9H_{10}F_3NO_2$: m135
$C_9H_{10}N$: a196, a197
$C_9H_{10}N_2$: a296, p121
$C_9H_{10}N_2O$: p151
$C_9H_{10}N_2O_2$: p85
$C_9H_{10}N_2O_3$: a129
$C_9H_{10}O$: a94, a95, c282, e14, e72, i11, m124, p147, p148, p149, p209, p217
$C_9H_{10}O_2$: b63, b76, d563, e33, e34, e76, h174, h175, m44, m45, m46, m309, m310, m311, m375, p103, p150, t190
$C_9H_{10}O_3$: d491, d492, e37, e38, e46, e55, e178, e261, f52, m101, m283, m297, m304, m305, p74
$C_9H_{10}O_4$: d496, d492, h135, m292
$C_9H_{11}Br$: b350, b353, b399, b435, b436
$C_9H_{11}BrO$: b413, p75
$C_9H_{11}Cl$: c222
$C_9H_{11}ClO_3S$: c135
$C_9H_{11}N$: a77, c333, m288, t78, t86
$C_9H_{11}NO$: d536, d562, m121, m374, m445
$C_9H_{11}NO_2$: d537, d538, e35, e64, e65, i126, p86
$C_9H_{11}NO_3$: t455
C_9H_{12}: e190, i103, p225, t357, t358, t359, v13
$C_9H_{12}N_2O_4$: a241
$C_9H_{12}N_2O_6$: u18
$C_9H_{12}N_2S$: b111
$C_9H_{12}O$: b98, d632, d633, i127, i128, i129, m373, p145, p146, p240, t385, t386, t387
$C_9H_{12}O_2$: b115, c316, c358, e48, p73, p148, t365, t374

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_9H_{12}O_3$: d499, m204, t332, t333, t334
$C_9H_{12}O_3S$: e263
$C_9H_{12}S$: p144
$C_9H_{13}N$: b595, d565, d706, e80, e203, e264 e265, e266, i101, t355
$C_9H_{13}NO$: b80, m96, n110
$C_9H_{13}NO_2$: a258, b596
$C_9H_{13}N_5$: t191
$C_9H_{14}BrN$: p162
$C_9H_{14}Br_3N$: p165
$C_9H_{14}ClN$: p163
$C_9H_{14}IN$: p164
$C_9H_{14}N_2$: n92, t388
$C_9H_{14}O$: d611, d613, i93, t364
$C_9H_{14}O_2$: m350
$C_9H_{14}O_2Si$: d510
$C_9H_{14}O_3$: b215, t76
$C_9H_{14}O_3Si$: p161
$C_9H_{14}O_5$: d315, d382
$C_9H_{14}O_6$: p200
$C_9H_{14}Si$: p166
$C_9H_{15}N$: t195
$C_9H_{15}NO$: c362
$C_9H_{15}N_3$: t439
C_9H_{16}: m348
$C_9H_{16}N_2$: d62
$C_9H_{16}O$: d612, n103
$C_9H_{16}O_2$: b571, c363, h80, n97
$C_9H_{16}O_3$: b568, b582
$C_9H_{16}O_4$: d368, d371, d478, d614, n93
$C_9H_{16}O_6$: d345
$C_9H_{17}BrO_2$: e87
$C_9H_{17}Cl$: c92
$C_9H_{17}ClO$: n102, t372
$C_9H_{17}ClO_2$: e167
$C_9H_{17}N$: a83, n95
$C_9H_{17}NO_2$: e216, e217
C_9H_{18}: i108, p229, t363
$C_9H_{18}NO$: t115
$C_9H_{18}N_2O$: d550
$C_9H_{18}O$: c385, d616, n99, n100, n101, n104, t370
$C_9H_{18}O_2$: e156, m349, n96
$C_9H_{18}O_3$: d144
$C_9H_{18}O_4$: d785
$C_9H_{19}Br$: b382
$C_9H_{19}BrO_2$: e90
$C_9H_{19}I$: i42
$C_9H_{19}NO$: d151
$C_9H_{19}NO_3Si$: t270
$C_9H_{19}N_2S$: d175
C_9H_{20}: d386a, d613a, e210a, n90, t370a
$C_9H_{20}Cl_2Si$: d238
$C_9H_{20}N_2$: a136, a290
$C_9H_{20}N_2S$: d136
$C_9H_{20}O$: d615, n98, t371
$C_9H_{20}O_2$: b556, n94
$C_9H_{20}O_2Si$: c377
$C_9H_{20}O_3$: d783, t291
$C_9H_{20}O_3Si$: a99
$C_9H_{20}O_4$: t430
$C_9H_{21}Al$: t428
$C_9H_{21}BO_3$: t427, t326
$C_9H_{21}BO_6$: t445
$C_9H_{21}ClO_3Si$: c239
$C_9H_{21}N$: n105, t429
$C_9H_{21}NO_2$: d470, d778
$C_9H_{21}NO_3$: t325
$C_9H_{21}N_3$: t287
$C_9H_{21}O_3P$: t329
$C_9H_{22}N_2$: d387, n91
$C_9H_{22}O_3$: d780, d781
$C_9H_{22}Si$: t330
$C_9H_{23}N_3$: p26
$C_9H_{24}N_4$: b147
$C_9H_{24}O_2Si_3$: m153
$C_9H_{27}BO_3Si_3$: t449
$C_9H_{31}ClO_3Ti$: c254

