

ganic chemistry from the very origins of chemical science to the present day.

Corresponding to its character of long-term balance, the Handbook always has, and will have, definite gaps from the immediate present in its individual volumes. This is a fact which will continue to exist despite all efforts to approach the present moment.

A chemist requires another information source in addition to the Handbook for information. Considerations at the Gmelin Institute, as well as those on a broader plane relating to forming a documentation center for chemistry in Germany, have recently resulted in establishing the Arbeitsgemeinschaft Chemie Dokumentation e.V. (Council for Chemical Documentation). Undertaking to create and staff a centralized documentation agency encompassing the entire field of chemistry follows from a realization that a sufficiently powerful means must be devised to cope with all of the tasks confronting individual documentation and information facilities—tasks which threaten to overwhelm such facilities in the relatively near future. However, the idea that an individual paper could be evaluated, arranged, and indexed by a large number of documentation centers made it seem reasonable to collect these centers into a single combined agency. It has proven to be desirable that the several institutions for chemical documentation agree upon and support common interests within this over-all concept, without losing their own individuality and assigned tasks. It was thus thought that a paper should be evaluated only by a single collaborator, with the resultant material being worked up in such a way as to satisfy simultaneously the requirements of the several information transmission arrangements being considered—i.e., express information services, handbooks, and computer services. The Handbook has thus acquired an essential position in the information field.

A computer can serve as an information source spanning the period of time between the literature closing date

of the Handbook and the present. Reference 2 discusses the position of the Handbook with respect to the computer. Reference is made here to the opinions of E. Pietsch³ and F. Richter⁴ according to whom "the mere arrangement of information promptly in a defined manner, such as is made possible by a computer, will not provide the final form which can serve satisfactorily the progress of science. A large number of bits of information summed up into a mosaic does not really provide a picture of the state of knowledge in a discipline. The Handbook does not merely give citations but rather provides a text, and is in fact a critically reworked text, and gives many kinds of stimuli among the topics near the subject being sought. In this respect, it far exceeds the performance of a machine."

Consequently, only a systematic Handbook can offer the scientist an opportunity for comparative evaluation and thus encourage creative initiative and effort; a computer is in a position only to provide answers to already formulated definite questions in an equally definite form. Although it is certainly important to have a computer available to aid in data compilation, the Handbook must retain its fundamental importance well into the future as a most important chemical information tool.

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Proposed Rules for Nomenclature for Compounds of Phosphorus, Sulfur, and Related Elements

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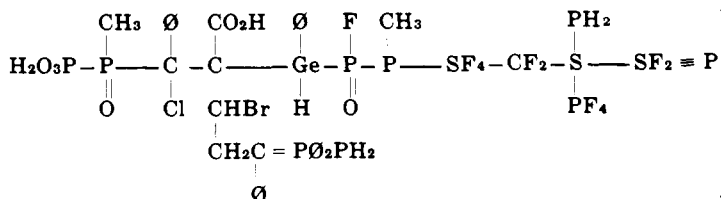
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A subcommittee of the ACS Committee on Inorganic Nomenclature has been meeting for a number of years to develop a rational system of nomenclature for the compounds of phosphorus and related elements. The report of the subcommittee is presented here at the suggestion of the parent committee for general consideration and comment. The membership of the subcommittee has included: A. F. Clifford (Chairman), Roy M. Adams (ex officio), Gail H. Birum, James E. Huheey, A. F. Isbell, Fred Leighton (deceased), Fred McCollough, Patricia M. McDonnell, George W. Parshall, Rudi Raetz (deceased), and Russell J. Rowlett, Jr.

The system of nomenclature for compounds of phosphorus, sulfur, and related elements proposed in the following pages has been developed in answer to objections to systems, proposed and adopted, which have been suggested in the past. As the known chemistry of phosphorus and related elements becomes more complicated and as molecules containing atoms of more different elements including nonsubstituent carbon become known, it is increasingly

necessary to have an internally consistent system of nomenclature for such compounds. Inasmuch as it seems highly inadvisable to create for these elements yet another new system which is different from that of other elements, every attempt has been made to build upon an existing accepted system—specifically the "a" system—augmenting it as necessary to meet the more complex demands of the chemistry of these elements. The choice of a system

designed for covalent compounds was dictated by the predominantly covalent nature of compounds of most of the elements on the right side of the periodic table. For example, the bonding of phosphorus to adjacent atoms, with the possible exception of certain salt-like phosphides, is almost always covalent. If the nomenclature for these elements were consistent with organic nomenclature, it would be possible to name such compounds as



without having to change nomenclature systems in the middle of the name. With this in mind, one of the cardinal aims of the Committee may be stated as follows:

Since most of the elements on the right of the transition elements in the periodic table are characterized by the covalency of their union with other elements and their proclivity to form catenation compounds, the nomenclature should follow the principles already established for covalent (i.e., carbon) compounds. However, it must take account of the greater complexity of the chemistry of the inorganic elements in terms of variation of valence and coordination number.

For this same reason it seemed advisable not to use coordination nomenclature for ions such as PF_6^- , since coordination nomenclature for similar anionic centers, for example in such compounds as



would be inconsistent with the covalent nomenclature used for the rest of the molecule.

Another concern of the Committee was that the naming of unicentric and polycentric compounds be mutually consistent, so that it would not be necessary to change systems when the number of central atoms in the compound changes. Since certainly the problems of naming polycentric compounds are the more formidable, it was felt the needs of the nomenclature of polycentric compounds should dictate the choice of systematic names for unicentric compounds.

A problem not met in organic nomenclature but which must be dealt with in the case of the nomenclature of these elements is that of variable valence. Various suggestions have been made for dealing with this problem—including ignoring it. One of the serious suggestions has been to classify compounds according to the coordination number of the central atom (generally with inclusion of nonbonding electron pairs in the enumeration). This approach, although having considerable merit, was rejected by the Committee for several reasons:

If coordination number were to be used in the same sense as organic unsaturation to define categories, at least five such categories would be required in the case of phosphorus and up to eight for some other elements.

If coordination number were used in the manner of coordination nomenclature, it would be required that every group on every hetero atom be individually enumerated, adding materially to the cumbersomeness of the name.

Use of coordination number for categorization would place in the same categories substances which chemists intuitively

class as different and place in different categories substances which chemists intuitively class together. Thus PCl_5 and PCl_5^- would be in different categories, although they are both usually considered to be examples of phosphorus(V). Again, this would place PF_5 and PF_4^- in the same category although PF_5 is normally considered to contain phosphorus(V) and is non-oxidizable, whereas PF_4^- is normally considered to contain phosphorus(III) and is oxidizable.

Another approach would be to use Stock numbers to indicate oxidation states. There are, however, at least two serious objections to this. The first lies merely in the awkwardness of having to enumerate a list of roman numerals of oxidation state in combination with arabic numerals of position. This would be particularly awkward in oral usage. [See, for example, the application of this system in J. CHEM. Doc. 4, 91 (1964), Table IX.] The second lies in the difficulty in defining the Stock oxidation state—for example, the compound $\text{H}_3\text{P}_2\text{O}_6$ according to the Stock system contains phosphorus(IV). However, it would be extremely awkward in the name of a complex molecule in order to define oxidation state to have to take into account whether a particular phosphorus atom is attached to another phosphorus or not. In the Stock system, the P in $\text{R}_2\text{PO}_2\text{H}$ may have any number of different arbitrary oxidation states depending on whether $\text{R} = \text{H}$, alkyl, or one or two other phosphorus atoms and also on the nature of the substituents on the phosphorus atoms—this despite the fact that the gross electronic structures do not change.

The system which is recommended here is based on the number of unshared pairs of electrons on each atom. This corresponds to the chemist's intuitive oxidation state regardless of coordination number or nature of attached atoms.

The distinguishing factor which differentiates one typical series of compounds of an element from other such series is not the number of ligand or attached groups, but rather, the number of nonbonding electrons in the valence level. This fact is recognized implicitly in the Stock numbering system, in which the formal oxidation state is a function of the number of nonbonding electrons for unicentric compounds (although not, it should be reiterated, of polycentric ones). Thus, all unicentric compounds of phosphorus having no nonbonding electrons are P(V); all having one nonbonding electron pair are P(III), and so forth, where nonbonding electrons are taken to be those not involved in sigma bonding. Likewise, all unicentric compounds of manganese having no nonbonding electrons are Mn(VII), all having one are Mn(VI), all having five are Mn(II), and so forth. For catenation compounds, which are most important for the nonmetals and metalloids, however, the Stock designation loses this meaning, as already shown in the case of hypophosphoric acid, which is a compound of P(IV), electronically similar to phosphoric acid containing P(V). A means of recognizing im-

mediately the electronic structures of such elements in catenation compounds would be desirable. Consequently, a series of suffixes is recommended to be used to designate oxidation states in exactly the same way as the suffixes -ane, -ene, and -yne are used to designate degrees of unsaturation in carbon compounds. This system, being used in the same way as organic designation of unsaturation, has the distinct advantages of being completely compatible with organic-type nomenclature and of not requiring reiteration of a designation of oxidation state or coordination number for each atom in the chain.

An extremely important class of covalent inorganic compounds is that having alternating atoms in the chains (Van Wazer's amoebo compounds). To have to specify the nature and position of each such atom is unnecessary and unduly complicating when the alternative of considering the atoms two at a time is available. Consequently, it is recommended that a slightly modified (or, actually, restricted) siloxane-type nomenclature be allowed as an exception to the strict rules.

Another extremely important class of compounds, especially for phosphorus, is that of the polycentric acids. These take on such a variety of forms that to have to give them nonfunctional names—i.e., naming and locating each oxo and hydroxy group—would produce excessively cumbersome names. Consequently, it is recommended that the names of phosphorus acids be derived from those of the hydrides in a manner similar to that in which those of the alkanic acids are derived from those of the alkanes. However, in deference to the inorganic inclination to do away with functional nomenclature, this is the only functional group so considered.

Although there is considerable objection to accepting the concept of multiple bonding in naming inorganic compounds, there are cases where it undeniably occurs and can occur within the backbones of long-chain molecules. Examples include many possible phosphorus and sulfur imines and methylenes. In answer to the argument that the multiplicities of these bonds are not integral, it must be pointed out that neither are those in many organic compounds—for example, in the isocyanides and in the imines. The principal advantage to allowing the designation of bond multiplicity, however, is a device to allow

The alternative to this would be to designate and locate each charge center, which under these conditions would be as uncertain a quantity as the bond multiplicity. This would tremendously complicate the naming. Consequently, it is recommended that formal bond multiplicities be recognized and designated in the organic manner. (Isolated charge centers must, of course, be dealt with as such.)

A further criterion considered by the Committee was that the system developed be equally applicable to all elements on the right of the copper family in the periodic table, "lest there arise a jungle of nomenclatures," one for each element, each incompatible with the others. The Committee feels that this aim has been accomplished. An example of the application of this system to halogen nomenclature is reported in J. CHEM. DOC. 4, 91 (1964).

It is recognized, of course, that the systematic names for unicentric compounds which are recommended here will no more replace in common usage the current common names than the name ethanoic acid has replaced acetic acid. However, just as seldom used Geneva names for organic compounds provide the basis for the more complicated names of more complex molecules derived from them, so can the recommended names for monophosphorus compounds be used in systematic fashion as the basis for names of much more complex molecules.

