The Measurement Process in Chemistry

Objectives

• To introduce the general procedural landmarks required for the reliable measurement of chemical parameters and delivery of results.
• To define the general features of analytical processes conducted inside and outside the laboratory.
• To provide a global description of the preliminary operations of the analytical process and underscore their significance.
• To provide a global description of measurement and transducing of the analytical signal, and of acquisition and processing of analytical data.
• To illustrate the process by which analytical results are obtained via suitable examples.

Table of Contents

4.1 Definition of Chemical Measurement Process ........................................ 144
4.2 General Steps of a Chemical Measurement Process .......................... 147
4.3 Preliminary Operations ................................................................. 149
  4.3.1 General Features ................................................................. 150
  4.3.2 Sub-steps ............................................................................ 154
  4.3.3 Sampling ............................................................................ 155
  4.3.4 Sample Treatment ............................................................... 161
4.4 Measurement and Transducing of the Analytical Signal ..................... 168
4.5 Signal Acquisition and Data Processing .......................................... 171
4.6 Validation of a Chemical Measurement Process ................................. 173
4.7 Salient Current Trends ................................................................. 174
Annex I ......................................................................................... 177
Annex II ....................................................................................... 182
Annex III ...................................................................................... 186
Annex IV ....................................................................................... 189
Annex V ....................................................................................... 190
Annex VI ...................................................................................... 192
Questions .................................................................................... 194
Seminars ...................................................................................... 196
Suggested Readings ........................................................................ 199

M. Valcárcel, Principles of Analytical Chemistry
© Springer-Verlag Berlin Heidelberg 2000
4.1 Definition of Chemical Measurement Process

The chemical analysis of a sample invariably raises a series of questions such as those of Fig. 4.1. First, one must know “what” is to be analysed, which entails identifying the sample and its analytes. The human component of the analysis, i.e. “who” is to perform it, is also very important; in fact, the agent of the analysis is a crucial element in management-analyst-operator and operator-automated system relationships, among others. “How” the analysis in question is to be conducted materializes in a chemical measurement process, which is the subject matter of this chapter.

Each chemical analysis has a purpose that is normally stated as an analytical problem (“why” the analysis is needed). The answer to this question is dictated by that to “what” and to those related to the system under study (“where” and “when”); also, obviously, it dictates “how” the analysis is to be carried out. Such a straightforward scheme (Fig. 4.1) exposes the relationships among the answers to the previous questions and, specifically, the fact that all influence the chemical measurement process, as shown in greater detail in Chap. 7, which is devoted to the analytical problem.

A chemical measurement process (CMP) is defined as a set of operations that separates the uncollected, unmeasured, untreated sample from the results it provides, expressed in a manner consistent with the analytical problem addressed (Fig. 4.2). Based on this definition, a CMP is a sort of “analytical black box”, a term coined by Chalmers and Bailescu. As discussed in Sect. 3.3, the essential difference between a CMP and a physical measurement process (PMP) is that the former involves not only measurement (and calibration) and data processing, but also other, equally important, operations.

As shown by the Analytical Chemistry ranking discussed in Sect. 1.6, a chemical measurement process is the materialization of an analytical technique.