C_{10}

$C_{10}H_2O_6$: b28
$C_{10}H_4Cl_2O_2$: d243
$C_{10}H_6Br_2O$: d113
$C_{10}H_6Cl_2O$: d242
$C_{10}H_6N_2$: b103
$C_{10}H_6N_2O_4$: d719
$C_{10}H_6N_2O_4S$: d64
$C_{10}H_6O_2$: n11
$C_{10}H_6O_3$: h161
$C_{10}H_6O_8$: b27
$C_{10}H_7Br$: b376
$C_{10}H_7BrO$: b377, b378
$C_{10}H_7Br_2NO$: d112
$C_{10}H_7Cl$: c185, c186
$C_{10}H_7NO_2$: n57, n80, p126
$C_{10}H_7NO_8S_2$: n81
$C_{10}H_8$: a316, d1, n2
$C_{10}H_8BrNO_2$: b339
$C_{10}H_8N_2$: d790
$C_{10}H_8N_2O_4$: b205, f53
$C_{10}H_8O$: n9, n10
$C_{10}H_8O_2$: d439, d440, d441, d442, m199
$C_{10}H_8O_3$: h148
$C_{10}H_8O_3S$: n6, n7
$C_{10}H_8O_4$: d443, d444
$C_{10}H_9N$: a228, a229, m420, m421, m422, n17
$C_{10}H_9NO$: a51, a232
$C_{10}H_9NO_2$: i16
$C_{10}H_9NO_3$: h128
$C_{10}H_9NO_3S$: a230
$C_{10}H_9NO_4S$: a189, a190, a191, a192
$C_{10}H_9NO_6$: d643
$C_{10}H_{10}$: d423
$C_{10}H_{10}BrClO$: b299
$C_{10}H_{10}ClFO$: c121
$C_{10}H_{10}ClNO_2$: c29
$C_{10}H_{10}Cl_2O_3$: d257
$C_{10}H_{10}N_2$: a279, n4, n5
$C_{10}H_{10}N_2O$: m378
$C_{10}H_{10}N_4O_2S$: s21
$C_{10}H_{10}O$: d363, m197, p94, p95
$C_{10}H_{10}O_2$: b63, m66, m198, s2
$C_{10}H_{10}O_3$: b72, m345
$C_{10}H_{10}O_4$: d590, d591, d592, m125, p155, r3
$C_{10}H_{11}BrO$: b375
$C_{10}H_{11}ClO_3$: c212
$C_{10}H_{11}ClO_4$: t336
$C_{10}H_{11}IO_4$: i24
$C_{10}H_{11}N$: p98
$C_{10}H_{11}NO_2$: a24, d514
$C_{10}H_{11}NO_4$: c8, d552a
$C_{10}H_{11}O_2S$: b94
$C_{10}H_{12}$: d292, t80
$C_{10}H_{12}N_2$: a170, b81
$C_{10}H_{12}O$: a89, b77a, b619, e59, e279, i84, i102, m107, m403, p96
$C_{10}H_{12}O_2$: d419, e204, e205, e206, e243, h154, h166, m79, m102, m108, m109, m111, m148, p79, p97, p111, p226
$C_{10}H_{12}O_3$: d487, e47, e195, m306, p71, p102, p235
$C_{10}H_{12}O_4$: d26a, d513, m231, m232, t331
$C_{10}H_{12}O_5$: p245, t335
$C_{10}H_{13}Br$: b280, b351
$C_{10}H_{13}BrO$: b281
$C_{10}H_{13}BrO_2$: b395
$C_{10}H_{13}Cl$: b536, c178
$C_{10}H_{13}NO$: d527, p131
$C_{10}H_{13}NO_2$: m380
$C_{10}H_{13}NS_2$: b95