PROPOSED SYSTEM FOR THE NOMENCLATURE OF COMPOUNDS OF PHOSPHORUS, SULFUR, AND RELATED ELEMENTS

PART I. UNICENTRIC COMPOUNDS

1. Parent Structures

1.1 Parent structures, which need not necessarily have independent existence, are the neutral hydrides having even numbers of unshared electrons. These are named by adding to the name of the central atom (appropriately curtailed) suffixes indicating the number of unshared pairs of electrons assigned to the central atom. The suffixes are

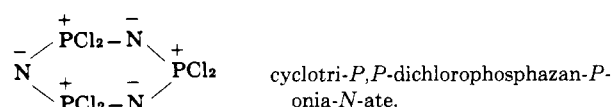
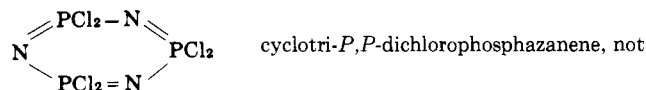
Number of unshared pairs	Suffix
0	-ane
1	-ine
2	-uane
3	-uine

Typical parent hydrides are

GaH ₃	SiH ₄	AsH ₃	SH ₆	ClH ₇	XeH ₈
gallane	silane	arsane	sulfane	chlorane	xenane
:GaH	:SiH ₂	:AsH ₃	:SH ₄	:ClH ₅	:XeH ₆
galline	siline	arsine	sulfine	chlorinine	xenine
		:AsH	:SH ₂	:ClH ₃	:XeH ₄
		arsuane	sulfuane	chloruane	xenuane
				:ClH	:XeH ₂
				chloruine	xenuine

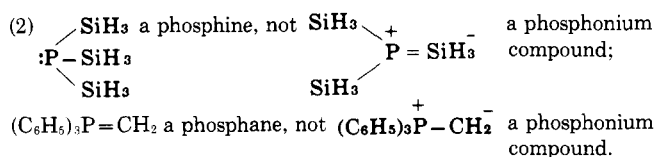
(1)	ZnH ₂
	zincane

the atoms involved to be considered neutral as long as there are adjacent compensating formal charges—e.g.,



Exceptions: —S— in heteroatomic chains = thia, and as a bivalent substituent = thio.

1.11 In the event of delocalization of electrons, which might cause doubt in the assignment, for the purposes of nomenclature only, the electrons are considered to be located in such a way as to reduce formal charges to a minimum. E.g.,



2. Structures Formed by Substitution

2.1 Oxygen Acids. In a manner similar to that in which the names of the alkanic acids are derived from those of the alkanes—e.g., ethanoic acid from ethane—the names of the oxygen acids are derived from those of the parent hydrides by replacement of hydrogen by its equivalent in hydroxy and oxo groups and addition of aquo groups to attain the appropriate standard coordination number for the central atom and adding -oic acid, -dioic acid, etc., to the name of the hydride, dropping the final e if necessary. In establishing the coordination number, each unshared electron pair accounts for one coordination posi-

tion. The standard coordination numbers (S.C.N.) used in forming the names of the acids are those usually observed in the most common unicentric oxy acids. They are specifically defined as follows:

(3)	Period	2	3,4	5,6	7,8
	S.C.N.	3	4	6	8

2.11 Acid Functionality. For acids not having aquo groups attached to the central atom, the number of acid equivalents is designated by enumerating the hydroxyl groups, and affixing the appropriate numerical prefix to the suffix -oic acid, e.g.,

(4) $(\text{HO})_2\text{PHO}$ phosphanedioic acid

For acids having aquo groups attached to the central atom, the number of acid equivalents is designated by enumerating the aquo groups, e.g.,

(5) $(\text{H}_2\text{O})_2\text{Sn}(\text{OH})_4$ stannanedioic acid

Further examples include

(6)	Period	S.C.N.										
	2	3	(a)	HOCHO methanoic								
			(b)	(HO) ₂ CO methanedioic								
			(c)	HONO ₂ nitranic	(d)	HOÑO nitruinoic	(e)	HOÑ: nitruanoic				
	3,4	4	(f)	(HO) ₄ Si silanetetroic								
			(g)	HOPH ₂ O* phosphanoic	(h)	HOḤH ₂ phosphinoic	(i)	HOḤ(OH) ₂ phosphuanoic				
			(j)	(HO) ₂ PHO # phosphanedioic	(k)	(HO) ₂ PH phosphinedioic						
			(l)	(HO) ₃ PO† phosphanetrioic	(m)	(HO) ₃ P: phosphinetrioic						
			(n)	(HO) ₂ SO ₂ sulfanedioic	(o)	(HO) ₂ ŠO sulfinedioic	(p)	(HO) ₂ Š: sulfuanedioic				
			(q)	HOClO ₃ chloranoic	(r)	HOČlO ₂ chlorinoic	(s)	HOČlO chloruanoic	(t)	HOČl: chloruinoic		
	5,6	6	(u)	(HO) ₅ Sb(OH) ₂ stibanoic	(v)	(HO) ₃ Šb(OH) ₂ stibinedioic	(w)	HOŠb(OH) ₂ stibuanetrioic				
			(x)	(HO) ₆ Te telluranehexoic	(y)	(HO) ₄ Ṫe(OH) ₂ tellurinoic	(z)	(HO) ₂ Ṫe(OH) ₂ telluranedioic				
			(aa)	(HO) ₅ IO iodanepentoic	(ab)	(HO) ₅ I: iodininepentoic	(ac)	(HO) ₃ Ī(OH) ₂ ioduanoic	(ad)	HOĪ(OH) ₂ ioduinedioic		
			(ae)	(HO) ₄ XeO ₂ xenanetetroic	(af)	(HO) ₄ ṲeO xeninetetroic	(ag)	(HO) ₄ Ṳe xenuanetetroic	(ah)	(HO) ₂ Ṳe(OH) ₂ xenuinoic		
	7,8	8	(ai)	(HO) ₅ Eb(OH) ₂ ekabismuthanetrioic	(aj)	(HO) ₃ Ėb(OH) ₂ ekabismuthinetetroic	(ak)	HOĖb(OH) ₂ ekabismuthuane pentoic				

[*Hypophosphorous, # Phosphorous, † (Ortho)phosphoric]

N.B. The common formulas for the preceding acids are as follows:

(a)	HCO_2H				
(b)	H_2CO_3				
(c)	HNO_3	(d)	HNO_2	(e)	HNO
(f)	H_4SiO_4				
(g)	H_3PO_2	(h)	H_3PO	(i)	$\text{HPO} \cdot \text{H}_2\text{O}$
(j)	H_3PO_3	(k)	$(\text{HO})_2\text{PH}$		
(l)	H_3PO_4	(m)	$(\text{HO})_3\text{P}$		
(n)	H_2SO_4	(o)	H_2SO_3	(p)	H_2SO_2
(q)	HClO_4	(r)	HClO_3	(s)	HClO_2
(u)	H_3SbO_6	(v)	$\text{Sb}(\text{OH})_3 \cdot 2\text{H}_2\text{O}$	(w)	$\text{SbOH} \cdot 3\text{H}_2\text{O}$
	or $\text{Sb}(\text{OH})_5 \cdot \text{H}_2\text{O}$				
(x)	H_6TeO_6	(y)	$\text{H}_2\text{TeO}_3 \cdot \text{H}_2\text{O}$	(z)	$\text{H}_2\text{TeO}_2 \cdot 2\text{H}_2\text{O}$
(aa)	H_5IO_6	(ab)	$\text{HIO}_3 \cdot 2\text{H}_2\text{O}$	(ac)	$\text{HIO}_2 \cdot 2\text{H}_2\text{O}$
			or H_5IO_5		or $\text{H}_5\text{IO}_3 \cdot \text{H}_2\text{O}$
(ae)	H_4XeO_6	(af)	H_4XeO_5	(ag)	H_4XeO_4
(ai)	$\text{H}_7\text{EbO}_6 \cdot 2\text{H}_2\text{O}$	(aj)	$\text{Eb}(\text{OH})_3 \cdot 4\text{H}_2\text{O}$	(ak)	$\text{EbOH} \cdot 5\text{H}_2\text{O}$
	or $\text{Eb}(\text{OH})_5 \cdot 3\text{H}_2\text{O}$				
				(t)	HClO
				(ad)	$\text{HIO} \cdot 2\text{H}_2\text{O}$
				(ah)	$\text{H}_2\text{XeO}_2 \cdot \text{H}_2\text{O}$

The naming of such acids as $\text{CH}_3\text{PO}_3\text{H}_2$ is discussed in section 2.111.

2.111 Substituted Acids. In the case of acids of standard coordination number having groups other than hydroxy, oxo, and aquo substituted for hydrogen in the parent hydride or substituted hydride, as, for example, $\text{CH}_3\text{PO}_3\text{H}_2$, the naming procedure is similar, e.g.,

- | | |
|---|---|
| (7) $\text{CH}_3\text{PO}_3\text{H}_2$ | methylphosphanedioic acid (the standard acid derived from CH_3PH_4 , methylphosphane) |
| (8) $(\text{CH}_3)_2\text{PO}_2\text{H}$ | dimethylphosphanoic acid (derived from $(\text{CH}_3)_2\text{PH}_3$, dimethylphosphane) |
| (9) $(\text{CH}_3)_2\text{POH}$ | dimethylphosphinoic acid (from $(\text{CH}_3)_2\text{PH}$, dimethylphosphine) |
| (10) FSO_3H (FSO_2OH) | fluorosulfanoic acid (from SH_3F , fluorosulfane) |
| (11) FSbO_5H_5
[(HO) ₅ SbFOH ₂] | fluorostibanoic acid (from SbH_4F , fluorostibane) |

(Comparisons with Drake report names are given in the Appendix.)

When there are more than one kind of substituent groups requiring prefixes, they are named in the alphabetical order.

2.12 Since substitution by S, Se, Te, and Po generally affects the coordination number and acidity in the same way as substitution by oxygen, products of substitution by these elements are named in the same way as their oxygen analogs, e.g.,

- | | |
|--|---|
| (12) $\text{HSPO}(\text{OH})_2$ | thiophosphanetricioic acid or S-hydrogen thiophosphanetricioic acid |
| (13) $(\text{HO})_3\text{P}=\text{S}$ or | thiophosphanetricioic acid |
| (14) $\begin{array}{c} \text{SH} \\ \\ \text{CH}_3-\text{P}=\text{Se} \\ \\ \text{SH} \end{array}$ | S,S-dihydrogen selenodithiomethylphosphanedioic acid |
| (15) $\text{S}=\text{SO}(\text{OH})_2$ | thiosulfanedioic acid |
| (16) $\begin{array}{c} \text{CH}_3 \\ \\ \text{S}=\text{SOH} \\ \\ \text{O} \end{array}$ | methylthiosulfanoic acid |
| (17) $\begin{array}{c} \text{S} \\ \\ \text{CH}_3\text{AsOH} \\ \\ \text{F} \end{array}$ | fluoromethylthioarsanoic acid |

2.13 The anionic center resulting from the loss of all protons from an -oic acid is designated by the suffix -oate. Salts are named in the usual way.

