INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

ANALYTICAL CHEMISTRY DIVISION

COMMISSION ON ANALYTICAL NOMENCLATURE

RECOMMENDED NOMENCLATURE FOR SCALES OF WORKING IN ANALYSIS

Prepared for publication by
E. B. SANDELL
Chemistry Department, University of Minnesota, USA
and
T. S. WEST
Macaulay Institute for Soil Research, Aberdeen, UK

PERGAMON PRESS
OXFORD · NEW YORK · PARIS · FRANKFURT
This report was prepared for the Commission by Professors E.B. Sandell and T.S. West in con- 
junction with a working party consisting of Professor H. Flaschka and Dr O. Menis. It is 
an extension of previously approved nomenclature published in Pure and Applied Chemistry 
1960, 1, 143 based on further tentative nomenclature first published in Information Bulletin 
No.18, 1972 subsequently revised and approved for publication finally by the Inter-Divisional 
Committee on Nomenclature and Symbols and the Council of the Union at its 29th General 
Assembly in 1977.

"Scales of working" in analysis primarily implies the size of the sample (test portion) 
taken. To the extent that there is a choice, sample size, 'S', is determined by the method 
(specifically procedure) applied, the relative content of constituent, 'C', and other factors 
such as the precision required. It is desirable to have a scheme for the classification of 
analytical methods based on the magnitudes of S and C. It is proposed that methods 
(procedures) be described and classified, from the standpoint of the scale of working, with 
the aid of a bipartite designation:

Sample size (weight) - Constituent content (e.g. in percent or ppm)

which can be extended to liquid and gaseous samples. When the ranges of these two variables 
given, the range of the absolute quantity, 'Q' of the constituent is of course fixed.

Methods can be classified with any desired degree of fineness on this basis and their fields 
represented in a Cartesian plot, in which sample weights are plotted as abscissae and 
relative contents as ordinates. Convenient units are g for S and % or ppm for C. Because 
of the wide ranges that need to be covered, a double logarithmic plot of S and C is required 
(Fig.1). Diagonal lines in the Figure represent the absolute amounts, Q, of a particular 
constituent.

Although numbers alone are sufficient, and indeed necessary, for the precise designation 
and classification of methods, it is convenient, both in written and oral communication, to 
designate the size ranges of S and C by suitable terms. The use of words is especially 
convenient when approximate ranges are to be indicated.

SAMPLE WEIGHT CLASSIFICATION (S)

Sample sizes can be classified as gram (1-10 g), decigram (0.1-1 g), centigram (0.01-0.1 g), 
milligram (0.001-0.01 g), microgram (10^{-6}-10^{-3} g), nanogram (10^{-9}-10^{-6} g), picogram (10^{-12} 
10^{-9} g), femtogram (10^{-15}-10^{-12} g), etc. See A, Fig.1.

Macro, semimicro, and micro have been used for many years to indicate sample sizes and
therewith the scale of analytical operations. Such terms serve a useful purpose and are worth retaining.

Quite generally, a macro sample is considered to be one weighing more than 0.1 g. An upper limit is not specified, but most methods, considered macro, call for samples in the range 0.1-1 g. The term semimicro is an unfortunate one in that it does not mean half micro, but larger than micro. For this reason the term meso is preferred to semimicro. A meso sample (semimicro) may then logically be taken as falling in the range 0.1-0.01 g. Samples in the range $10^{-3}$-$10^{-4}$ may be called submicro, and those below $10^{-4}$ g, ultramicro, with no lower limit specified for the latter class; see B, in Fig.1.

CONSTITUENT CONTENT CLASSIFICATION (C)

The terms major, minor, and trace may be used to indicate a broad classification of constituents on the basis of their relative contents, as follows:

- Major constituent .... .... 100 - 1%
- Minor constituent .... .... 1 - 0.01%
- Trace constituent .... .... <0.01% (<100 ppm)

There are good reasons (historical and practical) for setting the upper limit of trace at 100 ppm and it has been, until now, advantageous to set no lower limit, so that anything below 100 ppm has been considered as a trace. However, advances in analytical technology now suggest that the trace range should be further sub-divided taking 100 ppm as the upper limit as follows:

- Trace .... .... 10^2 - 10^{-4}
- Microtrace .. .... 10^{-4} - 10^{-7}
- Nanotrace .... .... 10^{-7} - 10^{-10}
- Picotrace .... .... 10^{-12} - 10^{-13}

In Microanalysis an 'S' classification is normally used, i.e. the analyst is concerned with the smallness or size of his sample and not so much with the relative concentration of the constituent to be determined. Frequently indeed in microanalysis and in submicro or ultramicro analysis the sought constituent is a major one, i.e. C >1%.

In Trace analysis on the other hand, the value of 'C' is of paramount importance and usually the value of 'S', the sample size, is a minor consideration. Consequently 'C' may be $10^{-2}$ - $10^{-5}$ ppm and 'S' may be 1 - 100 g.

There are, however, occasions when constituent 'C' may lie in the ppm or sub-ppm level, a typical trace problem, but where the sample size 'S' may only be 100 µg, i.e. a true microanalysis type of problem. In such instances it is felt that an S or C classification is not sufficient and that an S/C one may be necessary.

It is, therefore, proposed that the term Ultra-trace (i.e. Ultramicro-trace) be reserved for such analyses. This term could be used generally to describe the whole area of trace analysis using micro-sized samples, but could where desired be more precisely specified as follows:

Ultra-trace Analysis i.e. S ≤ $10^{-4}$ g; C ≤ 100 ppm (0.01%)

For larger sized samples, similarly one would have the general terms:
Recommended nomenclature for scales of working in analysis

Sub-trace Analysis i.e. $S \ 10^{-3} \ - 10^{-6} \ g; \ C \leq 100 \ ppm \ (0.01\%)$

Micro-trace Analysis i.e. $S \ 10^{-2} \ - 10^{-3} \ g; \ C \leq 100 \ ppm \ (0.01\%)$

Meso-trace Analysis i.e. $S \ 10^{-1} \ - 10^{-2} \ g; \ C \leq 100 \ ppm \ (0.01\%)$

Fig. 1. Classification of analytical methods (and procedures) on the basis of sample size and constituent content.