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_{10}H_{13}N_5O_4$: a67
$C_{10}H_{13}O_2S$: b94
$C_{10}H_{14}$: b521, b522, b523, d340a, d341, d342, i67, i118, i119, i120, t97, t98, t99
$C_{10}H_{14}ClN$: c130
$C_{10}H_{14}NO_5PS$: p3
$C_{10}H_{14}N_2$: n19, p141
$C_{10}H_{14}N_2O$: d383
$C_{10}H_{14}N_2O_4$: b206
$C_{10}H_{14}N_4O_4$: d446
$C_{10}H_{14}O$: c20, i104
$C_{10}H_{14}O$: b585, b586, b587, b588, b591, c20, i104, i121, i122, i123, k2, m376, t162a, t260
$C_{10}H_{14}O_2$: b534, d516, p78
$C_{10}H_{14}O_3$: c7
$C_{10}H_{14}O_4$: b461, e23, e140, m100, t337
$C_{10}H_{14}O_5PS$: p3
$C_{10}H_{15}BrO$: b284
$C_{10}H_{15}N$: b516, b517, b518, b519, d336, d278, e2, e277, i105, i117, m377, p96
$C_{10}H_{15}NO$: b490, c403, d330, e2, p219
$C_{10}H_{15}NO_2$: d517
$C_{10}H_{15}NO_4$: d309
$C_{10}H_{16}$: a65, c2, d595, d648, d736, L7, L8, m467, p25, p175, p176, t10, t11, t259, t400a
$C_{10}H_{16}ClN$: b131
$C_{10}H_{16}Cl_2O_2$: d13
$C_{10}H_{16}N_2$: d388
$C_{10}H_{16}N_2O_4$: d35
$C_{10}H_{16}N_2O_8$: e134
$C_{10}H_{16}O$: c3, c4, c286, d416, d614, d645, L9, L10, p177, p250, t376
$C_{10}H_{16}O_2$: c383, m344
$C_{10}H_{16}O_4$: c4, d319
$C_{10}H_{16}O_4S$: c5
$C_{10}H_{16}O_5$: d317, d366
$C_{10}H_{16}Si$: b132
$C_{10}H_{17}N$: a64, p284
$C_{10}H_{17}NO$: c386, m465
$C_{10}H_{18}$: d2, d3
$C_{10}H_{18}NO_2$: b514
$C_{10}H_{18}N_2O_7$: h124
$C_{10}H_{18}O$: b245, b545, b546, c277, d4, g2, i62, i132, L11, m13, t12, t13, t375
$C_{10}H_{18}O_2$: c379, d17, d650
$C_{10}H_{18}O_3$: d680, t77, t350, v1
$C_{10}H_{18}O_4$: b185, d10, d158, d318, d394, d651, t283
$C_{10}H_{18}O_6$: d481
$C_{10}H_{18}S_2$: b154
$C_{10}H_{19}ClO$: d21
$C_{10}H_{19}N$: d13, d13a, t356
$C_{10}H_{19}NO_2$: d329, e251
$C_{10}H_{20}$: b541, b542, c335, d22
$C_{10}H_{20}Br_2$: d91
$C_{10}H_{20}Cl_2$: d216
$C_{10}H_{20}N_2S_4$: t62
$C_{10}H_{20}O$: b543, b544, c290, d7, d18, d19, d20, e7, e175, m12, m313
$C_{10}H_{20}O_2$: d15, e164, e231, m177, o42
$C_{10}H_{20}O_4$: b496, b530
$C_{10}H_{20}O_5$: p46
$C_{10}H_{20}O_5Si$: t347
$C_{10}H_{21}Br$: b315
$C_{10}H_{21}Cl$: c94
$C_{10}H_{21}I$: i29
$C_{10}H_{21}N$: d353
$C_{10}H_{21}NO$: a226
$C_{10}H_{21}NO_2$: e218
$C_{10}H_{21}NO_4Si$: t271
$C_{10}H_{22}$: d8
$C_{10}H_{22}N_2$: d51
$C_{10}H_{22}O$: d16, d646, d647, d738, t79
$C_{10}H_{22}O_2$: d11, d12, d137
$C_{10}H_{22}O_3$: d699, t433
$C_{10}H_{22}O_4$: t432
$C_{10}H_{22}O_5$: b212, p47, t55
$C_{10}H_{22}O_7$: d735
$C_{10}H_{23}N$: d23, d649, d737
$C_{10}H_{23}NO$: d141
$C_{10}H_{23}NO_2$: d313
$C_{10}H_{24}N_2$: d9, t57, t111
$C_{10}H_{24}N_2O_2$: d731
$C_{10}H_{24}N_4$: b146, t89
$C_{10}H_{24}O_3Si$: i76
$C_{10}H_{28}N_6$: p23
$C_{10}H_{30}O_3Si_4$: d6
$C_{10}H_{30}O_5Si_5$: d5

C_{11}

$C_{11}H_7N$: c327
$C_{11}H_7NO$: n18
$C_{11}H_8O$: n1
$C_{11}H_8O_2$: h157, m321, n3
$C_{11}H_8O_3$: h158, h159, h160
$C_{11}H_9Br$: b370
$C_{11}H_9Cl$: c175
$C_{11}H_9N$: p152
$C_{11}H_{10}$: m318, m319
$C_{11}H_{10}O$: m87, m88
$C_{11}H_{12}ClF$: c140
$C_{11}H_{12}N_2O$: a299
$C_{11}H_{12}N_2O_2$: t454
$C_{11}H_{12}O_2$: b107, c281, e112, m115
$C_{11}H_{12}O_3$: b77, b200, e77, e145, e244
$C_{11}H_{13}ClO$: b527
$C_{11}H_{13}ClO_3$: c259
$C_{11}H_{13}NO$: b124, d666
$C_{11}H_{13}NO_4$: b580
$C_{11}H_{13}N_3O$: a110
$C_{11}H_{14}O$: p44, m114
$C_{11}H_{14}O_2$: a84, b524, b526, d522, e52, e176, p113
$C_{11}H_{14}O_3$: b491, b584, b590, e200
$C_{11}H_{14}O_4$: e158
$C_{11}H_{15}N$: p142
$C_{11}H_{15}NO$: b121, d326
$C_{11}H_{15}NO_2$: b512, d542, e127
$C_{11}H_{16}$: b602, p24, p55
$C_{11}H_{16}N_2$: b119
$C_{11}H_{16}O$: b87, b573, b574, b575, d667, p57
$C_{11}H_{16}O_4$: d800
$C_{11}H_{17}N$: b538, d403
$C_{11}H_{17}NO$: e267
$C_{11}H_{17}NO_2$: b109, m416
$C_{11}H_{17}O_3P$: d344
$C_{11}H_{18}N_2O_2$: t366
$C_{11}H_{18}O$: d372, n106
$C_{11}H_{18}O_5$: d316
$C_{11}H_{19}ClO$: u15
$C_{11}H_{19}NO_2$: e168, o45
$C_{11}H_{20}O$: u12
$C_{11}H_{20}O_2$: e165, i89, u13
$C_{11}H_{20}O_4$: d155, d347, d354, d373
$C_{11}H_{21}BrO_2$: b442
$C_{11}H_{21}N$: u3
$C_{11}H_{21}O_2$: c287
$C_{11}H_{22}$: u12a
$C_{11}H_{22}N_2$: d776
$C_{11}H_{22}O$: u1, u9, u10, u11, u14
$C_{11}H_{22}O_2$: e171, e228, m69, m226, u4, u5, u6
$C_{11}H_{23}Br$: b441
$C_{11}H_{23}I$: i57
$C_{11}H_{24}$: u2