- | | |
|------------------------------------|------------------------|
| (18) PO_4^{3-} | phosphanetricioate |
| (19) PHO_3^{2-} | phosphanedioate |
| (20) $\text{CH}_3\text{PO}_3^{2-}$ | methylphosphanedioate |
| (21) SO_3F^- | fluorosulfanoate |
| (22) IOF_4^- | tetrafluoroiodininoate |
| (23) XeO_2F_3^- | trifluoroxeninoate |
| (24) OsO_3F_3^- | trifluoroosmanoate |

2.131 In the case of standard acids having aquo groups in the coordination sphere, the standard anion is that resulting from the loss of only one of the two protons from each aquo group. Thus,

- | | |
|--------------------------------|-------------------|
| (25) $\text{HOP}(\text{OH})_2$ | phosphuanoic acid |
| $\text{P}(\text{OH})_2^-$ | phosphuanoate ion |

2.14 Anionic centers resulting from only partial loss of acidic hydrogen are named as hydrogen salts of the acids.

- | | |
|--------------------------------|-------------------------------|
| (26) H_2PO_4^- | dihydrogen phosphanetricioate |
| (27) HPO_3^- | hydrogen phosphanedioate |

2.15 Esters are named like salts containing the hydrocarbon cation

- | | |
|------------------------------------|---|
| (28) diethyl methylphosphanedioate | $\text{CH}_3\text{PO}(\text{OC}_2\text{H}_5)_2$ |
|------------------------------------|---|

Partial esters are named as though they are acid salts.

- | | |
|--|---|
| (29) ethyl hydrogen methylphosphinedioate, | $\text{CH}_3\text{P}(\text{OH})\text{OC}_2\text{H}_5$. |
|--|---|

When it can be determined, the location of substituents in esters containing S and its analogs is denoted by the symbols *O*-, *S*-, *Se*-, *Te*-, and *Po*- prefixed to the radical name; these symbols are used in conjunction with the prefixes thio and its analogs, the prefixes hydrothio, thiono, and their analogs being used only where ambiguity would otherwise arise. Examples:

- | | |
|--|--|
| (30) <i>O,O</i> -diethyl hydrogen dithiophosphanetricioate | $\text{HSP}(\text{S})(\text{OC}_2\text{H}_5)_2$ |
| (31) <i>S</i> -ethyl thiophosphanoate | $\text{H}_2\text{P}(\text{O})\text{SC}_2\text{H}_5$ |
| (32) <i>S</i> -methyl methyl(methylamino)-phosphanoate | $\text{CH}_3\text{P}(\text{O})(\text{SCH}_3)\text{NHCH}_3$ |
| (33) <i>O</i> -ethyl <i>S</i> -methyl <i>O</i> -hydrogen dithiophosphanetricioate | $\text{HOP}(\text{S})(\text{SCH}_3)(\text{OC}_2\text{H}_5)$ |
| (34) <i>O</i> -methyl <i>S</i> -ethyl <i>Te</i> -phenyl (propylimino)tellurothiophosphanetricioate | $\text{C}_3\text{H}_7\text{N}=\text{P}(\text{OCH}_3)(\text{SC}_2\text{H}_5)(\text{TeC}_6\text{H}_5)$ |
| (35) <i>S</i> -methyl <i>O</i> -phenyl thiosulfanedioate | $\text{CH}_3\text{SSO}_3\text{C}_6\text{H}_5$ |

Salts of esters are named similarly except for the lack of a position designation for the cation. For example,

- | | |
|---|--|
| (36) sodium <i>S</i> -ethyl thio-phosphinedioate | $\text{Na}[\text{OPHSC}_2\text{H}_5]$ |
| (37) sodium <i>O</i> -ethyl <i>S</i> -hydrogen dithiophosphanetricioate | $\text{Na}[\text{HSP}(\text{O})\text{S}(\text{OC}_2\text{H}_5)]$ |

2.16 Anionic centers resulting from addition of a negative ion to a neutral center, the number of unshared electron pairs being the same as for the neutral center, are designated by the suffix -ate, all groups being specified except attached hydrogen.

- | | |
|----------------------------------|------------------------------|
| (38) CH_3PF_5^- | methylpentafluorophosphanate |
| (39) $\text{CH}_3\text{AsH}_3^-$ | methylarsinate |

2.17 Anionic centers resulting from loss of protons or other positive ions from the parent hydride—i.e., loss of a proton attached to a central atom or an atom in a chain—the number of unshared electron pairs being one more than for the neutral center, are treated as derivatives of the next lower hydride by the rules of section 2.16. Electron pairs will not generally be shown from here on.

- | | |
|-------------------------------|-----------------------------------|
| (40) PH_4^- | phosphinate |
| [Compare (41) PH_5^- | phosphanate] |
| (42) PH_3^{2-} | phosphinate(2-) or phosphinediate |
| (43) PH_2^- | phosphuanoate |
| (44) HPCO_2^- | phosphaethan-1-uan-1-atoate |

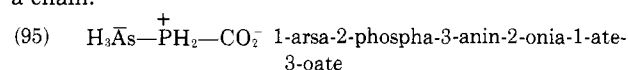
NOMENCLATURE FOR COMPOUNDS OF P, S, AND RELATED ELEMENTS

2.2 Neutral derivatives of the parent hydrides are named by the rules for substitution compounds.

(45)	$\text{H}_3\text{P}=\text{O}$	oxophosphane
(46)	$(\text{CH}_3)_3\text{P}=\text{O}$	trimethyloxophosphane
(47)	$\text{CH}_3\text{PH}_2=\text{Se}$	methylselenophosphane
(48)	CH_3SePH_2	(methylseleno)phosphine or [1-phospha-2-selenapropan- 1-in-2-uane]
(49)	H_2PF_3	trifluorophosphane
(50)	HPF_4	tetrafluorophosphane
(51)	CH_3PCl_4	tetrachloromethylphosphane
(52)	$(\text{CH}_3)_2\text{SCl}_2$	dichlorodimethylsulfine
(53)	$(\text{CH}_3)_3\text{AsCl}_2$	dichlorotrimethylarsane
(54)	$(\text{CH}_3)_4\text{PCl}$	(five coordinate phosphorus) chloro- tetramethylphosphane
	[cf. $(\text{CH}_3)_4\text{P}^+\text{Cl}^-$]	tetramethylphosphonium chloride]
(55)	$\text{HP}=\text{O}$	oxophosphine
(56)	$\text{CH}_3\text{P}=\text{O}$	methyloxophosphine
(57)	CH_3OPH_2	methoxyphosphine
(58)	PF_3	trifluorophosphine (phosphorus trifluoride)
(59)	CH_3P	methylphosphuane
(60)	$\text{C}_6\text{H}_5\text{ICl}_2$	dichlorophenylioduane

	Hydride		Cation	
(88)	phosphane	PH_5	phosphanium	PH_6^+
(89)	methyl- phosphane	CH_3PH_4	methylphos- phanium	CH_3PH_5^+
(90)	pentamethyl- phosphane	$(\text{CH}_3)_5\text{P}$	pentamethyl- phosphanium	$(\text{CH}_3)_5\text{PH}^+$
(91)			hexamethyl- phosphanium	$(\text{CH}_3)_6\text{P}^+$
(92)	phosphine	PH_3	phosphinium	PH_4^+
(92a)	siline	SiH_2	silinium	SiH_3^+
(92b)	methine	CH_2	methinium- (carbenium)	CH_3^+
(93)			phosphadiinium	PH_5^{2+}
(94)	phosphuane	PH	phosphuanium	PH_2^+
(94a)	sulfuane	SH_2	sulfuanium	SH_3^+

In multicentered compounds such positive centers are designated by the suffix -onium, if terminal; onio-, if a sidechain; or onia- (placed before -ate and -oate) if within a chain.



See Part II.

List of Prefixes

Prefix	Name	Structure
amino-	(61) aminophosphanedioic acid	$(\text{HO})_2\text{P}(\text{O})\text{NH}_2$
	(62) aminoiminophosphanedioic acid	$(\text{HO})_2\text{P}(\text{NH})\text{NH}_2$
	(63) aminochlorophosphanedioic acid	$\text{HOP}(\text{O})\text{Cl}(\text{NH}_2)$
azido-	(64) S-hydrogen azidothiophosphanedioic acid	$\text{HOP}(\text{O})\text{N}_3(\text{SH})$
bromo-	(65) bromophosphinoic acid	$\text{HP}(\text{OH})\text{Br}$
chloro-	(66) chlorophosphanedioic acid	$(\text{HO})_2\text{P}(\text{O})\text{Cl}$
	(67) chloropentafluorosulfane	SF_5Cl
cyanato-	(68) dicyanatophosphanoic acid	$\text{HOP}(\text{O})(\text{OCN})_2$
cyano-	(69) dicyanophosphanoic acid	$\text{HOP}(\text{O})(\text{CN})_2$
fluoro-	(70) fluorophosphanoic acid	$\text{HP}(\text{O})(\text{OH})\text{F}$
imino-	(71) iminophosphanetrioic acid	$(\text{HO})_3\text{PNH}$
	(72) iminoiodophosphanedioic acid	$(\text{HO})_2(\text{NH})\text{I}$
iodo-	(73) diiodophosphinoic acid	HOPI_2
isocyanato-	(74) O-hydrogen isocyanatothiophosphanoic acid	$\text{HP}(\text{S})\text{OH}(\text{NCO})$
isothiocyanato-	(75) iminodiisothiocyanatophosphanoic acid	$\text{HOP}(\text{NH})(\text{NCS})_2$
nitrilo-	(76) nitrilophosphanoic acid	$\text{HP}(\text{N})\text{OH}$
nitroso-	(77) nitrososulfanoic acid	ONSO_3H
thiocyanato-	(78) chlorothiocyantophosphinoic acid	$\text{HOPCl}(\text{SCN})$
-thio-	Used generically or when sulfur, selenium, or tellurium connects another radical to a central atom or chain	
-seleno-		
-telluro-		
-polono-		
mercapto or sulfuanyl	(80) $-\text{SH}$	
selenuanyl	(81) $-\text{SeH}$	
telluruanyl	(82) $-\text{TeH}$	
polonuanyl	(83) $-\text{PoH}$	
thio-	(84) $=\text{S}$	
seleno-	(85) $=\text{Se}$	
telluro-	(86) $=\text{Te}$	
polono-	(87) $=\text{Po}$	

2.3 Positive centers formed by adding a proton or its equivalent to the central atom of a hydride or substituted hydride are denoted by adding the suffix -ium to the name of the compound so treated, with elision of the final e where required.

3. Radicals

3.1 The fundamental radicals attached to another group at the central atom (i.e., derived from the parent hydride by removal of a hydrogen atom) are named by adding

-yl to the name of the hydride, with elision of the final e. For example,

(96) —PH ₄	phosphanyl
(97) —PH ₂	phosphinyl
(98) —P	phosphuanyl
(99) —SH ₅	sulfanyl
(100) —SH ₃	sulfinyl
(101) —SH	sulfuanyl (mercapto)

3.11 Other univalent radicals with the free valence at a central atom are named as compounds of the fundamental radicals. Substituent groups are named according to the Organic Rules.

Radicals formed by loss of all hydroxyl groups from inorganic hydroxy acids are named by replacing -ic with -yl. Thus H₂POOH phosphanoic acid, H₂PO— phosphanoyl (cf. HO₂CCO₂H ethanedioic acid, —OCCO— ethanedioyl), OP(OH)₃ phosphanetricioic acid, OP≡ phosphanetrioyl.

