

IUPAC Recommendations

Willem H. Koppenol, John Corish, Javier García-Martínez, Juris Meija and Jan Reedijk*

How to name new chemical elements (IUPAC Recommendations 2016)

DOI 10.1515/pac-2015-0802

Received August 20, 2015; accepted March 1, 2016

Abstract: A procedure is proposed to name new chemical elements. After the discovery of a new element is established by the joint IUPAC-IUPAP Working Group, the discoverers are invited to propose a name and a symbol to the IUPAC Inorganic Chemistry Division. Elements can be named after a mythological concept, a mineral, a place or country, a property or a scientist. After examination and acceptance by the Inorganic Chemistry Division, the proposal follows the accepted IUPAC procedure and is then ratified by the Council of IUPAC. This document is a slightly amended version of the 2002 IUPAC Recommendations; the most important change is that the names of all new elements should have an ending that reflects and maintains historical and chemical consistency. This would be in general “-ium” for elements belonging to groups 1–16, *i.e.* including the f-block elements, “-ine” for elements of group 17 and “-on” for elements of group 18.

Keywords: element; Inorganic Chemistry Division; naming process; nomenclature; periodic table; recommendations.

CONTENTS

1. INTRODUCTION	401
2. EXISTING RECOMMENDATIONS	402
3. CHOICE OF NAMES FOR NEW ELEMENTS	403
4. PROCEDURE FOR NAMING A NEW ELEMENT	404
5. MEMBERSHIP OF SPONSORING BODIES.....	404
6. REFERENCES AND NOTES	405

1 Introduction

As early as 1782 it was stated by Guyton de Morveau that, in the interest of science, it was necessary to have “a constant method of denomination, which helps the intelligence and relieves the memory” [1]. Ideally, a chemical element or a compound should have a unique name because the proliferation of names for the same substance can lead to confusion.

Article note: This recommendation is an update of: *Pure Appl. Chem.* **74**, 787–791, (2002). Prepared for publication in 2001 by W. H. KOPPENOL, see Ref. 3. <http://dx.doi.org/10.1351/pac200274050787>.

*Corresponding author: Jan Reedijk, Leiden Institute of Chemistry, Leiden University, P.O. Box 9502, 2300 RA, Leiden, The Netherlands, e-mail: reedijk@chem.leidenuniv.nl

Willem H. Koppenol: Laboratorium für Anorganische Chemie, ETH, CH-8093 Zürich, Switzerland

John Corish: School of Chemistry, Trinity College, University of Dublin, Dublin-2, Ireland

Javier García-Martínez: Department of Inorganic Chemistry, University of Alicante, E-03690 Alicante, Spain

Juris Meija: National Research Council Canada, Ottawa, ON K1A 0R6, Canada

A case in point, but not the only one, is element 104, for which the names rutherfordium and kurchatovium were used for nearly three decades by competing laboratories. At the heart of the problem is the belief of the discoverers that they have the sole right to name a new element. However, given a decision by IUPAC in 1947, discoverers have the right to *suggest* a name to IUPAC. In fact, only the IUPAC Commission on Nomenclature of Inorganic Chemistry, after an examination of the suggested name to determine its suitability and a public and expert review process, could make a recommendation to the IUPAC Council. On 1 January 2002, when the IUPAC Commission for the Nomenclature of Inorganic Chemistry ceased to exist, this responsibility was taken over by the IUPAC Inorganic Chemistry (Division II) to which this Commission belonged. The IUPAC Council still makes the final decision (see below).

While the origin of the names of some elements is obscure, the names of many have been based on a property of the element, a mineral from which it was isolated, its place or area of discovery, a mythological character or concept, an astronomical object, or the name of an eminent scientist.

At the time of writing the previous recommendation (years before 2002), it was apparently not anticipated that the pace of discoveries of new heavy elements would soon lead to new elements of the halogen and the noble gas groups. As it is now expected that these elements are well within reach and given the objections to the suffix *-ium* for these elements to avoid linguistic confusion and educational difficulties [2], IUPAC has decided to amend the 2002 Recommendation [3] in order to allow for more appropriate naming of future elements that would belong to group 17 and 18.