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_{11}H_{24}O$: u7, u8
$C_{11}H_{24}O_6Si$: t444
$C_{11}H_{25}NO_2$: a292
$C_{11}H_{26}N_2$: b555, d166
$C_{11}H_{26}N_2O_6$: b237

C_{12}

$C_{12}H_4Cl_6S_2$: b226
$C_{12}H_6Br_4O_4S$: s28
$C_{12}H_6O_3$: n8
$C_{12}H_6O_{12}$: b20
$C_{12}H_7Cl_6O$: d296
$C_{12}H_8$: a3
$C_{12}H_8Br_2$: d80
$C_{12}H_8Cl_2OS$: b172
$C_{12}H_8Cl_2O_2S$: b171, c223
$C_{12}H_8N_2$: p63
$C_{12}H_8N_2O_4S$: b216
$C_{12}H_8O$: d66
$C_{12}H_8S$: d67
$C_{12}H_9Br$: b273
$C_{12}H_9BrO$: b325, b398
$C_{12}H_9ClO_2S$: c221
$C_{12}H_9N$: c6, d751, n16
$C_{12}H_9NO$: b73, b74, b75
$C_{12}H_9NO_2$: n46, n47
$C_{12}H_9NO_3$: n68, n69
$C_{12}H_9NS$: p67
$C_{12}H_9N_3O_4$: d717
$C_{12}H_{10}$: a2, b138
$C_{12}H_{10}ClN$: a145
$C_{12}H_{10}ClO_3P$: c748
$C_{12}H_{10}ClP$: c118
$C_{12}H_{10}Cl_2Si$: d223
$C_{12}H_{10}Hg$: d758
$C_{12}H_{10}N_2$: a312
$C_{12}H_{10}N_2O$: n79, p90
$C_{12}H_{10}N_2O_2$: n51
$C_{12}H_{10}N_3O_3P$: d764
$C_{12}H_{10}O$: d753, m322, m323, p135, p136
$C_{12}H_{10}OS$: d772
$C_{12}H_{10}O_2$: d436, h89, n14, n15
$C_{12}H_{10}O_2S$: d771, t145
$C_{12}H_{10}O_3$: n12
$C_{12}H_{10}O_3S$: b142
$C_{12}H_{10}O_4$: q1
$C_{12}H_{10}O_4S$: s30
$C_{12}H_{10}S$: d770
$C_{12}H_{10}S_2$: d750
$C_{12}H_{10}Se_2$: d749
$C_{12}H_{11}N$: a130, a131, b122, b123, d743
$C_{12}H_{11}NO$: h115, n13, p70
$C_{12}H_{11}N_3$: p88
$C_{12}H_{11}O_3P$: d763
$C_{12}H_{12}N_2$: b140, d757, p137
$C_{12}H_{12}N_2O$: o68
$C_{12}H_{12}N_2O_2$: b40
$C_{12}H_{12}N_2O_2S$: d47, d48
$C_{12}H_{12}O$: e50
$C_{12}H_{12}O_2Si$: d769
$C_{12}H_{12}O_3$: e78
$C_{12}H_{12}O_6$: t193, t360
$C_{12}H_{13}N$: t68
$C_{12}H_{13}N_3$: d34
$C_{12}H_{13}NO_3S$: p272
$C_{12}H_{14}$: d467
$C_{12}H_{14}N_2$: d46
$C_{12}H_{14}N_4O_2S$: s22
$C_{12}H_{14}O$: b525
$C_{12}H_{14}O_3$: e179
$C_{12}H_{14}O_4$: d391
$C_{12}H_{15}NO$: b121
$C_{12}H_{15}N_3O_3$: t196
$C_{12}H_{15}N_3O_4S$: d42
$C_{12}H_{16}$: b598, c376, m221
$C_{12}H_{16}O_2$: p64
$C_{12}H_{16}O_3$: d298
$C_{12}H_{17}N$: b120
$C_{12}H_{17}NO$: d402
$C_{12}H_{18}$: c338, d473, d474, p116, t453
$C_{12}H_{18}Cl_2N_4OS$: t135
$C_{12}H_{18}N_2$: p186
$C_{12}H_{18}N_2O_2$: i94
$C_{12}H_{18}O$: b552, d479, e4
$C_{12}H_{18}O_2$: b550
$C_{12}H_{18}O_3$: o41
$C_{12}H_{18}O_4$: b463, h58
$C_{12}H_{19}N$: d471
$C_{12}H_{20}O_2$: b202, b296, e112, g3, L12
$C_{12}H_{20}O_3Si$: p160
$C_{12}H_{20}O_4$: d154
$C_{12}H_{20}O_4Sn$: d179
$C_{12}H_{20}O_7$: t278
$C_{12}H_{21}N$: t446
$C_{12}H_{21}NO_3Si$: t345
$C_{12}H_{21}N_3$: t429
$C_{12}H_{22}$: c339, d288
$C_{12}H_{22}BCl$: c95
$C_{12}H_{22}N_2O_8$: d45
$C_{12}H_{22}O$: c337, e5
$C_{12}H_{22}O_2$: d811, e172, m14
$C_{12}H_{22}O_3$: h65
$C_{12}H_{22}O_4$: d168, d384, d597, d787, d805
$C_{12}H_{22}O_6$: d174
$C_{12}H_{22}O_{11}$: L3, L4, m7, s20
$C_{12}H_{23}N$: d289
$C_{12}H_{23}NO$: a308, o47
$C_{12}H_{24}$: d813
$C_{12}H_{24}Cl_2$: d224
$C_{12}H_{24}O$: c326, d817, e8, m459
$C_{12}H_{24}O_2$: d809, e120
$C_{12}H_{24}O_6$: c314
$C_{12}H_{25}Br$: b327
$C_{12}H_{25}Cl$: e119
$C_{12}H_{25}Cl_3Si$: d821
$C_{12}H_{25}I$: i30
$C_{12}H_{25}N$: c340
$C_{12}H_{25}N_3$: i6
$C_{12}H_{26}$: d803
$C_{12}H_{26}O$: d414, d810
$C_{12}H_{26}O_2$: d806, d807
$C_{12}H_{26}O_3$: b151
$C_{12}H_{26}O_4$: d460, t91
$C_{12}H_{26}O_3S$: d820
$C_{12}H_{26}O_5$: t53
$C_{12}H_{26}S$: d808
$C_{12}H_{27}Al$: t322
$C_{12}H_{27}B$: t209
$C_{12}H_{27}BO_3$: t207
$C_{12}H_{27}ClSn$: t213
$C_{12}H_{27}N$: d413, d818, t208
$C_{12}H_{27}O_3P$: t212
$C_{12}H_{27}O_4P$: t211
$C_{12}H_{28}BrN$: t130
$C_{12}H_{28}N_2$: d804
$C_{12}H_{28}O_4Si$: t129
$C_{12}H_{28}O_4Ti$: t164, t165
$C_{12}H_{28}Sn$: t215
$C_{12}H_{29}N$: t323
$C_{12}H_{29}N_3$: b196