In the case of radicals derived from acids by loss of hydroxyl groups, which might also be named as radicals derived from substituted hydrides, organic practice is to consider the radical as derived from the acid. For example, —CHO is formyl or methanoyl, not oxomethyl; —OCCH₂CO— is malonyl or propanedioyl, not 1,3-dioxotrimethylene. In like manner, when a similar choice arises for radicals formed by removal of hydroxyl groups from a standard acid of phosphorus and related elements, the name derived from the acid shall be preferred. Thus —PH₂O is phosphanoyl, not oxophosphanyl.

(102) H ₂ P(O)—	phosphanoyl (not oxophosphanyl)
(103) H ₂ P(S)—	thiophosphanoyl (not thiophosphanyl or thionophosphanyl)
(104) H ₂ P(NH)—	iminophosphanyl
(105) HP(N)—	nitrilophosphanyl
(106) N≡SF ₂ —	difluoronitrosulfanyl
(107) (HO) ₂ P(O)—	dihydroxyphosphanoyl
(108) FSO ₂ —	fluorosulfanoyl
(109) FSO—	fluorosulfinoyl
(110) CH ₃ PH ₃ —	methylphosphanyl
(111) CH ₃ PH—	methylphosphinyl
(112) (CH ₃ O)PCl—	chloromethoxyphosphinyl
(113) (ClCH ₂ O)PH—	(chloromethoxy)phosphinyl
(114) CH ₃ OPH ₂ Cl—	chloromethoxyphosphanyl
(115) ClCH ₂ OPH ₃ —	(chloromethoxy)phosphanyl
(116) CH ₃ (HO)P(O)—	hydroxymethylphosphanoyl
(117) CH ₃ (n-C ₄ H ₉)P(S)—	n-butylmethylthiophosphanoyl
(118) n-C ₄ H ₉ (CH ₃ S)PH ₂ —	n-butyl(methylmercapto)phosphanyl
(119) H(CH ₃ S)P(NH)—	imino(methylmercapto)phosphanyl
(120) CH ₃ O(HS)P(O)—	mercaptomethoxyphosphanoyl
(121) CH ₃ SO ₂ —	methylsulfanoyl
(122) CH ₃ SF ₄ —	tetrafluoromethylsulfanyl
(123) IF ₄ —	tetrafluoroiodinyl
(124) IO ₂ —	dioxoiodinyl (not from standard acid)

3.2 Bivalent and trivalent radicals formed by the loss of H in a hydride radical or equivalent (i.e., not an "acid" radical) are named by adding to the final -yl ending the suffix -idene (bivalent) or -idyne (trivalent).

(125) HP=	phosphinylidene
(126) P=	phosphinylidyne
(127) PH ₃ =	phosphanylidene
(128) PH ₂ ≡	phosphanylidyne
(129) CH ₃ O(CH ₃)P=	methoxymethylphosphanylidyne
(130) (HO) ₃ P=	trihydroxyphosphanylidene

(131) (HO) ₂ P=	dihydroxyphosphanylidyne
but	
(132) CH ₃ OP(O)=	methoxyphosphanedioyl
and	
(133) OPH=	phosphanedioyl

3.3 Compound radicals are named in the usual manner.

(134) (CH ₃ O) ₂ P(S)O—	dimethoxythiophosphanoyloxy
(135) H ₂ N(CH ₃)P(O)S—	aminomethylphosphanoylthio
(136) CH ₃ PH(S)NH—	(methylthiophosphanoyl)amino
(137) H ₄ PN=	phosphanylimino
(138) H ₃ P=N—	phosphanylidenamino
(139) (HO) ₂ P(O)O—	dihydroxyphosphanoyloxy
(140) (HO) ₂ P(S)O—	dihydroxythiophosphanoyloxy
(141) (HO)(HS)P(O)O—	hydroxymercaptophosphanoyloxy
(142) (HO) ₂ P(O)S—	dihydroxyphosphanoylthio
(143) (HO) ₂ P(O)NH—	dihydroxyphosphanoylamino
(144) (HO) ₃ P=N—	trihydroxyphosphanylidenamino
(145) (HO) ₂ P≡C—	dihydroxyphosphanylidynemethyl
(146) (HO) ₃ P=CH—	trihydroxyphosphanylidenemethyl
(147) SF ₄ =N—	tetrafluorosulfanylidenamino
(148) SF ₂ =N—	difluorosulfanylidenamino
(149) SF ₃ ≡C—	trifluorosulfanylidynemethyl
(150) SiH ₃ O—	silyloxy (or siloxy)
(151) CH ₃ SiH ₂ NH—	methylsilylamino
(152) CH ₃ SiH ₂ N=	methylsilylimino
(153) ClO ₃ NH—	chloranoylamino
(154) F ₂ ClO ₂ N=	difluorodioxochloranylimino (not from standard acid)
(155) (HO) ₂ XeO ₂ (NH) ₂ =	dihydroxyxenanedioyldiamino
(156) (CF ₃) ₄ P—	tetrakis(trifluoromethyl)phosphanyl

3.4 The same names apply to the free radicals—i.e., the molecules with an odd number of electrons

(157) (CF ₃) ₄ P·	tetrakis(trifluoromethyl)phosphanyl
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PART II. POLYCENTRIC COMPOUNDS

The system of nomenclature outlined in the following sections for polycentric compounds builds almost without change on that for unicentric compounds, thus providing a single unifying system. The principal difference is that whereas the names of polycentric compounds are derived from the name of the hydrocarbon of the same chain length, the unicentric compounds are not named as analogs of methane.

1. **Compounds containing chains of atoms** are named according to the principles of "a" nomenclature, except that if only elements of one kind occur in the basic chain the numerals denoting the positions of the chain of atoms may be omitted—e.g.,

(158) PH ₄ PH ₃ PH ₃ PH ₄	tetraphosphabutane
(159) PH ₂ PHPHPH ₂	tetraphosphabutine

For chains containing only phosphorus atoms names such as tetraphosphane or tetraphosphine would be allowed as contractions.

When more than one oxidation state is present each must be designated by an appropriate suffix following the root name showing the chain length. The suffixes are given in order of decreasing oxidation state, i.e., taken

in the order -ane, -ine, -uane, -uine and numbered in such a way as to keep the numbers as low as possible.

The positions of the atoms having other than the largest representation are located by numeral, e.g.,

- (160) $\text{PH}_4\text{P}(\text{H})\text{P}(\text{H})\text{P}(\text{H})\text{P}(\text{H})_4$ tetraphosphabut-2-ine
 (161) $\text{PH}_4\text{P}(\text{H})\text{P}(\text{H})\text{P}(\text{H})_2$ tetraphosphabut-1-anine
 (162) $\text{PH}_4\text{P}(\text{H})\text{P}(\text{H})\text{P}(\text{H})$ tetraphosphabut-1-anin-4-uane
 (163) $\text{CH}_3\text{P}(\text{H})\text{P}(\text{H})\text{P}(\text{H})$ 1,2,3-triphosphabut-4-anin-1-uane
 (164) $\text{H}_2\text{O}_3\text{PPO}_3\text{H}_2$ diphosphathetate

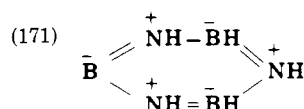
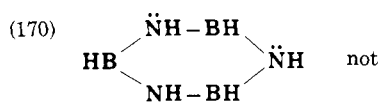
O

- (165) $\text{H}_2\text{O}_3\text{PPPO}_3\text{H}_2$ triphosphaprop-2-ine

OH

- (166) $\text{HO}_3\text{SSO}_3\text{H}$ disulfaethanedioic acid
 (167) $\text{HO}_2\text{SSO}_3\text{H}$ disulfaethanedioic acid
 (168) $\text{HO}_3\text{SSSSSO}_3\text{H}$ hexasulfahexa-1,6-dianuane-1,6-dioic acid
 (169) HSSSSSSH hexasulfahexuane or hexasulfuane

2. Unsaturation. Multiple bonds are designated by ene and yne, having their usual meaning, and being placed last in the name after ine, ane, etc., but before onium, ate, and oate. The bonds so designated are assumed to be nonpolar or to involve a minimum of charge (cf. section 1.11, Part I). For example, such a bond as occurs in $\phi_3\text{P}=\text{CH}_2$, $\phi_3\text{P}=\text{NH}$, $(\text{CH}_3)_2\text{S}=\text{CH}_2$, or $\text{N}=\text{SF}_3$ is considered to be double or triple, as the case may be, because this assumes the atoms to be neutral. On the other hand, the ring bonds in $\text{B}_3\text{N}_3\text{H}_6$ are designated as single bonds because the double bond designation would assume charges on the atoms.

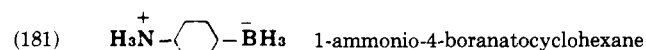
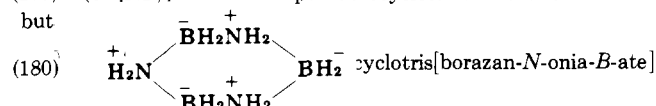


This is done regardless of the known or suspected polarities of the bonds. On the other hand, the P—N bonds in $\text{P}_3\text{N}_3\text{H}_6$ must be considered to be double. Thus

- (172) $\text{B}_3\text{N}_3\text{H}_6$ cyclotriborazane
 (173) $\text{P}_3\text{N}_3\text{H}_6$ cyclotriphosphazene
 (174) $\text{P}_3\text{N}_3\text{Cl}_6$ cyclotris [*P,P*-dichlorophosphazene]

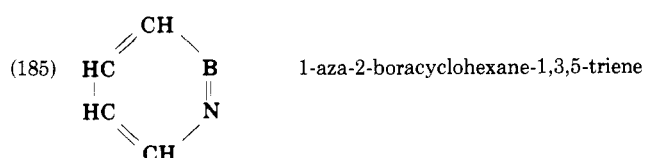
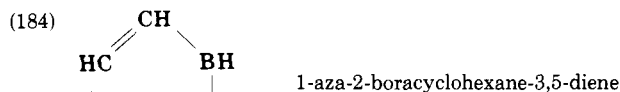
- (175) $(\text{SO}_3)_3$ cyclotris[dioxosulfoxane]
 (176) $(\text{HSN})_4$ cyclotetrasulfazene
 (177) S_4N_4 cyclotetrasulfazene
 (178) $(\text{H}_2\text{SN})_4$ cyclotetrasulfazene
 (179) $(\text{SF}_4\text{NF})_4$ perfluorocyclotetrasulfazene

but



also

- (183) C_6H_6 cyclotriethane or cyclohexatriene



- (186) $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}_3$ butan-1-ene
 (187) $(\text{OPO}_2^-)_3$ cyclotriphosphoxanoate
 (188) $\text{P}(\text{H})_3\text{BH}_2\text{P}(\text{H})_3$ 2-bora-1,3-diphosphaprop-2-enediine-1,3-dionia-2-ate
 (189) $^-\text{O}_2\text{P}(\text{H})\text{P}(\text{H})\text{OPO}_3^{2-}$ 3-oxa-1,2,4-triphosphan-2-ine-1,4,4-trioate

(Further discussion of compounds with repeating polyatomic units will be found in Part II, section 7.)