2 Existing recommendations

Although the historical aspects of the debate on the naming of the transfermium elements is outside the scope of this article, there are three issues that are relevant here: (1) priority of discovery, (2) the right of discoverers to suggest names, and (3) the role of the IUPAC Commission on Nomenclature of Inorganic Chemistry (now under IUPAC Division II). These issues were first addressed in 1947, as discussed in Ref. [4]:

“It was decided at the 1947 conference of the International Union of (Pure and Applied) Chemistry, held in London, that in the future the naming of elements and all questions relating to the names and symbols of the elements should be dealt with by joint meetings of the Commissions of Inorganic Nomenclature and of Atomic Weights. Such matters had previously been dealt with by the Commission of Atomic Weights alone.

It has been accepted in the past that the discoverers of a new element had the sole right to name it. Sometimes two different names have been given for the same element at about the same time and now it is often difficult to decide which was actually given first. Moreover, a name which was given later in point of time may have come into more general use or be more suitable than the name first given and there are cases of this kind in the International Table of Atomic Weights, so that the acceptance of a given name for an element must not be regarded as bearing any claim to priority of discovery. Priority is only one factor to be considered in deciding which name is the best for general international adoption. This presumptive right to name new elements is now accorded to the discoverers of new elements produced artificially, but subject to the approval of the Nomenclature Commission of IUPAC.”

The right of discoverers to suggest names was again restated in 2005 ([5] Section IR-3.1):

“In the past, some elements were given two names because two groups claimed to have discovered them. To avoid such confusion it was decided in 1947 that after the existence of the new element had been proved beyond reasonable doubt, ‘discoverers’ had the right to *suggest* a name to IUPAC, but that only the Commission on Nomenclature of Inorganic Chemistry could make a recommendation to the IUPAC Council to make the final decision.”

While primarily focusing on the establishment of a systematic nomenclature and symbols for elements of atomic number greater than 100, a specific 1979 IUPAC recommendation [6] stated:

“The existence of a systematic nomenclature for the unknown elements does not deny the right of ‘discoverers’ of new elements to suggest other names to the Commission after their discovery has been established beyond all doubt in the general scientific community.”

These important quotations establish that, in the past: (1) the discoverers of new elements had the right to suggest names, (2) the IUPAC Commission on Nomenclature of Inorganic Chemistry was given the responsibility to examine such names and to conduct a public and private review process to determine their suitability before recommending one of them to the Council of IUPAC for decision, and (3) priority of discovery could, but did not have to, be taken into account. As to the involvement of the IUPAC Commission on Atomic Weights, in 1949 it ceded the responsibility for naming the newly discovered elements 43, 61, 85, 87, 93–96 and elements 4, 41, 71, 72, 74 and 91, for which two or more names were current, to the Commission on Nomenclature for Inorganic Chemistry [7]. Furthermore, it could be established that in 1957 the Commission on Atomic Weights was not involved in the naming of elements 99–102 [8].

The following quotations are relevant to the selection of names:

“Any new metallic elements should be given names ending in -ium”. [4]

“...Other elements recognised (or discovered) during the past three centuries were named according to various arbitrary associations of origin, physical or chemical properties, etc., and more recently to commemorate the names of eminent scientists.” ([5] Section IR-3.1)

“It is obviously desirable that the names used in any language resemble these names as closely as possible, but it is recognized that for elements named in the past there are often well-established and very different names in other languages.” ([5] Section IR-3.1)

This strategy and the guidelines originally formulated in 1947 should obviate the problem of multiple names from different laboratories for the same element. The responsibility for formally recommending a name to the Council of IUPAC now rests solely with the Inorganic Chemistry Division, which then follows the procedure outlined below for recommending a name to the Council of IUPAC. This procedure differs from the IUPAC guidelines of 1947 in that priority of discovery will be assigned by a joint IUPAC-IUPAP Working Group [9–11], and that only the laboratory(ies) to which priority has been assigned is (are) allowed to propose a name and a symbol. The issue of priority applies only to newly discovered elements; if and when the priority of discovery of an already-named element is successfully challenged, then this element will not be renamed [12], which was the case of element 102 (nobelium) [13].