C_{13}

$C_{13}H_6Cl_2O_2$: h29
$C_{13}H_8ClNO_3$: c198
$C_{13}H_8Cl_2O$: d205
$C_{13}H_8O$: f3
$C_{13}H_8OS$: t162
$C_{13}H_8O_2$: x3
$C_{13}H_9BrO$: b267
$C_{13}H_9ClO$: c56, c57
$C_{13}H_9ClO_2$: c151
C_3H_9N: a60
$C_{13}H_{10}$: f2
$C_{13}H_{10}ClNO$: a140, a141, d745
$C_{13}H_{10}Cl_2$: d221
$C_{13}H_{10}Cl_2O_2$: m243
$C_{13}H_{10}F_2$: b195
$C_{13}H_{10}N_2$: p91

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_{13}H_{10}N_2O_3$: a235
$C_{13}H_{10}O$: b53, x1
$C_{13}H_{10}O_2$: b139, h103, m68, p92
$C_{13}H_{10}O_3$: d435, d747, p154, r5
$C_{13}H_{10}O_4$: t320
$C_{13}H_{10}O_5$: t88
$C_{13}H_{11}Br$: b326
$C_{13}H_{11}Cl$: c116
$C_{13}H_{11}N$: b102
$C_{13}H_{11}NO$: a124, b5
$C_{13}H_{11}NO_3$: p87
$C_{13}H_{12}$: d759
$C_{13}H_{12}NO_2$: b112
$C_{13}H_{12}N_2$: b54, d754
$C_{13}H_{12}N_2O$: d775
$C_{13}H_{12}N_2S$: d774, t141
$C_{13}H_{12}N_4O$: d746, p89
$C_{13}H_{12}N_4S$: d773
$C_{13}H_{12}O$: d760, h116, h117, m63, p76
$C_{13}H_{12}O_2$: m320
$C_{13}H_{12}O_4$: d32
$C_{13}H_{12}S$: b118
$C_{13}H_{13}ClSi$: c117
$C_{13}H_{13}N$: d761, m238, p93
$C_{13}H_{13}NO_2$: t187
$C_{13}H_{13}N_3$: d755
$C_{13}H_{14}N_2$: d35, m249
$C_{13}H_{14}N_2O_3$: a59
$C_{13}H_{14}N_4O$: d746
$C_{13}H_{15}NO$: i96
$C_{13}H_{16}O_3$: e79
$C_{13}H_{16}O_4$: d389
$C_{13}H_{17}NO_2$: e82
$C_{13}H_{18}O_3$: b117
$C_{13}H_{18}O_5$: t267
$C_{13}H_{20}$: p115
$C_{13}H_{20}O$: i58, i59
$C_{13}H_{22}ClN$: b130
$C_{13}H_{22}N_2$: d290
$C_{13}H_{22}O_3Si$: b129
$C_{13}H_{24}O_2$: e273, i86
$C_{13}H_{24}O_4$: d337
$C_{13}H_{26}$: t265
$C_{13}H_{26}N_2$: m246, t369
$C_{13}H_{26}O$: t263, t264
$C_{13}H_{26}O_2$: e232, t262
$C_{13}H_{27}Br$: b433
$C_{13}H_{28}$: t261
$C_{13}H_{28}O_4$: t431
$C_{13}H_{29}Cl$: c250
$C_{13}H_{29}NO_4$: b176
$C_{13}H_{30}OSn$: t216

