



A Revolution that never happened



Ursula Klein

Max Planck Institute for the History of Science, Germany

ARTICLE INFO

Article history:

Available online 19 December 2014

Keywords:

Chemical revolution;
Ontology of substances;
Elements;
Mixts;
Chemical compounds;
Affinity

ABSTRACT

If we define scientific revolutions as changes of scientists' ontologies, types of causal explanation, and paradigmatic types of methods and instruments, Antoine-Laurent Lavoisier's contribution to chemistry did not amount to a scientific revolution. Contrary to the received view that Lavoisier initiated a "chemical revolution," which is accepted by Chang and Kusch, I argue that Lavoisier shared with the phlogistonists their "flat ontology" of chemical substance, established decades before the 1770s, their types of explaining chemical transformation, and their quantitative methods. Based on my historical reconstruction, I criticize Chang's argument that the late eighteenth-century phlogistic systems and Lavoisier's system belonged to two different theoretical traditions. As a consequence, I also question Chang's argument that the acceptance of Lavoisier's system can be explained in terms of dominance of "compositionism" over "principlism."

© 2014 Elsevier Ltd. All rights reserved.

When citing this paper, please use the full journal title *Studies in History and Philosophy of Science*

1. Introduction

As is well known, Thomas Kuhn highlighted Lavoisier's "chemical revolution" as a clear example of a large scientific revolution (Kuhn, 1962, pp. 6, 56, 92, 118). This contribution to our symposium on the "chemical revolution" challenges the view that Lavoisier initiated a revolution of chemistry. I will study the following questions. Did Lavoisier (and his collaborators) introduce "deep" changes of chemistry that can be reasonably called a revolution? Did he change chemists' ontology of substances? Did he change their type of causal explanation of chemical transformations? And did he introduce novel methods and instruments?¹ Instead of

¹ E-mail address: Klein@mpiwg-berlin.mpg.de.

¹ This essay elaborates arguments presented in Klein and Lefèvre (2007). For reasons of space, I do not discuss in any detail the fourth question concerning instruments and methods. It should be noted, however, that many phlogistonists performed exact quantitative experiments (see my remarks in part 2). I also omit many interesting questions concerning biographical details as well as institutional, social and technological contexts of eighteenth-century chemistry. Hence, it is also beyond the scope of this paper to discuss the question of whether Lavoisier's system led to a separation of chemistry from pharmacy and other artisanal practices; as Sacha Tomic has recently shown, much of the old connection between chemistry and pharmacy were preserved in nineteenth-century France (Tomic, 2010).

following the path to Lavoisier's system, I will compare the phlogistic and the antiphlogistic system from a broader historical and philosophical perspective. My approach invites restricting the meaning of "scientific revolution" to radical change that is analogous to social and political revolutions (Kuhn, 1962, pp. 92–94).

I will show in the following that an examination of the questions asked above yields an overall negative result. Lavoisier's work affected less fundamental levels than chemists' ontology, ways of causal explanation, and paradigmatic empirical methods. Moreover, they were not changes of chemistry, but rather changes *within* the chemical discipline that left many chemical subjects untouched. As F. L. Holmes pointed out many years ago, Lavoisier's system did not extend to all fields of chemistry.²

Based on my conclusion that there was no chemical revolution, the question of acceptance of Lavoisier's system appears in a new light. As the phlogistic and anti-phlogistic systems were not incommensurable, but rather shared significant conceptual features, paradigmatic classes of substances, and methods, chemists

² Holmes (1989), p. 107. Lavoisier made no systematic contribution to the flourishing chemical sub-field studying proximate organic components. Nor did he extend his system to useful materials and minerals such as ores and stones, which were at the center of mineralogical chemistry; see also Klein and Lefèvre (2007).

could easily shift from one system to the other. It is out of the scope of this essay to study comprehensively the reasons why chemists accepted Lavoisier's system in the course of some twenty years after the publication of Lavoisier's *Traité élémentaire de chimie* (1789). Apart from reasons discussed by Chang and Kusch, I propose additional ones, which relate to late eighteenth-century chemists' shared goals and communal interests. I argue that Lavoisier's system facilitated both chemical teaching and communication and that this fact played an important role for its acceptance.

2. Chemists' ontology of substances

The question of what kinds of substances were included in Lavoisier's theoretical program, and what kinds of substances were excluded, has been rarely asked in the existing histories of the "chemical revolution."³ In Lavoisier's theories several substances—phlogiston, oxygen, caloric, water, acids, and permanent gases—played a paradigmatic role. However, the range of substances he studied from a theoretical perspective was also clearly restricted. The eighteenth-century chemists studied a much broader variety of substances than Lavoisier did in the context of his self-pronounced chemical revolution. They analyzed minerals as well as animal fats, vegetable oils, gums, resins and many other "proximate principles" of plants and animals. In addition, chemists examined a plethora of useful materials that were of highly complex nature. Indeed, Lavoisier, too, studied materials such as porcelain and coal, which were not on his theoretical agenda. Why did Lavoisier exclude ores, stones and other raw minerals as well as plant and animal substances from his system? Inversely, what were his criteria for focussing on substances such as gases, metals, acids, and salts? What were eighteenth-century chemists' beliefs about the kinds of substances that existed in the world? What causes did they invoke to explain the existence of the enormously broad variety of substances? And how did they connect their ontology of substances with their causal explanation of chemical transformations?