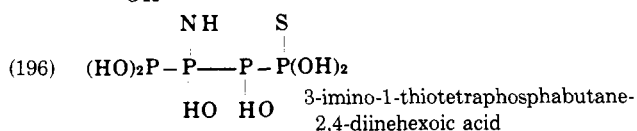
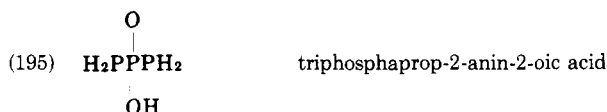
Note that where assumption of atomic neutrality gives rise to an absurd or highly unlikely electronic structure, the principle of neutrality must be abandoned, e.g., in the amine oxides. These may be called oxonitrans.

In the case of a single charged site, the multiplicity is taken as the minimum consistent with placing the charge on only one atom. This tends to locate negative charge on the more electronegative atom and positive charge on the less electronegative atom. Thus

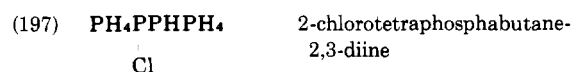
- (190) $(\text{R}_3\text{PCR})^-$ is $\text{R}_3\text{P}=\text{CR}$ a carbanion,
 not $\text{R}_3\text{P}\equiv\text{CR}$ a phosphanate
 (191) $(\text{R}_3\text{PNR}_2)^+$ is $\text{R}_3\text{P}^+-\text{NR}_2$ a phosphonium ion,
 not $\text{R}_3\text{P}=\text{NR}_2$, an ammonium ion

This principle also serves to decide the number of unshared pairs on the atoms. For example, each nitrogen atom in both $\text{B}_3\text{N}_3\text{H}_6$ and $(\text{R}_2\text{PN})_3$ is considered to have one unshared pair of electrons.

- (192) $\text{HP}=\text{P}(\text{H})\text{P}(\text{H})_2$ tetraphosphabut-1-ene
 (193) $\text{HP}=\text{P}(\text{H})_2\text{P}(\text{H})\text{P}(\text{H})_2$ tetraphosphabut-2-anin-1-ene
 (194) $\text{HP}=\text{P}(\text{CH}_3)_2\text{P}(\text{H})\text{P}(\text{H})_2$ 2,2-dimethyltetraphosphabut-2-anin-1-ene



3. Structures Formed by Substitution on the Chain. The usual radical names for substituents (see Part I) are prefixed to the name of the parent compound in alphabetical order with position numbers in the usual way (cf. section 2.12).



4. Structures Formed by Substitution in the Chain. The fundamental chain is defined as the longest chain in the

molecule including nonunicoordinate atoms, except for atoms in acidic groups—i.e., —OH, —SH, —SeH, —TeH, —PoH—and atoms in common polyatom substituent groups such as are given in the List of Prefixes, Part I, section 2.3.

Because of the almost invariable bivalency of oxygen, hetero oxygen (designated oxa) and bivalent hetero sulfur (designated thia—distinguished from the higher oxidation states, which are designated sulfa) do not require the use of the suffix -uane. Trivalent nitrogen (aza) similarly requires no ine designated. Pentavalent nitrogen is indicated by the suffix -ane with an appropriate locant. Hetero atoms are designated in alphabetical order according to the principles of "a" nomenclature following the names of the substituents on the chain and preceding the root name designating the chain length.

Examples:

- (198) $\text{H}_2\text{POPHNHPH}_2$ 2-aza-4-oxa-triphosphapentine
- (199) $\text{CH}_3\text{CH}_2\text{PHOPHNHPHCH}_3$ 3-aza-5-oxa-2,4,6-triphosphaoctane-2,4,6-triine
- (200) $(\text{HO})_2\text{POPHOPHOC}_2\text{H}_5$ 2,4,6-trioxa-1,3,5-triphosphaoctane-1,3,5-triine-1-dioic acid (but see also section 7)
- (201) $\begin{array}{c} \text{O} \quad \text{OH} \\ \parallel \quad | \\ (\text{H}_2\text{N})_2\text{POPOP}(\text{OH})_2 \\ | \\ \text{NH} \end{array}$ 1,1-diamino-5-imino-1-oxo-2,4-dioxa-1,3,5-triphosphapentane-3-ine-3,5,5-trioic acid
- (202) $\text{SF}_5\text{OSO}_2\text{OSO}_2\text{OSF}_5$ 1,1,1,1,1,7,7,7,7-decafluoro-3,3,5,5-tetraoxo-tetrasulfoxane (see section 7)
- (203) $\text{FSO}_2\text{OSF}_4\text{OSO}_2\text{F}$ 1,3,3,3,3,5-hexafluoro-1,1,5,5-tetraoxotrisulfoxane (see section 7)
- (204) $\text{SF}_5\text{NHSF}_4\text{NHSF}_5$ 1,1,1,1,1,3,3,3,3,5,5,5,5-tetradecafluorotrisulfazane (see section 7)
- (205) $\text{SF}_5\text{NFSF}_4\text{NFSF}_5$ perfluorotrisulfazane (see section 7)
- (206) $(\text{N}=\text{SF}_3)_3$
OH perfluorocyclotrisulfazanene (see section 7)
- (207) $\begin{array}{c} \text{OH} \\ | \\ \text{CH}_3\text{OPSPPOCH}_2\text{CH}_2\text{OCH}_3 \end{array}$ 2,6,9-trioxa-3,5-diphospho-4-thiadecane-3,5-diine-3,5-dioic acid
- (208) $\begin{array}{c} \text{OH} \\ | \\ (\text{HO})_2\text{POCH}_2\text{CH}_2\text{OPSP}(\text{SH})_2 \end{array}$ 1,1-dithio-4,7-dioxa-1,3,8-triphospho-2-thiaoctane-1,3,8-triine-1,1,3,8,8-pentoic acid
- (209) $\text{SiF}_3\text{SSiF}_2\text{SSiF}_3$ perfluorotrisilathiane
- (209a) $\text{SiF}_3\text{SF}_2\text{SiF}_2\text{SF}_4\text{SiF}_3$ perfluorotrisilasulfane

5. The term "function" is customarily used to mean any atom, group, or arrangement which causes a compound to behave in some characteristic way. Indications of oxidation state are usually made by means of suffixes—e.g., -ene, -yne, -ate, -ite, -(O), -(III), etc. Of other possible functions usually one (the most important, characteristic, convenient, etc.) is selected to be denoted by a suffix and all others by prefixes. In this system the only function besides functions of oxidation state (i.e., -ene, -uane, etc.) and charge (-onia, -ate) which is designated by a suffix is the acidic function (and its corresponding anion). All other functions are denoted by prefixes. Substituents and

functions (radicals) on the fundamental chain are named by the commonly accepted prefixes. (Alkoxy and aryloxy derivatives and other analogous chalcogen-containing compounds may be named according to the usual rules for esters.) The parent compound should be chosen to include the maximum number of acidic functions.

Examples:

- (210) $\text{H}_2\text{O}_3\text{PPO}_3\text{H}_2$ diphosphaethanetetroic acid (cf. $\text{HO}_2\text{CCO}_2\text{H}$ ethanedioic acid)
- (211) $\text{H}_2\text{O}_3\text{PPH}_3\text{PO}_3\text{H}_2$ triphosphopropane-1,1,3,3-tetroic acid (cf. $\text{HO}_2\text{CCH}_2\text{CO}_2\text{H}$ propanedioic acid)
- (212) $\text{H}_2\text{O}_3\text{PCH}_2\text{PO}_3\text{H}_2$ 1,3-diphosphopropane-1,1,3,3-tetroic acid
- (213) $(\text{H}_2\text{O}_3\text{P})_2\text{PO}_2\text{H}$ triphosphopropanepentoic acid (no carbon analog)
- (214) $\text{PH}_4(\text{PO}_2\text{H})\text{CH}_3$ 1,2-diphosphopropane-2-oic acid
- (215) $\text{PH}_4(\text{PO}_2\text{H})\text{CO}_2\text{H}$ 2,3-diphosphopropane-1,2-dioic acid
- (216) $\text{SF}_5\text{N} = \text{SF}_2\text{SO}_3\text{H}$
SO₃H 2,2-difluoro-2-(pentafluoro-sulfanylimino) trisulfapropane-1,3-dioic acid
- (217) $\begin{array}{c} \text{HO}_3\text{SeAsO}_2\text{HPO}_2\text{HSiH}_2\text{CH}_3 \\ \text{SO}_3\text{H} \end{array}$ 2-methylsilyl-3-arsa-2-phospha-4-selena-1-sulfabutane-1,2,3,4-tetroic acid
- (218) $\begin{array}{c} \text{CH}_3\text{OPOPOP}(\text{OCH}_3)_2 \\ \text{HO} \quad \text{OCH}_3 \end{array}$ 1,3,5,5-tetramethyl 1-hydrogen 2,4-dioxa-1,3,5-triphosphapenta-1,3,5-triine-1,1,3,5,5-pentoate (but see also section 7)
- (219) $\begin{array}{c} \text{CH}_3 \quad \text{C}_6\text{H}_4\text{NO}_2 - \text{p} \\ \diagdown \quad \diagup \\ \text{N} \\ \diagup \quad \diagdown \\ \text{C}_2\text{H}_5\text{O} \quad \text{OCH}_3 \\ \text{S} = \text{P} - \text{S} - \text{P} - \text{S} - \text{P} = \text{O} \\ \diagdown \quad \diagup \quad \diagdown \quad \diagup \\ \text{C}_2\text{H}_5\text{O} \quad \text{O} \quad \text{SCH}_3 \end{array}$ 1,1-O,O'-diethyl 5-O'', 5-S-dimethyl 3-(methyl-p-nitrophenylamino)-3-oxo-1,5-dithio-1,3,5-triphospho-2,4-dithiapentane-1,1,5,5-tetroate
- (220) $\begin{array}{c} \text{O} \quad \text{O} \quad \text{S} \\ \parallel \quad \parallel \quad \parallel \\ [(\text{CH}_3)_2\text{N}]_2\text{POPSP}[\text{N}(\text{CH}_3)_2]_2 \\ | \\ \text{OH} \end{array}$ 1,1,5,5-tetrakis(dimethylamino)-1-oxo-5-thio-2-oxa-1,3,5-triphospho-4-thiapentane-3-oic acid
- (221) $\begin{array}{c} -\text{O} \quad \quad \quad \emptyset \quad \emptyset \\ \quad \quad \quad + \\ \text{CH}_3 - \text{P} - \text{CH}_2\text{NH}_2\text{CH} = \text{P} - \text{P}^+ - \text{CH}_2\text{BiCH}_3 \\ \quad \quad \quad \text{O} \quad \quad \quad \emptyset \quad \emptyset \end{array}$ 6,6,7,7-tetraphenyl-4-aza-9-bismutha-2,6,7-triphosphadecan-9-in-5-ene-4,7-dionia-9-at-2-oate

5.1 If substituent radicals are present which contain only one central atom, the names for unicentric radicals are used.

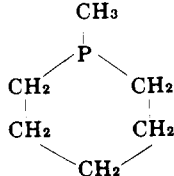
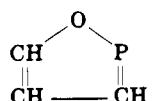
- (222) $\begin{array}{c} \text{O} \quad \text{N}(\text{CH}_3)_2 \\ \parallel \quad | \\ (\text{CH}_3\text{O})_2\text{POPOPPOP}(\text{OC}_2\text{H}_5)_2 \\ \parallel \quad \parallel \\ \text{O} \quad \text{O} \\ | \quad | \\ \text{O} = \text{P}(\text{OCH}_3)_2 \end{array}$ 1,1-diethyl 7,7-dimethyl 3-(dimethylamino)-5-(dimethoxyphosphanyloxy)-2,4,6-trioxa-1,3,5,7-tetraphosphoheptane-1,5-diine-1,1,7,7-tetroate

- (223) SF_5 4-chloranoyl-4-pentafluoro-sulfanyl-6,6,6,6-pentafluoro-2,2,5,5-tetramethyl-3-phospho-2,4,5-tristanna-6-sulfa-hexan-3-oic acid
- $(\text{CH}_3)_3\text{SnPO}_2\text{HSn}(\text{CH}_3)_2\text{SF}_5$
- ClO_3

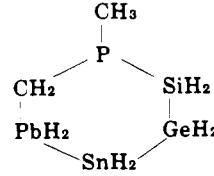
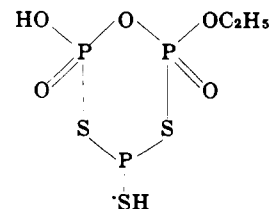
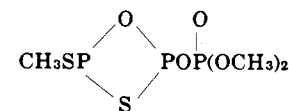
5.2 If the substituent radical contains more than one central atom the radical name is composed in the same manner as for a polycentric compound with the point of attachment at the number one position, except that acidic groups are denoted by prefixes.