C_{14}

$C_{14}H_6Cl_2O_2$: d193
$C_{14}H_7ClO_2$: c41, c42
$C_{14}H_8O_2$: a298
$C_{14}H_8O_4$: d426
$C_{14}H_9Br$: b391
$C_{14}H_9ClO_3$: c63
$C_{14}H_9Cl_5$: b173
$C_{14}H_9NO_2$: a108, a109
$C_{14}H_{10}$: a297, d742, p62
$C_{14}H_{10}ClNO_3$: a144
$C_{14}H_{10}Cl_2O_4$: b168
$C_{14}H_{10}Cl_4$: b169
$C_{14}H_{10}N_2O_2$: d36, d37, d38, d39
$C_{14}H_{10}O_2$: b35
$C_{14}H_{10}O_3$: b45, b64, x2
$C_{14}H_{10}O_4$: b141, d69, b71a
$C_{14}H_{10}O_4S_2$: d796
$C_{14}H_{11}N$: d741, p123
$C_{14}H_{11}NOS$: a50
$C_{14}H_{12}$: d415, s9
$C_{14}H_{12}Cl_2O$: b170
$C_{14}H_{12}N_2O$: b38
$C_{14}H_{12}N_2O_2$: b36
$C_{14}H_{12}O$: a34, d26, m145
$C_{14}H_{12}O_2$: b46, b83, b84, b113, d740
$C_{14}H_{12}O_3$: b37, b100, b125, h144
$C_{14}H_{13}ClO$: c169
$C_{14}H_{13}N$: e104, i9
$C_{14}H_{13}NO$: b82, d739
$C_{14}H_{13}NO_2$: b50
$C_{14}H_{14}$: d752
$C_{14}H_{14}N_2$: a168
$C_{14}H_{14}N_2O$: m240
$C_{14}H_{14}N_2O_3$: a315
$C_{14}H_{14}O$: d73
$C_{14}H_{14}OS$: b223
$C_{14}H_{14}O_2$: b114
$C_{14}H_{14}O_4$: d33
$C_{14}H_{14}S_2$: b222, d72
$C_{14}H_{15}N$: d71
$C_{14}H_{16}N_2O_4$: b207
$C_{14}H_{16}O_2Si$: d503
$C_{14}H_{16}O_4$: d340
$C_{14}H_{18}N_2O_2$: m132
$C_{14}H_{18}O$: p56
$C_{14}H_{18}O_4$: d343
$C_{14}H_{18}O_7$: p21
$C_{14}H_{19}O_3$: d293
$C_{14}H_{22}O$: d160, d161, d162, d163
$C_{14}H_{22}O_2$: d145
$C_{14}H_{22}O_3$: d153
$C_{14}H_{22}O_4$: h59
$C_{14}H_{22}O_6$: t281
$C_{14}H_{22}O_7$: t52
$C_{14}H_{23}N$: d142
$C_{14}H_{23}N_3O_{10}$: d299
$C_{14}H_{26}O_2$: i87
$C_{14}H_{26}O_3$: h10
$C_{14}H_{26}O_4$: d152, d395, d459
$C_{14}H_{27}ClO$: t46
$C_{14}H_{28}$: t47
$C_{14}H_{28}O$: d822
$C_{14}H_{28}O_2$: d815, e272, t44
$C_{14}H_{29}Br$: b423
$C_{14}H_{29}O_4$: b156
$C_{14}H_{30}$: t43
$C_{14}H_{30}O$: t45
$C_{14}H_{30}O_2Sn$: d136
$C_{14}H_{31}N$: d602
$C_{14}H_{32}N_2O_4$: t90
$C_{14}H_{32}OSn$: t214

C_{15}

$C_{15}H_{10}N_2O_2$: m247
$C_{15}H_{10}O_2$: b105, m136, p122
$C_{15}H_{11}NO$: d762
$C_{15}H_{11}NO_2$: m128
$C_{15}H_{12}N_2O_2$: d756
$C_{15}H_{12}O$: c23
$C_{15}H_{12}O_2$: d68
$C_{15}H_{13}NO$: a13
$C_{15}H_{14}O$: d767
$C_{15}H_{14}O_2$: b49, d768, h169
$C_{15}H_{14}O_3$: b116, m239
$C_{15}H_{16}O$: c316a
$C_{15}H_{16}O_2$: e189, i113
$C_{15}H_{17}N$: b96a
$C_{15}H_{17}N_3$: d797
$C_{15}H_{20}O_6$: e184
$C_{15}H_{22}O_3$: d117, e174
$C_{15}H_{22}O_5$: o46
$C_{15}H_{23}N$: b583
$C_{15}H_{24}$: t327
$C_{15}H_{24}O$: d156
$C_{15}H_{26}O_6$: g20
$C_{15}H_{28}O_2$: d816, i112
$C_{15}H_{29}N$: p12
$C_{15}H_{30}N_2$: t368
$C_{15}H_{30}O$: p13
$C_{15}H_{30}O_2$: m428
$C_{15}H_{32}$: p11
$C_{15}H_{32}O_{10}$: t409
$C_{15}H_{33}NO_6$: t443

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

C_{16}

$C_{16}H_{10}$: b52, f1, p255
$C_{16}H_{11}NO_2$: p153
$C_{16}H_{12}N_4O_9S_2$: t5
$C_{16}H_{13}N$: p132, p133
$C_{16}H_{14}$: d744, e71
$C_{16}H_{14}O_2$: b93
$C_{16}H_{14}O_6S$: s29
$C_{16}H_{16}O_2$: b47
$C_{16}H_{16}O_3$: d515
$C_{16}H_{18}ClN_3S$: m248
$C_{16}H_{19}ClSi$: b537
$C_{16}H_{20}N_2$: d74
$C_{16}H_{20}N_2O$: b178
$C_{16}H_{20}O_2Si$: d302
$C_{16}H_{22}O_4$: d165, d410
$C_{16}H_{22}O_{11}$: g9
$C_{16}H_{24}N_2$: d150
$C_{16}H_{26}O_3$: d814
$C_{16}H_{26}O_7$: t54
$C_{16}H_{28}O$: c346
$C_{16}H_{30}O_2$: d819
$C_{16}H_{30}O_4$: b158, d157, d167, d360
$C_{16}H_{32}$: h37
$C_{16}H_{32}O$: e10
$C_{16}H_{32}O_2$: h34
$C_{16}H_{33}Br$: b345
$C_{16}H_{33}Cl$: c148
$C_{16}H_{33}I$: i35
$C_{16}H_{33}NO$: d359
$C_{16}H_{34}$: h4, h31, h36
$C_{16}H_{34}O$: d729, h35
$C_{16}H_{34}O_2$: h32
$C_{16}H_{34}O_4$: b157
$C_{16}H_{34}S$: d720, h33
$C_{16}H_{35}N$: d728, h37
$C_{16}H_{35}O_3P$: b192
$C_{16}H_{36}BF_4N$: t25
$C_{16}H_{36}BrN$: t21
$C_{16}H_{36}BrP$: t29
$C_{16}H_{36}Br_3N$: t26
$C_{16}H_{36}ClN$: t22
$C_{16}H_{36}IN$: t24
$C_{16}H_{36}O_4Si$: t28
$C_{16}H_{36}Sn$: t30
$C_{16}H_{37}NO_4S$: t23