2.1. The pre-modern hierarchical ontology of substances

Let us start with a brief discussion of the pre-modern ontology of substances, which differed in important aspects from the views of both the late phlogistonists and Lavoisier and his group. For centuries chemists had assumed that the substances belonging to the mineral, animal and plant kingdom were composed of different simple "elements" (or "principles") and that the qualities of the elements, and their interactions, caused the properties of the broad variety of different kinds of natural substances. However, chemists' attitude towards "elements" and their understanding of the substances they handled in their laboratories underwent considerable change over time.

The vast majority of pre-modern chemists (or alchemists) conceived of elements as causes that engendered the different kinds of substances existing in the natural world. In sharp contrast to the large number of ordinary natural substances, the number of elements was small, ranging from one to five.⁴ All naturally occurring species of substances belonging to the mineral, vegetable and animal kingdom were defined as "mixts," without any exception. The term "mixts" expressed the belief that the different kinds

of mineral, plant and animal substances were "generated" from elements and that the qualities of the latter mixed in the process of generation. In the context of this pre-modern chemical ontology, elements were not ordinary natural substances but rather causes, few in number, that brought the variety of mixts into existence and determined their specificity.⁵

Pre-modern chemists' distinction between different ontological levels of material "substances"—the causal elements and the variety of natural mixts—was an Aristotelian heritage. The distinction implied an ontological hierarchy according to which the simple elemental causes were more important than the multiplicity of natural mixts generated by them. The Aristotelian heritage was also alive in the most influential version of pre-modern alchemy, Paracelsianism, which re-interpreted Aristotelian concepts from a hylozoistic perspective.

In the intellectual framework of the Aristotelian (and Paracelsian) tradition all mixts were further defined as homogeneous substances, the same in all their parts. Homogeneity of mixts emerged in the process of "generation," in which the qualities of the constituting elements interacted and converged into a uniformly balanced whole, whose "form" or specificity depended on the proportions of the elements. The meaning of "generation" was also determined by its Aristotelian context. "Generation" of mixts from elements was a slow, natural process, which differed in many aspects from chemical transformations performed in the laboratory. Unlike the early modern chemical concepts of analysis and synthesis, the concept of generation was not embedded in, and not derived from, experimentation in the laboratory.

This very rough outline of the pre-modern philosophy of elements and mixts omits many interesting aspects, such as critical questions addressed to it from the late middle ages and the early modern atomists' and corpuscular philosophers' attempt to answer these questions. In the course of the seventeenth century, the concepts of mixts and elements became a target of fierce critique by corpuscular philosophers like Robert Boyle (1627–1691). Chemists had long tried to separate the elements from the mixts by chemical art. As a result of their failure, many late seventeenth-century chemists' grew sceptical that chemical art was able to achieve this goal. Perhaps the elements were so intricately mixed that even the strongest fire was unable separate them from each other. Thus it is not accidental that Boyle choose the title *The Sceptical Chymist* (1661) for one of his most prominent chemical publications. As I will show in the next part, other fields of chemical art were crowned with more success.

2.2. The early modern 'flat ontology' of chemical substances

In the course of the seventeenth century, chemists, chemical physicians and apothecaries produced an increasing number of salts from acids and certain "bases"—metals, alkalis and earths—and again decomposed these salts into their original ingredients, mostly by way of displacement reactions adding a third substance. Likewise, early modern chemists, goldsmiths, masters of the mint and other metallurgists were able to mix different kinds of metals to produce brass, bronze and other alloys and further to recover the original metals from the alloys. Performing these kinds of "reversible" compositions and decompositions, they had also observed that substances could not be transformed at will and that there were rather preferences or "affinities" between pairs of certain substances that were absent in other cases and seemed to direct chemical interaction.

³ In Klein and Lefèvre (2007) we have focussed on this question.

⁴ The following is a rough outline of pre-modern chemical ontology, which omits differences such as the one between Aristotelian four elements, Paracelsian elements and principles, the Paracelsian distinction between active and passive principles, and J. B. Van Helmont's elemental water. For more detail see Klein (1994).

⁵ They were material and formal causes in the Aristotelian sense.

Download English Version:

<https://daneshyari.com/en/article/1160233>

Download Persian Version:

<https://daneshyari.com/article/1160233>

[Daneshyari.com](https://daneshyari.com)