3 Choice of names for new elements

In keeping with tradition, elements are named after:

- (a) a mythological concept or character (including an astronomical object),
- (b) a mineral, or similar substance,
- (c) a place, or geographical region,
- (d) a property of the element, or
- (e) a scientist.

To avoid confusion in the literature, when a name has been used for a particular element, but a different name is ultimately chosen for that element then the first name cannot be transferred for use for another element. A case in point is element 105 for which the name hahnium has been in use. Since the name dubnium was ultimately chosen for that element, hahnium cannot be used for another as yet unnamed element. In addition, when a certain symbol has been in use for a particular element, it cannot be transferred for use for another element [3, 14]. For example, for element 112 the symbol Cp was not acceptable because it was used for casiopeium (now lutetium) in the past.

The names of all new elements should have an ending that reflects and maintains historical and chemical consistency. This would be in general “-ium” for elements belonging to groups 1–16, “-ine” for elements of group 17 and “-on” for elements of group 18. *N.B. The present recommendation is here more specific than that written in the 2002 document* [3].

4 Procedure for naming a new element

4.1 Formal proposal of a name

When the joint IUPAC-IUPAP Working Group has decided that the claims for the discovery of a new element fulfill the necessary criteria, the discoverers and the IUPAC Inorganic Chemistry Division are informed. Within two months of receiving the report from the joint IUPAC-IUPAP Working Group, the President of the Inorganic Division will invite the discoverers to propose a name and symbol for consideration. The proposal must be accompanied by a justification of the choice. If no such proposal is received within six months after the invitation, the Inorganic Chemistry Division shall take the initiative to propose a name, which will be submitted to the Council of IUPAC within two years of initiating the process. Similarly, when, in the case of a joint discovery, the laboratories involved cannot agree on a name and symbol within six months after the invitation, then the Inorganic Chemistry Division shall take the initiative.

4.2 Examination by the Inorganic Chemistry Division and public review

The Inorganic Chemistry Division examines the proposed name and symbol for suitability and, if satisfied, takes these through the accepted IUPAC procedure [15], according to which a Provisional Recommendation is written and sent to 15 experts, officers of other interested commissions, the Interdivisional Committee on Terminology, Nomenclature and Symbols, and posted on the IUPAC website for interested individuals. The opinion of IUPAP will also be sought. Should difficulties arise in any of these processes that make the proposed name unacceptable, then the Inorganic Chemistry Division will correspond with the laboratory or laboratories concerned to seek their agreement to any necessary changes or to an alternative name or symbol suggested for its consideration.

4.3 Formal naming of the element

When these processes are complete, the President of the Inorganic Chemistry Division forwards the Division's final recommendation for the name of a new element to the Council of the IUPAC for formal approval by the Union and publication in *Pure and Applied Chemistry*.

4.4 Interim names

Prior to and during the naming process, the element may be referred to by its atomic number, for example as in 'element 118', or by its provisional systematic name, 'ununoctium'. If a symbol is needed, the systematic, provisional three-letter symbol should be used ([5], Section IR-3.1.1 and Table II, [6]), irrespective of the position of the element.