- (224) $(\text{CH}_3\text{O})_2\text{POP}-$ 1-hydroxy-3,3-dimethoxy-3-oxo-2-oxa-1,3-diphosphopropan-1-ynyl (or dimethoxyphosphanoyloxy) phosphinoyl
- O OH
- (225) $(\text{HO})_2\text{PSPS}-$ 4,4-dihydroxy-2-methoxy-2,4-diphospha-1,3-dithiabutynyl (or 1-methyl 1,3-diphospha-2-thiapropan-1,3-diin-oylthio)
- OCH_3

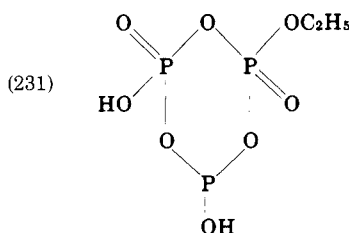
6. Cyclic compounds which contain at least one carbon atom may be named by the present methods of the Ring Index except for addition of the suffixes of oxidation state, charge, and acidity. The prefix cyclo- is inserted before the root name denoting the number of atoms in the fundamental ring. However, the names may be constructed in the same manner as for linear compounds. In addition, formal elimination of the rings from the name by use of such designations as epoxy may considerably simplify the problem of naming.

- (226)  1-(methylphospha)cyclohexane (R.I. 204: 1-methylphosphacyclohexane)
- (227)  1-oxa-2-phosphacyclopentan-2-ene (R.I. 99: 1,2-oxaphosphole)

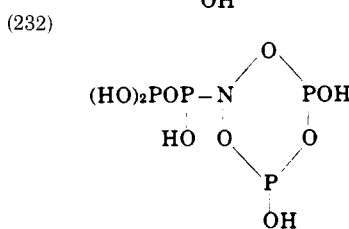
6.1 When no carbon atoms are in the ring, atoms are numbered to give the lowest alphabetical order.

- (228)  3-methyl-1-germana-3-phospha-5-plumba-2-sila-6-stannacyclohexan-3-ine
- (229)  2-ethyl 4,6-dihydrogen 4-thio-1-oxa-2,4,6-triphospha-3,5-dithia-cyclohexan-4-ine-2,4,6-trioate
- (230)  1,1-dimethyl 3,5-epoxy-2-oxa-1,3,5-triphospha-4,6-dithiaheptane-3,5-diin-1-oate

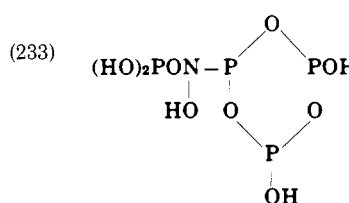
For justification of this use of epoxy, see IUPAC Org. Rules 1965 §212.2, 3rd example.



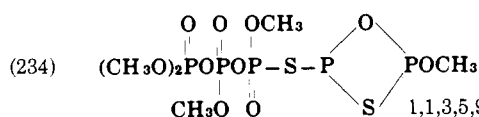
1-ethyl 3,5-dihydrogen 2,4,6-trioxa-1,3,5-triphosphacyclohexan-3-inetrioate



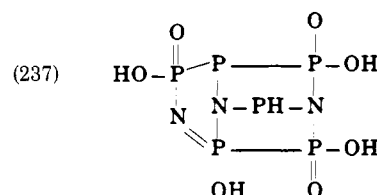
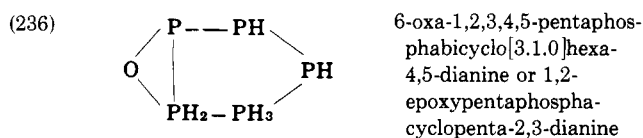
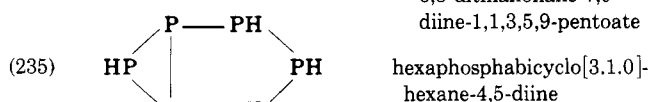
1-(1,3,3-trihydroxy-2-oxa-1,3-diphosphapropinyl)-1-aza-2,4,6-trioxa-3,5-diphosphacyclohexine-3,5-dioic acid or 4,8-epoxy-4-aza-2,5,7-trioxa-1,3,6,8-tetraphosphaoctine-1,1,3,6,8-pentoic acid



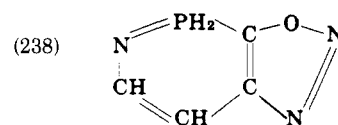
1-(1,3,3-trihydroxy-2-oxa-1-aza-3-phosphapropinyl)-2,4,6-trioxa-1,3,5-triphosphacyclohexine-3,5-dioic acid or 4,8-epoxy-3-aza-2,5,7-trioxa-1,4,6,8-tetraphosphaoctine, 1,1,3,6,8-pentoic acid or (See section 7) 1-(1,3,3-trihydroxy-1-aza-2-oxa-3-phosphapropinyl)-cyclotriphosphoxine-3,5-dioic acid



1,1,3,5,9-pentamethyl-7,9-epoxy-2,4-dioxa-1,3,5,7,9-pentaphospha-6,8-dithianonane-7,9-diine-1,1,3,5,9-pentoate



3,6,8-triaza-1,2,4,5,7,9-hexaphosphatricyclo[3.2.1.1^{3,5}]nonane-1,9-diin-5-ene-2,4,5,7-tetroic acid



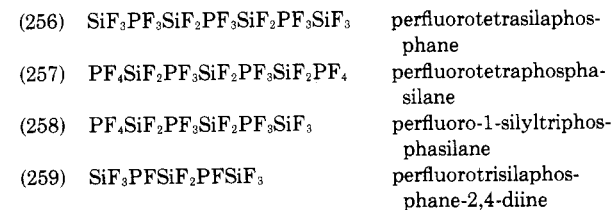
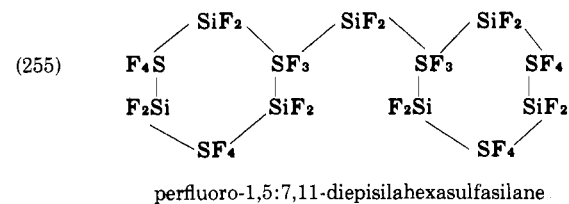
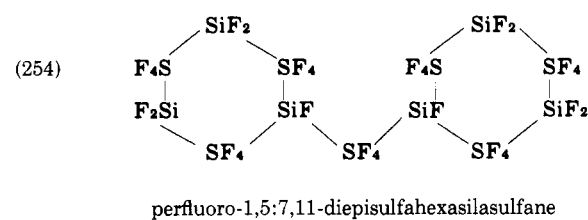
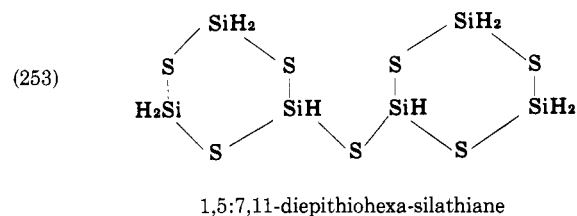
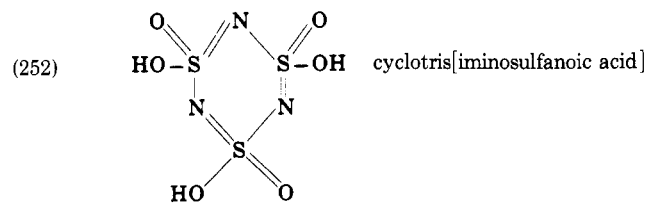
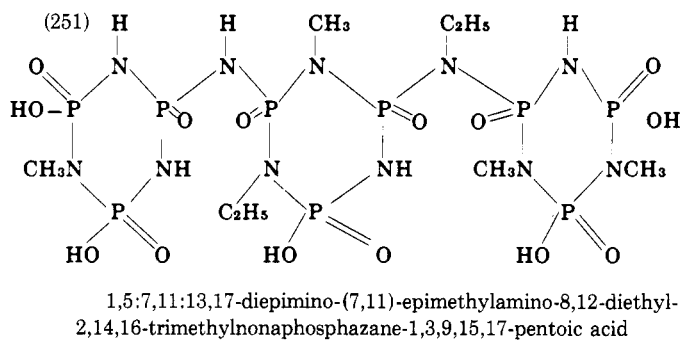
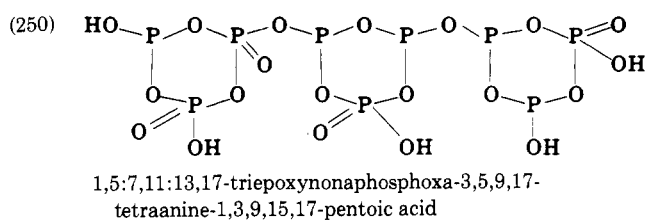
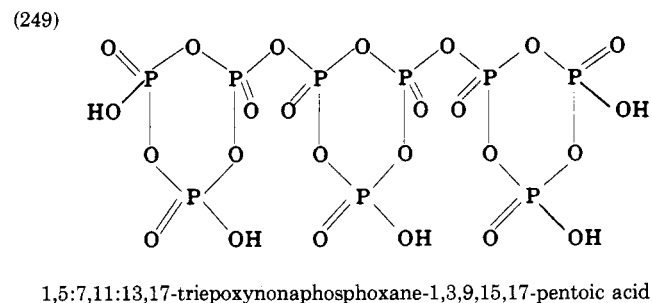
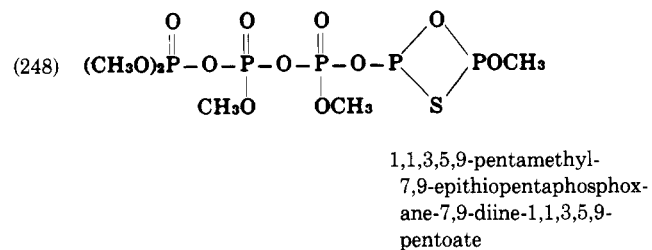
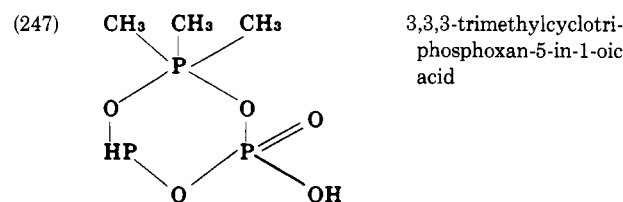
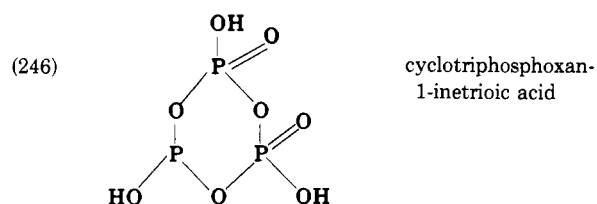
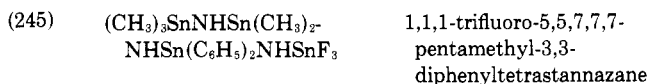
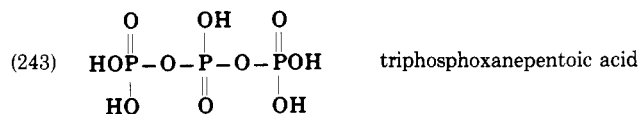
6-aza-7-phospha-1,2,3-benzoxadiazia-7-anole

