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Competition — 1st prize

Analytical Chemistry – today's definition and interpretation

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Analytical Chemistry is defined as the self-reliant, chemical sub-discipline which develops and delivers appropriate methods and tools to gain information on the composition and structure of matter, especially concerning type, number, energetic state and geometrical arrangement of atoms and molecules in general or within any given sample volume. Modern Analytical Chemistry can also be considered applied physical chemistry. In Analytical Chemistry, special techniques are used to transform measured chemical signals, derived mostly from specific interaction between matter and energy, into information and ordered knowledge. Thus this discipline succeeds in establishing exciting, new and unique possibilities which drastically expand our perception of the material world, by creating three-dimensional pictures of the true qualitative and quantitative chemical reality inside a material sample. Its magnificent cognitive power is also heavily used in the process of knowledge accumulation and theory formulation by a variety of other natural scientists.

Analytical Chemistry

Analytical Chemistry is the cognitive sense of every natural science discipline grasping for an unbiased chemical reality of the microcosm, whether it is an isolated sample of matter in our hands or a star far away in the universe. It is the type and number of atoms, together with their arrangement in three-dimensional space, which determine the properties of matter.

Prior to any hypothesis and theory, there is always the perception of the outer world and, prior to any nomenclature, there are the active interactions of scientists with the material environment with both leading to proper epistemology. The process of identification has led, by way of the classification of properties and the building of categories, to defined objects with settled names. Therefore every chemical identification demands a reliable recognition of one or more specific properties of the object (atom or molecule) under study. Recognition of the elemental particles of matter and their specific interactions with energy requires a precisely described operational sequence of actions. The results of these experiments or tests, a series of several "yes" or "no" answers which eventually define and identify the object under study, represent the information gained on the sample. This knowledge is quantifiable in terms of the information unit "byte".

Analytical Chemistry provides the methods and tools needed for insight into our material world and leads to a variety of perceptions about the world depending on the chosen atom- or molecule-specific sensory input. In this respect Analytical Chemistry has greatly expanded our view of reality. Qualitative, quantitative and structural chemical information, made available through Analytical Chemistry, has led to exciting three-dimensional representations of matter. These pictures or visions were not foreseeable by many philosophers who discussed our limited abilities to grasp "the things in themselves".

Analytical Chemistry was, and still is, above all, applied chemistry. Modern instrumental analysis is physical chemistry especially devoted to obtaining information about the composition of matter and the energetic state of the elementary particles involved. Since the number of available analytical methods is steadily increasing and the applied instrumentation developed has become more and more complex, Analytical Chemistry has grown to become a self-reliant, chemical subdiscipline. Analytical Chemistry, as the way to an unbiased, reliable perception of the chemical nature of the material world, has participated overwhelmingly in the process of knowledge accumulation and theory formulation; therefore it cannot be disregarded by any natural scientist interested in the hidden structure of matter. In this contex, one should keep in mind that every discovery is the combined relationship of analysis and synthesis. For example, any pollution control regulation without positive feedback about its success is a pointless action. Analytical Chemistry provides just such a feedback mechanism and, thus, plays an integral and important part in our understanding and control of the material world (e.g. process control, high-tech production steps).

The Analytical Chemist

The Analytical Chemist is specialized in providing reliable methods and tools for answering four basic questions about a material sample: What? Where? How much? What arrangement, structure or form?

The tremendous increase in experimental methodologies developed by scientists to answer these key questions requires experienced and skilled experimenters who are confident with the details of several hundred different analytical methods. It is the duty of an Analytical Chemist to constantly improve the methodologies or the developed instrumental analyzers, in order to obtain the true result in shorter time or in an easier and more economical way.

The true result is defined as the agreement with the true situation in the reality under study. It is obvious that there can be only one true result in one and the same reality. It is not at all a purely philosophical question regarding how one obtains the true content or the true elemental distribution of a sample. It is the true situation of the compositional and structural distribution which is responsible for certain measurable properties of the material under study. Reproducibility of analytical results does not guarantee a true description of the chemical reality. The true analytical result is defined as a pragmatic approximation of the chemical reality. It has to be an intersubjectively testable statement of observation. If, in this observation process, totally different analytical methods lead to the same result, then the probability of systematic measurement errors is very low and the analytical result may be considered to be true.

The Analytical Chemist is also responsible for keeping the systematic errors in chemical analysis as small as possible. This can only be guaranteed if he/she is involved at least once before the work becomes routine analysis in the whole analytical process, starting with sampling and ending with a statistical treatment of the results obtained. The only interpretation a serious Analytical Chemist should offer is the level of confidence he/she has in delivering the analytical result! The interpretation of the relevance of the analytical results for the corresponding science (natural and material sciences, life sciences etc.) generally exceeds the capabilities of the Analytical Chemist and is better left to experts in those fields.

It is not the duty of the Analytical Chemist to run everyday routine analyses, which can be performed by technicians or scientists needing those analytical chemical results in their special research areas. However, to control the quality of routine analysis the Analytical Chemist has to develop so-called good laboratory practice (GLP) to check the reliability of the results produced using chemometrics, certified standard reference materials and other methods.

The Analyst

The Analyst is the user of the analytical methods and instruments developed by the Analytical Chemist to yield reliable and true results if clearly given instructions are properly followed. The Analyst can be any trained person who performs the test and runs the needed measuring instruments in a reliable fashion. In a certain way, any analytical method including the necessary instrumentation can be regarded as a rifle (constructed by the Analytical Chemist) such that every hunter (Analyst) can hit the center of the target (obtaining the right result) without being an expert in ballistics (Analytical Chemistry).

Conclusion

Since every science is defined as a way of knowledge accumulation and theory formulation, the magnificent cognitive power of Analytical Chemistry cannot be disregarded by any natural scientist. Therefore the state of the art in the field of Analytical Chemistry has a strong impact on other scientific disciplines. Without the cognitive feedback of analysis, no synthesis, no high-tech process, or pollution control actions are possible. Since the whole perception of the properties and laws of the material world are so strongly dependent on the level of performance of Analytical Chemistry it has become a self-reliant, chemical subdiscipline. Analytical Chemistry also includes a tremendous economic side, directly through the market for analytical instruments and, above all, indirectly through decisions taken in industry and the society as a whole based on analytical results. Because nearly a third of all chemists work in the field of Analytical Chemistry, it should be taught at a sufficient level at every University which has a Chemistry Department, in order to ensure the continued knowledge base which this subdiscipline uniquely provides.