Isotopic Abundances and Atomic Weights

IUPAC Commission II.1 Today

by Juris Meija

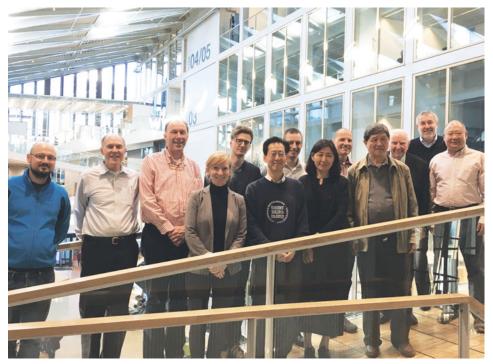
t is hard to imagine IUPAC without the Periodic Table, and in turn, without atomic weights. As IUPAC celebrates its centennial, its oldest body, the Commission on Isotopic Abundances and Atomic Weights (CIAAW) turns 120. The parent Commission was formed in March 1899 and its inaugural task was to decide the atomic weight standard; should it be based on hydrogen or oxygen? Although the issue was settled in favor of oxygen, when the CIAAW formally joined the IUPAC in 1919, the question of the atomic weight scale was back for debate suggesting that many issues before this Commission transcend their scientific merit. In fact, many view the Periodic Table and changes therein as a part of larger cultural fabric of science so any changes are likely to be debated for a long time.

Atomic weights have a history that spans two centuries. Kepler and Newton taught us how to weigh planets and stars, and Dalton and with his contemporaries taught us how to weigh atoms. Atomic weights lay the foundations for many scientific measurements, many

of which go largely unnoticed. For example, the 2007 definition of the kelvin (the SI unit of thermodynamic temperature) refers to a triple point of water with specific isotopic composition. Likewise, atomic weight of silicon played a special role in the recent efforts to redefine the kilogram and the mole.

Most recently, the CIAAW was recognized in the International Vocabulary of Metrology, and its recommendations have been endorsed by the International Committee on Weights and Measures (of BIPM, the *Bureau International des Poids et Mesures*).

The CIAAW has changed significantly over the last several decades. One of the biggest impacts to its work has undoubtedly been the rise of digital communications. The CIAAW has recognized the value of disseminating its outcomes on the World Wide Web as early as 1995. Championed by Robert D. Loss, the first CIAAW website was setup in 1997 on servers at the Curtin University of Technology in Perth, Western Australia. In 2007, the ciaaw.org domain was registered, and the CIAAW website was redesigned to its current form in 2014. Recognizing that formal paper-based publication of standard reference data is a time-consuming process,



The 2017 Atomic Weights Commission biennial meeting in the Netherlands (from left): Heiko Moossen, Tyler Coplen, Harro A.J. Meijer, Johanna Irrgeher (acting Secretary), Juris Meija (Chair), Shigekazu Yoneda, Philip J.H. Dunn, Jun Wang, Jochen Vogl, Tiping Ding, Norman Holden, Manfred Gröning, Xiang-Kun Zhu

recent revisions to the standard atomic weights have been first disseminated through jupac.org and claaw. org well before they appear in the pages of the IUPAC official journal Pure and Applied Chemistry. Note that atomic weights are summary outcomes derived from the isotope amount ratios. The CIAAW has not yet disseminated the isotope ratios in its publications but the online platform seems more appropriate than paper. In addition, online platform offers searchable data and interactive calculators.

The work of the CIAAW relies on the volunteers who are willing to engage in evaluation of isotope ratio measurements for the benefit of broader goals. Since 1902, the International Committee has been shaped by 120+ expert volunteers. A major change of the CIAAW in the recent decades has been the gradual increase in the youth of its members. In 1947, the average age of the CIAAW was at its peak-72-whereas today it is nearly at its lowest—just under 50. In addition, the gender diversity has improved significantly over the last decades. Marie Curie was the first woman elected member of the CIAAW in 1930 and of the eight women ever to serve to the CIAAW, half are

3.3

average number of

decimal digits in the

1902 Periodic Table

from the last decade alone. These are all positive changes which will position the CIAAW to be more responsive in the upcoming years.

Although the issue that comes up most frequently is the name "weight." which many find inappropriate, the CIAAW has plenty of technical issues at hand. Evaluation atomic weight data is a complex endeavour. Here, one often faces mutually inconsistent measurement results which are separated in time by several decades. Given that scientific norms and standards evolve. it is not trivial to evaluate such results. Near-Iv one in ten revisions of the standard atomic

weights, in fact, result in 'less precise' values. This is due

to the fact that new measurements might reveal biases in the past measurements. The most recent example of this was the atomic weight of ytterbium with two available contemporary measurements more than ten standard uncertainties apart. Alternatively, standard atomic weights of other elements become 'less precise' as we learn the true extent of natural variations, as happened most recently for argon.

Whereas the 19th century chemists set out to determine the atomic-weight values with highest precision, culminating with the 1914 Nobel Prize in Chemistry for Theodore W. Richards, the 20th century was largely shaped by the quest to understand these values which lead to the discovery of isotopes and the realization that the atomic-weight values of many elements do vary in nature. Our drive to measure atomic weights and isotope ratios with ever-increasing precision is bound to reveal new phenomena.

6

number of elements which have not been revised since 1969 (Cu, Gd, Pb, Rb, Sr, Te)

Juris Meija <Juris.Meija@nrc-cnrc.gc.ca> is an Officer in Metrology at the National Research Council Canada, Ottawa and chair of IUPAC Commission II.1 on Isotopic Abundances and Atomic Weights (CIAAW).

8

average number of revisions of the standard atomic weight of an element since 1902

79 years

longest period of a standard atomic weight unchanged disregarding the uncertainty (selenium, from 1934-2013)

52 years

longest period of a standard atomic weight unchanged (magnesium and europium, from 1909-1961)

2-digit standard atomic weight (1930)

Zr

last element to have

1

14 years

the average life-time of a

standard atomic weight

between revisions

the most frequent number which occurs in the standard atomic weights, also known as the Benford's law

6.4

average number of decimal digits in the 2017 Periodic Table

Ag and I

first elements to reach 6-digit standard atomic weight (1925)





IUPAC books from the Royal Society of Chemistry



Nomenclature of Organic Chemistry

IUPAC Recommendations and Preferred Names 2013

Detailing the latest rules and international practice, this new volume can be considered a guide to the essential organic chemical nomenclature, commonly described as the "Blue Book".

9780854041824 | £175.00 | \$280.00



Compendium of Terminology and Nomenclature of Properties in Clinical Laboratory Sciences

IUPAC Recommendations 2016

Significant developments in clinical laboratory sciences since the previous edition of this book in 1995 means that this book is appropriate for all laboratory scientists, medical professionals and students.

9781782621072 | £99.99 | \$160.00

Other titles of interest



Principles of Chemical Nomenclature

A Guide to IUPAC Recommendations 2011 Edition

Aimed at pre-university and undergraduate students, this volume surveys the current IUPAC nomenclature recommendations in organic, inorganic and macromolecular chemistry.

9781849730075 | £24.99 | \$40.00



Comprehensive Glossary of Terms Used in Toxicology

Fully comprehensive and rigorously reviewed by IUPAC Committees, this is a reference glossary for students, researchers, and those involved in chemicals legislation, regulation and risk assessment.

9781782621379 | £76.99 | \$138.00

All IUPAC members can use the discount code IUPACMEM30 to get 30% off the UK list price at rsc.li/books