5 Membership of sponsoring bodies

Membership of the Inorganic Chemistry Division Committee for the period 2014–2015 was as follows:

President: J. Reedijk (The Netherlands); **Vice President:** L. Öhrström (Sweden); **Secretary:** M. Leskela (Finland), **Past President:** R. D. Loss (Australia); **Titular Members:** T. Ding (China), M. Drabik (Slovakia), D. Rabinovich (USA), E. Tshuva (Israel), T. Walczyk (Singapore/Switzerland), M. Wieser (Canada); **Associate Members:** J. Buchweishaija (Tanzania), P. Karen (Norway), J. Garcia Martinez (Spain), A. Kiliç (Turkey), K. Sakai (Japan), R-N. Vannier (France); **National Representatives:** Y. Abdul Aziz (Malaysia), A. Badsha

(Pakistan), L. Armelado (Italy), V. Chandrasekhar (India), L. Galamba-Correia (Portugal), S. Kalmyakov (Russia), B. Prugovečki-Biserka (Croatia), N. Trendafilova (Bulgaria), L. Meesuk (Thailand). S. Mathur (Germany).

Funding: This manuscript (PAC-REP-15-08-02) was prepared in the framework of IUPAC project 2015-0311-200.

6 References and notes

- [1] “...il exige une méthode constante de dénominations qui aide l’intelligence et soulage la mémoire.” L. B. Guyton de Morveau. *Observations sur la Physique, sur l’Histoire Naturelle et sur les Arts* **19**, 370 (1782).
- [2] B. F. Thornton, S. C. Burdette. *Nature Chem.* **5**, 350 (2013); B. F. Thornton, S. C. Burdette. *Chem Int.* **35**(6), 26 (2013).
- [3] W. H. Koppenol. *Pure Appl. Chem.* **74**, 787 (2002).
- [4] IUPAC. *Commission de Nomenclature de Chimie Inorganique, Tentative Rules for Inorganic Nomenclature*. in: Comptes Rendus de la Dix-Septième Conférence, Stockholm, pp. 98–119 (1953).
- [5] *Nomenclature of Inorganic Chemistry – IUPAC Recommendations 2005*. Edited by N. G. Connelly, T. Damhus, R. M. Hartshorn, A. T. Hutton, Royal Society of Chemistry, Cambridge, UK, ISBN 0-85404-438-8.
- [6] J. Chatt. *Pure Appl. Chem.* **51**, 381 (1979).
- [7] IUPAC. *Commission des Poids Atomiques, (Commission Report)*. in: Comptes Rendus de la Quinzième Conférence, Amsterdam, pp. 50–51 (1949).
- [8] IUPAC. *Commission de Nomenclature de Chimie Inorganique, (Commission Report)*. in: Comptes Rendus de la Dix-Neuvième Conférence, Paris, pp. 93–93 (1957).
- [9] A. H. Wapstra. *Pure Appl. Chem.* **63**, 879 (1991).
- [10] D. H. Wilkinson, A. H. Wapstra, I. Ulehla, R. C. Barber, N. N. Greenwood, A. Hryniewicz, Y. Jeannin, M. Lefort, M. Sakai. (Transfermium working group of IUPAC and IUPAP). *Pure Appl. Chem.* **65**, 1757 (1993).
- [11] P. J. Karol, H. Nakahara, B. W. Petley, E. Vogt. *Pure Appl. Chem.* **73**, 959 (2001).
- [12] To avoid confusion, the suggestion by Paneth that elements be renamed after priority has been reassigned, is not followed. F. A. Paneth. *Nature* **159**, 8 (1947).
- [13] IUPAC Inorganic Chemistry Division, Commission on Nomenclature of Inorganic Chemistry. *Pure Appl. Chem.* **69**, 2471 (1997).
- [14] J. Meija. *Nature* **461**, 341 (2009).
- [15] IUPAC website, <http://www.iupac.org/what-we-do/recommendations/procedure-for-publication/>, Accessed: April 11, 2016.

Note: Republication or reproduction of this report or its storage and/or dissemination by electronic means is permitted without the need for formal IUPAC or De Gruyter permission on condition that an acknowledgment, with full reference to the source, along with use of the copyright symbol ©, the name IUPAC, the name De Gruyter, and the year of publication, are prominently visible. Publication of a translation into another language is subject to the additional condition of prior approval from the relevant IUPAC National Adhering Organization and De Gruyter.