



Max-Planck-Institut
für Biogeochemie

Dr. Willi A. Brand
**Chair IUPAC Commission on Isotopic
Abundances and Atomic Weights (CIAAW)**

E-Mail: wbrand@bgc-jena.mpg.de

Dr. R. Kaarls
Secretary of the CIPM
Klaverwydenstraat 13

2381 VX Zoeterwoude

THE NETHERLANDS

PO Box 10 01 64
D-07701 Jena

Tel. +49-(0)3641-576400
Fax +49-(0)3641-577400

www.bgc-jena.mpg.de

Directors
Sue Trumbore
Martin Heimann

September 23, 2011

Re: Definition of the mole

Dear Dr. Kaarls,

Ongoing efforts to redefine certain units, in particular the redefinition of the kilogram, the mole and the ambiguous interpretation of the quantity "amount of substance" were discussed extensively at the 2011 meeting of the Commission on Isotopic Abundances and Atomic Weights in Calgary, July 26-27.

From these discussions, it was noted that the atomic mass unit (the dalton) is the unit in which all atomic and molecular masses are reported. It is defined as 1/12 of the mass of the carbon-12 isotope.

Together with the Avogadro constant, when its value is fixed as a defined integer, the dalton could also form the basis for a redefinition of the kilogram. This has the advantage that mass would be tied to something very basic in physics, and not to an arbitrary, historical artifact kept at BIPM in Paris, which is likely changing its mass over the last century.

Our discussion results are summarized in the accompanying text, which I submit to you as the Commission's official statement for further consideration and communication to the CIPM and CGPM.

With kindest regards,

cc. President of IUPAC, Prof. Nicole J. Moreau (nj.moreau@free.fr)

IUPAC Inorganic Chemistry Division Commission on Isotopic Abundances and Atomic Weights (CIAAW)

At its 2011 meeting in Calgary, Canada, the CIAAW examined the ongoing approaches to redefine the mole, unit of amount-of-substance. The currently proposed future definition of the mole (SI Brochure, 9th ed, Draft chapter 2) reads as follows:

“The mole, mol, is the unit of amount of substance of a specified elementary entity, which may be an atom, molecule, ion, electron, any other particle or a specified group of such particles; its magnitude is set by fixing the numerical value of the Avogadro constant to be equal to exactly $6.022\ 14 \times 10^{23}$ when it is expressed in the unit mol^{-1} .”

The CIAAW,

noting

1. the request of CCQM for “open debate ...” so as to enable the preparation of an informed proposal by the CCU of a future redefinition of the mole by the CGPM,
2. the 2009 statement by ICTNS that “the name of the ISQ base quantity ‘amount of substance’ has been a source of much confusion” and that “the greatest effort should be made to change the name ... at the same time that a new definition of the mole is approved”,
3. the ICTNS (2009) is of the opinion that the mole is often thought of by chemists as an Avogadro number of entities,
4. a unanimous opinion of the CCQM Working Group on the mole has not yet been attained for submission to CCQM, and

considering that

1. the non-SI unit of mass, the dalton (symbol Da), is defined as 1/12th of the mass of a single ^{12}C atom,
2. atomic-mass values of the elements are commonly expressed in daltons, not in kilograms,
3. all atomic-weight values of the elements have traditionally been published as ratios to atomic-mass values,
4. all molecular-weight values for large molecules such as proteins are increasingly expressed in daltons,
5. numerous chemical measurements consist of measurement of ratios of number of entities (atoms, molecules, ...).

recommends

1. changing the name of the quantity “amount of substance” to “number of entities”,
2. the following future definition of the mole:
Mole, the unit of number of entities, symbol ‘mol’, is a number of specified entities equal to $6,022\ 14 \times 10^{23}$ entities exactly.
3. that, in addition, together with the fixed value of the Avogadro constant, the dalton could serve to redefine the kilogram in a way that would suit the needs of the chemists:
Kilogram, the unit of mass, symbol ‘kg’, is the mass of $6,022\ 14 \times 10^{23}$ atoms of ^{12}C in their nuclear ground state multiplied by 1000/12,
or
Kilogram, the unit of mass, symbol ‘kg’, is the mass of one mole of ^{12}C atoms in their nuclear ground state multiplied by 1000/12.
4. that any decision on the redefinition of the mole be deferred until full consideration is given to the interests of the chemical and isotopic measurement communities.