7. Chains containing many repeating diatomic units such as P—O, P—S, P—NH, etc., may be named according to siloxane nomenclature in which the numerical prefix

denotes the number of chain atoms in excess or numbered lower. This must be considered as a contraction of the basic nomenclature. The numbering remains as for the full name, thus accommodating such cases as (251).

Examples:

- (239) H_4POPH_4 diphosphoxane
 (240) H_2POPH_2 diphosphoxine
 (241) POP diphosphoxuane
 (242) H_2POPH_4 diphosphoxanine



NOMENCLATURE FOR COMPOUNDS OF P, S, AND RELATED ELEMENTS

Appendix. Comparison of names from this system with those for selected examples from the "Drake Report" of March 23, 1952. [See also *Chem. Eng. News* **30**, 4515 (1952).]


Page of Drake Report	Compound	Drake Report	This System
1	H ₃ P	phosphine	phosphine
	H ₃ PO	phosphine oxide	oxophosphane
	H ₃ PS	phosphine sulfide	thiophosphane
	H ₃ PSe	phosphine selenide	selenophosphane
	H ₃ PTe	phosphine telluride	tellurophosphane
	H ₃ PNH	phosphine imide	iminophosphane
	H ₃ P	phosphorane	phosphane
2	(HO) ₃ P	phosphorous acid	phosphinetriolic acid or trihydroxyphosphine
	HOP(OH) ₂	phosphonous acid	phosphinedioic acid or dihydroxyphosphine
	H ₂ POH	phosphinous acid	phosphinoic acid or hydroxyphosphine
	HOP=O	phosphenous acid	hydroxyoxophosphine
	(HO) ₃ PO	phosphoric acid	phosphanetricioic acid
	HPO(OH) ₂	phosphonic acid	phosphanedioic acid
	H ₂ POOH	phosphinic acid	phosphanoic acid
	HOPO ₂	phosphenic acid	hydroxydioxophosphane
	H ₄ POH	phosphoranoic acid	hydroxyphosphane
	H ₃ P(OH) ₂	phosphoranedioic acid	dihydroxyphosphane
	H ₂ P(OH) ₃	phosphoranetricioic acid	trihydroxyphosphane
	HP(OH) ₄	phosphoranetetricioic acid	tetrahydroxyphosphane
	P(OH) ₅	phosphoranepentioic acid	pentahydroxyphosphane
3	PhPO(OH) ₂	phenylphosphonic acid	phenylphosphanedioic acid
	Et ₂ POH	diethylphosphinous acid	diethylhydroxyphosphine
	ClCH ₂ CH ₂ PH ₂	(2-chloroethyl)phosphine	(2-chloroethyl)phosphine
	HP=O	oxophosphine	oxophosphine
	HP(=S)(S)	thionophosphine sulfide	dithiophosphane
5	(HO) ₂ P(O)NH ₂	phosphoramidic acid	aminophosphanedioic acid
	(HO) ₂ P(NH)NH ₂	phosphoramidimidic acid	aminoiminophosphanedioic acid
	HOP(O)Cl(NH ₂)	phosphoramidochloridic acid	aminochlorophosphanoic acid
	HP(OH)Br	phosphonobromidous acid	bromohydroxyphosphine or bromophosphinoic acid
	(HO) ₂ P(O)Cl	phosphorochloridic acid	chlorophosphanedioic acid
	HOP(O)(OCN) ₂	phosphorodicyanatidic acid	dicyanatophosphanoic acid
	HOP(O)Cl(CN)	phosphorochloridocyanidic acid	chlorocyanophosphanoic acid
	HP(O)OH(F)	phosphonofluoridic acid	fluorophosphanoic acid
	(HO) ₃ PNH	phosphorimidic acid	iminophosphanetricioic acid
	(HO) ₂ P(NH)I	phosphorimidiodidic acid	iminoiodophosphanedioic acid
	HOPI ₂	phosphorodiiodidous acid	diiodophosphinoic acid or hydroxydiiodophosphine
	HP(S)OH(NCO)	phosphonisocyanatidothionic acid	isocyanatothiophosphanoic acid
	HOP(NH)(NCS) ₂	phosphorimidodiisothiocyanatidic acid	iminodiisothiocyanatophosphanoic acid
	HP(N)OH	phosphononitridic acid	hydroxynitriophosphane
	HOPCl(SCN)	phosphorochloridothiocyanatidous acid	chlorothiocyantophosphinoic acid
7	HSP(S)(OEt) ₂	<i>O,O</i> -diethyl hydrogen phosphorodithioate	<i>O,O</i> -diethyl hydrogen dithiophosphanetricioate
	H ₂ P(O)SEt	<i>S</i> -ethyl phosphinothioate	<i>S</i> -ethyl thiophosphanoate
	MeP(O)(SMe)NHMe	<i>S</i> -methyl <i>N,P</i> -dimethylphosphonamidothioate	<i>S</i> -methyl methyl(methylamino)-thiophosphanoate
	HOP(S)(SMe)(OEt)	<i>O</i> -ethyl <i>S</i> -methyl hydrogen phosphorothiolothionate	<i>O</i> -ethyl <i>S</i> -methyl hydrogen dithiophosphanetricioate
	HP(ONa)(SEt)	<i>O</i> -sodium <i>S</i> -ethyl phosphonothioate	sodium <i>S</i> -ethyl thiophosphinedioate
8	POCl ₃	phosphoric trichloride	phosphanetricioyl chloride or trichlorooxophosphane
	MeP(O)Cl(NH ₂)	methylphosphonamidic chloride	aminochloromethyloxophosphane or methylphosphanedioyl amide chloride
	P(CN)(NH ₂) ₂	phosphorocyanidous diamide	diaminocyanophosphine
	H ₂ P—	phosphino	phosphinyl
	H ₂ P(O)—	phosphinyl	phosphanoyl
	H ₂ P(S)—	phosphinothioyl	thiophosphanoyl
	H ₂ P(NH)—	phosphinimyl	iminophosphanoyl

(continued)

9	HP(N)— MeO(Cl)P— ClCH ₂ O(H)P— Me(HO)P(O)— Me(<i>n</i> -Bu)P(S)— H(MeS)P(NH)— MeO(HS)P(O)— MeOP(O)=	phosphinonitridyl chloromethoxyphosphino (chloromethoxy)phosphino hydroxymethylphosphinyl <i>n</i> -butylmethylphosphinothioyl methylthiophosphinimyl mercaptomethoxyphosphinyl methoxyphosphinylidene	nitriophosphanyl chloromethoxyphosphinyl (chloromethoxy)phosphinyl hydrogen methylphosphanoyl <i>n</i> -butylmethylthiophosphanoyl imino(methylmercapto)phosphanyl mercaptomethoxyphosphanoyl methoxyphosphanoylidene (to 1 ligand) or methoxyphosphanedioyl (to 2 ligands)
	but Me ₃ P=		trimethylphosphanylidene
13	MeO(Me)P≡ HP= P(O)≡	methoxymethylphosphoranylidene phosphinidene phosphinylidene	methoxymethylphosphanylidene phosphinylidene phosphanetrioyl (to 3 ligands) phosphanoylidene (to 1 ligand), or oxophosphanylidene
	(MeO) ₂ P(S)O— H ₂ N(Me)P(O)S— Me(H)P(S)NH— H ₃ PPH ₂ PH ₂ PHPHPH ₂ HP=PPHPH ₂ HP=PH ₂ PHPH ₂ HP=P(CH ₃) ₂ PHPH ₂	dimethoxyphosphinothioxyloxy aminomethylphosphinylthio methylphosphinothioylamino diphosphane tetraphosphane 1-tetraphosphene 2,2-dihydro-1-tetraphosphene 2,2-dihydro-2,2-dimethyl-1-tetraphosphene 2-hydroxy-2-oxidotriphosphane	dimethoxythiophosphanoyloxy aminomethylphosphanoylthio methylthiophosphanoylamino diphosphine or diphosphaethine tetraphosphine or tetraphosphabutine tetraphosphabut-1-ene tetraphosphabut-2-anin-1-ene 2,2-dimethyltetraphosphabut-2-anin-1-ene triphosphaprop-2-anin-2-oic acid
14	(H ₂ P) ₂ P(O)OH		
	$\begin{array}{c} \text{NH} \quad \text{S} \\ \parallel \quad \parallel \\ (\text{HO})_2\text{P}-\text{P}-\text{P}-\text{S}(\text{OH})_2 \\ \parallel \quad \parallel \\ \text{HO} \quad \text{OH} \end{array}$	1,1,2,3,4,4-hexahydroxy-3-imido-1-sulfidotetraphosphane	3-imino-1-thiotetraphospha-1-sulfabutane-2,4-diinehexoic acid
15	H ₂ POPHNHPH ₂ CH ₃ CH ₂ PHOPHNHPHCH ₃ (HO) ₂ POPHOPHOC ₂ H ₅	2-oxa-4-azapentaphosphane 1-ethyl-5-methyl-2-oxa-4-azapentaphosphane 5-ethoxy-1,1-dihydroxy-2,4-dioxapentaphosphane	2-oxa-4-azatriphosphabutine 3-aza-5-oxa-2,4,6-triphosphaoctan-2,4,6-triine 2,4,6-trioxa-1,3,5-triphosphaoctine-1,1-dioic acid or 5-ethoxytriphosphoxine-1,1-dioic acid
	(H ₂ N) ₂ P(O)OPOP(NH)(OH) ₂	1,1-diamino-3,5,5-trihydroxy-5-imido-1-oxido-2,4-dioxapentaphosphane	5,5-diamino-1-imino-5-oxotriphosphoxan-3-ine-1,1,3-trioic acid
16	$\begin{array}{c} \text{CH}_3\text{OPSPC}_2\text{H}_4\text{OCH}_3 \\ \parallel \quad \parallel \\ \text{HO} \quad \text{OH} \end{array}$	1,3-dihydroxy-1-methoxy-3-(2-methoxyethoxy)-2-thiatriphosphane	2,6,9-trioxa-3,5-diphospha-4-thiadecane-3,5-diine-3,5-dioic acid
	$\begin{array}{c} \text{CH}_3\text{OPSPOC}_2\text{H}_4\text{OCH}_3 \\ \parallel \quad \parallel \\ \text{HO} \quad \text{OH} \end{array}$	1,3-dihydroxy-1-methoxy-3-(2-methoxyethyl)-2-thiatriphosphane	2,8-dioxa-3,5-diphospha-4-thianonane-3,5-diine-3,5-dioic acid
16	(HO) ₂ POC ₂ H ₄ OPSP(SH) ₂	1,1,6-trihydroxy-8,8-dimercapto-2,5-dioxa-7-thia-3,4-dicarbaoctaphosphane	1,1-dithio-4,7-dioxa-1,3,8-triphospha-2-thiaoctine-1,1,3,8-pentoic acid
	$\begin{array}{c} \text{CH}_3\text{OPOPOP}(\text{OCH}_3)_2 \\ \parallel \quad \parallel \\ \text{HO} \quad \text{OCH}_3 \end{array}$	1-hydroxy-1,3,5,5-tetramethoxy-2,4-dioxapentaphosphane	1,1,3,5-tetramethyl 5-hydrogen triphosphoxanepentoate
16	$\begin{array}{c} \text{CH}_3 \quad \text{C}_6\text{H}_4\text{NO}_2-p \\ \diagdown \quad \diagup \\ \text{N} \\ \diagup \quad \diagdown \\ (\text{C}_2\text{H}_5\text{O})_2\text{P}-\text{S}-\text{P}-\text{S}-\text{P}(\text{O})\text{OCH}_3 \\ \parallel \quad \parallel \quad \parallel \\ \text{S} \quad \text{O} \quad \text{SCH}_3 \end{array}$	1,1-diethoxy-5-methoxy-5-(methylthio)-3-(<i>N</i> -methyl- <i>p</i> -nitroanilino)-3,5-dioxido-1-sulfido-2,5-dithiapentaphosphane	1,1-diethyl 5,5-dimethyl 3-(methyl- <i>p</i> -nitrophenylamino)-3-oxo-1-thio-triphosphathiane-1,1,5,5-tetroate
	$\begin{array}{c} [(\text{CH}_3)_2\text{N}]_2\text{POP}(\text{O})\text{SP}(\text{N}(\text{CH}_3)_2)_2 \\ \parallel \quad \parallel \quad \parallel \\ \text{O} \quad \text{OH} \quad \text{S} \end{array}$	1,1,5,5-tetrakis(dimethylamino)-3-hydroxy-1,3-dioxido-5-sulfido-2-oxa-4-thiapentaphosphane	1,1,5,5-tetrakis(dimethylamino)-1-oxo-5-thio-2-oxa-1,3,5-triphospha-4-thiapentan-3-oic acid