C_{17}

$C_{17}H_{12}O_3$: p118, p119
$C_{17}H_{13}N_3O_5S_2$: p173
$C_{17}H_{15}N_2O$: d355
$C_{17}H_{16}O_4$: d75, p194
$C_{17}H_{18}N_2O_4$: p193
$C_{17}H_{18}O_2$: b589
$C_{17}H_{18}O_3$: b592
$C_{17}H_{18}O_4$: b203
$C_{17}H_{20}N_2O$: b178
$C_{17}H_{20}N_4O_6$: r8
$C_{17}H_{21}NO_4$: b291
$C_{17}H_{22}N_2$: m245
$C_{17}H_{23}NO_3$: a305
$C_{17}H_{24}O_6$: b492
$C_{17}H_{25}NO_2$: m15
$C_{17}H_{27}NO_2$: e170
$C_{17}H_{28}NO$: d149
$C_{17}H_{28}O_7$: d181
$C_{17}H_{34}O_2$: m269a, i131
$C_{17}H_{34}O_4$: b160
$C_{17}H_{36}$: h1
$C_{17}H_{36}O$: h1a
$C_{17}H_{37}N$: m236

C_{18}

$C_{18}H_{12}$: b6, b7
$C_{18}H_{12}N_5O_6$: d766
$C_{18}H_{14}$: t7, t8, t9
$C_{18}H_{14}O_8$: d70
$C_{18}H_{15}As$: t412
$C_{18}H_{15}B$: t414
$C_{18}H_{15}ClSn$: c268, t425
$C_{18}H_{15}N$: t410
$C_{18}H_{15}NO_2$: e116
$C_{18}H_{15}N_3Si$: a310
$C_{18}H_{15}OP$: t421
$C_{18}H_{15}O_3P$: t422
$C_{18}H_{15}O_4P$: t419
$C_{18}H_{15}P$: t420
$C_{18}H_{15}Sb$: t411
$C_{18}H_{16}OSn$: t426
$C_{18}H_{16}O_2$: b520, d280
$C_{18}H_{16}Si$: t423
$C_{18}H_{18}O_3$: e81
$C_{18}H_{20}N_2O_2$: e152
$C_{18}H_{20}O$: b548
$C_{18}H_{20}O_2$: b48
$C_{18}H_{22}$: b182
$C_{18}H_{26}O_6$: e185
$C_{18}H_{30}O$: t210
$C_{18}H_{30}O_2$: o7
$C_{18}H_{32}N_4O_{14}$: d364
$C_{18}H_{32}O_2$: o1
$C_{18}H_{32}O_{16}$: r1
$C_{18}H_{33}ClO$: o13
$C_{18}H_{34}O_2$: o10, o11
$C_{18}H_{34}O_4$: d143
$C_{18}H_{36}$: o8
$C_{18}H_{36}O$: e13, o12
$C_{18}H_{36}O_2$: e157, o5
$C_{18}H_{37}Br$: b384
$C_{18}H_{37}Cl$: c203a
$C_{18}H_{37}Cl_3Si$: o17
$C_{18}H_{37}I$: i43
$C_{18}H_{37}N$: o9
$C_{18}H_{37}NO$: o2
$C_{18}H_{38}$: o3
$C_{18}H_{38}O$: o6
$C_{18}H_{38}S$: o4
$C_{18}H_{39}ClSi$: t315
$C_{18}H_{39}N$: o15, t313
$C_{18}H_{39}O_7P$: t435
$C_{18}H_{40}Si$: t316

C_{19}

$C_{19}H_{15}Br$: b440, t417
$C_{19}H_{15}Cl$: c267, t418
$C_{19}H_{16}$: t415
$C_{19}H_{16}O$: t416
$C_{19}H_{18}BrP$: m458
$C_{19}H_{19}N_7O_6$: f31
$C_{19}H_{20}Br_4O_4$: i110
$C_{19}H_{20}O_4$: b88
$C_{19}H_{22}N_2O$: c276
$C_{19}H_{30}O_5$: m252
$C_{19}H_{31}N$: d24
$C_{19}H_{34}ClN$: b127
$C_{19}H_{36}O_2$: m347
$C_{19}H_{37}NO$: o16
$C_{19}H_{38}O_2$: i109, m346
$C_{19}H_{40}$: n89, t114

C_{20}

$C_{20}H_{10}Br_2O_5$: d105
$C_{20}H_{12}$: b56, b57, d65
$C_{20}H_{12}O_5$: f4
$C_{20}H_{14}O_4$: d765, p66
$C_{20}H_{15}Br$: b439
$C_{20}H_{18}O_2Sn$: t424
$C_{20}H_{19}N_3$: b2
$C_{20}H_{20}BrOP$: h136
$C_{20}H_{32}O_5$: d782
$C_{20}H_{24}N_2O_2$: q2
$C_{20}H_{26}O_4$: d291
$C_{20}H_{27}O_3P$: i90
$C_{20}H_{30}O_2$: a1
$C_{20}H_{30}O_6$: b184
$C_{20}H_{31}N$: d20
$C_{20}H_{34}O_4$: b159
$C_{20}H_{36}O_2$: e229

TABLE 1.14 Empirical Formula Index of Organic Compounds (*Continued*)

The alphanumeric designations are keyed to Table 1.15.

