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RECOMMENDED NOMENCLATURE FOR SCALES OF WORKING IN ANALYSIS

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This report was prepared for the Commission by Professors E.B. Sandell and T.S. West in conjunction 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 are 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.

<center>CONSTITUENT CONTENT CLASSIFICATION (C)</center>

The terms *major*, *minor*, and *trace* may be used to indicate a broad classification of constit-
uents 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^{-10} 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 ultra-
micro 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 micro-
analysis 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:

<center>*Ultra-trace Analysis* i.e. S $\leq 10^{-4}$ g; C $\leq$ 100 ppm (0.01%)</center>

For larger sized samples, similarly one would have the general terms:

Sub-trace Analysis   i.e.   S 10^{-3} – 10^{-4} 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.

Classification Content and Class Designation

Range of Trace Constituent

ppm	%
10^{-8}	10^{-12}
10^{-7}	10^{-11}
10^{-6}	10^{-10}
10^{-5}	10^{-9}
10^{-4}	10^{-8}
10^{-3}	10^{-7}
10^{-2}	10^{-6}
10^{-1}	10^{-5}
10^{0}	10^{-4}
10^{1}	10^{-3}
10^{2}	10^{-2}
10^{3}	10^{-1}
10^{4}	10^{0}
10^{5}	10^{1}
10^{6}	10^{2}

Nanotrace

Microtrace

Trace

Minor

Major

Q   (g)

10^{-4}

10^{-3}

10^{-2}

10^{-1}

1   10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} g

A | Decigram | Centigram | Milligram | Microgram |

B $\leftarrow$ – – Macro – – – | Meso | Micro | Submicro | – – – Ultramicro – – – $\rightarrow$

Sample   Weight "S" and Class Designation