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(continued)

Page of Drake Report	Compound	Drake Report	This System
21	HPO HPS HPNH C ₃ H ₇ PO CH ₃ P=NCH ₃ CH ₃ (C ₃ H ₇)PH ClC ₂ H ₄ PH ₂ HPO ₂ HP(O)NH HP(O)S HPS ₂ HP(O)S HP(NH) ₂ HP(O)NH H ₃ PO	oxophosphine thionophosphine iminophosphine oxopropylphosphine methyl(methylimino)phosphine methylpropylphosphine (2-chloroethyl)phosphine oxophosphine oxide iminophosphine oxide thionophosphine oxide thionophosphine sulfide oxophosphine sulfide iminophosphine imide oxophosphine imide oxophosphorane phosphine oxide	same thiophosphine same same same same same dioxophosphane iminooxophosphane oxothiophosphine, etc. dithiophosphane oxothiophosphane, etc. diiminophosphane iminooxophosphane, etc. oxophosphane, etc.
22	H ₂ NP(O)(OH) ₂ (H ₂ N) ₂ P(O)OH (H ₂ N) ₃ PO ClP(O)(OH) ₂ [ClPH(O)OH Cl(H ₂ N)P(O)OH (HS) ₃ PS [HSPH ₂ S (HS) ₃ PO (HS) ₂ P(S)OH (H ₂ N) ₃ PS	phosphoramidic acid phosphorodiamidic acid phosphoric triamide phosphorochloridic acid phosphoramidochloridic acid phosphorotetrathioic acid phosphorotriethioic acid phosphorodithiolothionic acid phosphorothioic triamide phosphoramidothioic dichloride	aminophosphanedioic acid diaminophosphanoic acid triaminooxophosphane chlorophosphanedioic acid chlorophosphanoic acid aminochlorophosphanoic acid dithiophosphanoic acid S,S',S''-trithiophosphanetricioic acid O,S,S'-trithiophosphanetricioic acid triaminothiophosphane, etc.
23	Cl ₂ P(S)NH ₂ (H ₂ N) ₃ PNH HO(H ₂ N) ₂ PNH	phosphoramidothioic dichloride phosphorimidic triamide phosphorodiamidimidic acid	aminodichlorothiophosphane or aminothiophosphanedioyl chloride triaminoiminophosphane diaminoiminophosphanoic acid or diaminoiminohydroxyphosphane
24	Cl(HO) ₂ PS Cl(HO)(HS)PO Cl(HO)PN (HS) ₂ PN	phosphorochloridothionic acid phosphorochloridithioic acid phosphorochloridonitridic acid phosphoronitridodithioic acid	O,O'-chlorothiophosphanedioic acid O,S-chlorothiophosphanedioic acid chloronitriphosphanoic acid or chlorohydroxynitriphosphane nitrilodithiophosphanedioic acid or dimercaptonitriphosphane
25	Cl(H ₂ N)PN (HO)(H ₂ N)PHO (H ₂ N) ₂ PHO (HO) ₂ PHS (HO)(HS)PHO	phosphoramidonitridic chloride phosphonamidic acid phosphonic diamide phosphonothionic acid phosphonothioic acid	aminochloronitriphosphane, etc. aminophosphanoic acid diaminooxophosphane O,O'-thiophosphanedioic acid O,S-thiophosphanedioic acid, etc.
26	Cl(NaS)C ₅ H ₁₁ N)P ClCH ₂ CH ₂ - 	sodium <i>N</i> -amyl- <i>P</i> -[3-bromo-4-(2-chloroethyl)phenyl]- phosphonochloridimidothioate	sodium (amylimino)[3-bromo-4-(2-chloroethyl)phenyl]- chlorothiophosphanoate
27	(HO) ₂ P(O)Ph (MeO) ₂ P(NPh)Ph H ₂ NPH ₂ O HOPH ₂ S HSPH ₂ O H ₂ NPHNH NPH ₂ NPPH ₂	phenylphosphonic acid dimethyl diphenylphosponimidate phosphinic amide phosphinothionic acid phosphinothioic acid phosphinimidic amide phosphinic nitride diphenylphosphinic nitride	phenylphosphanedioic acid dimethylphenyl(phenylimino)phos- phanedioate, etc. aminooxophosphane O-thiophosphanoic acid S-thiophosphanoic acid aminoiminophosphane nitrilophosphane nitrilodiphenylphosphane, etc.
28	(HO) ₂ PNH ₂ HOP(NH ₂) ₂ PCl ₃ (MeS)(MeHN) ₂ P (HO)PHNH ₂ PH(NH ₂) ₂	phosphoramidous acid phosphorodiamidous acid phosphorous trichloride methyl <i>N,N'</i> -dimethylphos- phorodiamidothioate phosphonamidous acid phosphonous diamide	aminophosphinedioic acid diaminophosphinoic acid trichlorophosphine methyl bis(methylamino)thio- phosphinoate, etc. aminophosphinoic acid or aminohydroxyphosphine diaminophosphine

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Page of Drake Report	Compound	Drake Report	This System
29	(HO)(HS)PH	phosphonothious acid	thiophosphinedioic acid
	Cl(MeO)PPH	methyl phenylphosphono- chloridite	methyl chlorophenylphosphinoate or chloromethoxyphenylphosphine, etc.
	H ₂ NPH ₂ HSPH ₂	phosphinous amide phosphinothious acid	aminophosphine thiophosphinoic acid or mercaptophosphine
29	H ₂ NPO ₂ HSPS ₂	phosphenic amide phosphenotrithioic acid	aminodioxophosphane mercaptodithiophosphane
30	HOP(NH) ₂	phosphenodiimidic acid	hydroxydiiminophosphane, etc.
	HNP	phosphenimidic nitride	iminonitrilophosphane
	CH ₃ NHPO ₂	methylphosphenic amide	(methylamino)dioxophosphane
	C ₄ H ₉ OPO ₂	butyl phosphenate	butoxydioxophosphane
	CH ₃ OP(O)NH	methyl phosphenimide	iminomethoxyoxophosphane
	H ₂ NPO	phosphenous amide	aminooxophosphine
	HOPS	phosphenothionous acid	hydroxythiophosphine
	HSP	phosphenothiolous acid	mercaptooxophosphine
	H ₂ NPNH	phosphenimidous amide	aminoiminophosphine
	CH ₃ OP=O	methyl phosphenite	methoxyoxophosphine
	CH ₃ NHPNH	N-methylphosphenimidous amide	imino(methylamino)phosphine
	CH ₃ NPNH ₂	N'-methylphosphenimidous amide	amino(methylimino)phosphine, etc.

Resolution of Ambiguities in the Nomenclature of Spiro Ring Systems*

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Owing to the laxity extant in the existing rules for naming spiro ring systems, it was necessary to characterize unambiguously spiro ring systems before attempting to eliminate other ambiguities. Following this characterization, procedures are given for naming all types of spiro ring systems including those which contain more than two terminal rings and for naming branched spiro ring systems. A procedure for transforming the names into their corresponding graphical representations is also described.

The problems to which this paper is addressed are: eliminating the ambiguity which arises when one tries to transform into graphical representation the name of a spiro ring system which contains more than two terminal rings, providing a method for naming branched spiro ring systems, and providing a procedure for transforming such names into graphical representations. Solution of these problems is necessary to enable the user of indexes such as those to *Chemical Abstracts* to retrieve information on these compounds unambiguously, to improve the chances for successful translations of the names into atom-bond connection tables¹ or into linear notations such as the Wiswesser Line Notation,² to improve the chances for successful computer and human transformation of the

names into graphical representations,³ and to provide correct names to which stereochemical notations may be affixed.⁴

This paper is divided essentially into two parts. The first part is a discussion, on a rather intuitive level, of the ambiguities which exist in the rules for naming spiro ring systems. The second part is a mathematical treatment of the subject and is presented in part to illustrate the proper approach to the development of nomenclature rules.

DEFICIENCIES IN EXISTING RULES

The naming of spiro ring systems seems, at first glance, as simple a task as can be imagined within the realm of chemical nomenclature. Naming the systems is, however, only half the battle, since the utility of the

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