$C_{20}H_{38}O_2$: e230
$C_{20}H_{38}O_4$: b187
$C_{20}H_{40}$: i2
$C_{20}H_{40}O$: o18
$C_{20}H_{42}$: i1

C_{21} to C_{23}

$C_{21}H_{15}NO$: b143
$C_{21}H_{21}N$: t198
$C_{21}H_{21}O_4P$: t452
$C_{21}H_{22}N_2O_2$: s10
$C_{21}H_{24}O_2$: b144
$C_{21}H_{28}N_2O$: b177
$C_{21}H_{36}O$: p14
$C_{21}H_{40}O_2$: o14
$C_{21}H_{45}N_3O_{12}Si_3$: t448
$C_{22}H_{23}N_3O_9$: a306
$C_{22}H_{26}O$: b181
$C_{22}H_{30}O_2S$: t140
$C_{22}H_{34}O_4$: b547, d463
$C_{22}H_{42}O_8$: b152
$C_{22}H_{44}O_2$: b581, i75
$C_{22}H_{46}$: d801
$C_{22}H_{46}O$: d802
$C_{22}H_{48}N_2$: t27
$C_{23}H_{18}BrO_2P$: c18
$C_{23}H_{26}N_2O_4$: b447
$C_{23}H_{42}O_2$: b581a

C_{24} to C_{29}

$C_{24}H_{16}N_2O_2$: b218
$C_{24}H_{18}$: t413
$C_{24}H_{20}BNa$: t126
$C_{24}H_{20}Sn$: t128
$C_{24}H_{27}NO_2$: e169
$C_{24}H_{38}O_4$: b193, d374, d466, d466a
$C_{24}H_{40}O_5$: c275
$C_{24}H_{46}O_4$: d725, d812
$C_{24}H_{50}$: t41
$C_{24}H_{51}N$: t406
$C_{24}H_{51}O_3P$: t438
$C_{24}H_{54}OSn_2$: b224
$C_{25}H_{30}ClN_3$: c315
$C_{25}H_{34}Cl_6O_4$: b189
$C_{25}H_{48}O_4$: d465
$C_{26}H_{26}N_2O_2S$: b153
$C_{26}H_{42}O_2$: d138
$C_{26}H_{42}O_4$: d464
$C_{26}H_{47}O_3P$: d462
$C_{26}H_{46}O_8$: t312
$C_{26}H_{50}O_4$: b190
$C_{27}H_{42}O$: c274
$C_{27}H_{50}ClN$: b96
$C_{28}H_{31}ClN_2O_3$: r6
$C_{28}H_{32}$: t127
$C_{28}H_{50}O_8$: t314
$C_{28}H_{54}O_6Sn$: b601
$C_{29}H_{44}O_2$: m244
$C_{29}H_{50}O_7$: p20

C_{30} to C_{57}

$C_{30}H_{43}FO_2P$: e188
$C_{30}H_{46}O_2$: e187
$C_{30}H_{50}$: s8
$C_{30}H_{58}O_4S$: d295
$C_{30}H_{62}$: s7
$C_{30}H_{63}O_3P$: t324
$C_{32}H_{64}O_4Sn$: d178
$C_{32}H_{66}$: d823
$C_{36}H_{75}O_3P$: d726
$C_{39}H_{74}O_6$: g21
$C_{40}H_{82}O_6P_2$: b217
$C_{42}H_{82}O_4S$: d727
$C_{45}H_{86}O_6$: g25
$C_{51}H_{98}O_6$: g24
$C_{55}H_{98}O_6P_2$: i111
$C_{57}H_{104}O_6$: g23

TABLE 1.15 Physical Constants of Organic Compounds

See also the special tables of polymers, rubbers, fats, oils, and waxes.

Names of the compounds in the table starting on p. 1.76 are arranged alphabetically. Usually substitutive nomenclature is employed; exceptions generally involve ethers, sulfides, sulfones, and sulfoxides. Each compound is given a number within its letter classification; thus compound c209 is 3-chlorophenol. Section 1.1, Nomenclature of Organic Compounds, should be consulted to familiarize oneself with present nomenclature systems.

Synonyms or Alternate Names are found at the bottom of each spread in their alphabetical listing; the number following the same refers to the numerical place of this compound in the table. For example, epichlorohydrin, c120, indicates that this compound is found listed under the name 1-chloro-2,3-epoxypropane.

Formulas are presented in semistructural form when no ambiguity is possible. Complicated systems are drawn in complete structural form and located at the bottom of each page and keyed to the number of the entry.

Beilstein Reference. In this column is found the reference to the volume and page numbers of the fourth edition of Beilstein, *Handbuch der Organischen Chemie* (Springer-Verlag, New York, 1918). Thus the entry 9, 202 refers to an entry in volume 9 appearing on page 202. When the volume number has a superscript attached, reference is made to the appropriate supplementary volume. For example, 12^2, 404 indicates that the compound will be found listed in the second supplement to volume 12 on page 404. The earliest Beilstein entry is listed. Supplementary information may be found in the supplements to the basic series; such coordinating references (series number, volume number, and page number of the main edition) along with the system number are found at the top of each *odd-numbered page.* Similarly, a back reference such as H93; E II 64; E III 190 in a volume of Supplementary Series IV means that previous items on this compound are found in the same volume of the