• История и философия на химията •
• History and Philosophy of Chemistry •

A HISTORY OF CHEMISTRY *À LA* KOYRÉ. INTRODUCTION AND SETTING OF AN EPISTEMOLOGICAL PROBLEM

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Abstract. Alexandre Koyré brilliantly summed up the birth of the modern science trough two historical categories: "destruction of the cosmos" and "geometrization of space". The aim of this research (still in progress) is inquiring to what extent the revolutionary birth of Chemistry between the 18th and 19th century, along with Arnold Thackray's excellent criticism to *Newtonianism*, can be explained trough particular historical and interpreting categories. Those are based upon alternative choices to the ones suggested by Alexandre Koyré in order to clear up the birth of the modern science; thus it is to be grasped how they can express a history of chemistry *à la* Koyré in a general sense. Considering the specific aim of the present study and for shortness as well I shall avoid to argue about the history of chemistry in general as well as about other important authors; however any reference will be reported in footsteps. My investigation has been developed through two categories of historical interpretation: the order of ideas as an element of understanding the evolution of scientific thought on one hand; and on the other, the use of logic as an element of scanning and control of the organization of the theory. This kind of examination of a theory through the use of categories is valid since the historical exploration of the foundations will not be analyzed using the traditional approach. Obviously, the content of this work could appear potentially factious, since it cannot be assumed to be the only possible perspective.

Keywords: paradigm, Chemistry-Physics relationship, historiography categories, infinite in Mathematics, Logics

1. Newtonian Paradigm and birth of the chemical theory

In general, the first scientific theory[1] [1-8] assumed as systematic and mathematical was René Descartes' (1596-1650) theory *Optics*[2] [9]: any phenomenon was followed by its mathematical interpretation, eventually enriched with a geometrical one. Later on, a major relevance was attributed to the birth of the Newtonian mechanics[3] (*Principia*, 1687) [10, 11], since its mathematical content seemed full of potential and Newton's project so all inclusive as to involve any other theories (optics as well) through an arrangement based on the Aristotelian–axiomatic model. (AO)[4] [12, 13].

It is well known that Isaac Newton (1642-1727) would not publish his works about optics but at the end of his life, even though he was quite deluded about that since he had not been able to circumscribe the whole of the phenomena within Axiomatics[5] [14]. As a matter of fact, the English scientist considered that arrangement of major importance. Newton researched much in the field of Chemistry as well, though once again he did not manage to produce an Aristotelian –axiomatic theory. As a conclusion of the *Optiks*[6] (1704) [15], he formulated 31 long Queries by which the unsolved problems and his doubts about the theory were expressed. He dealt much with Chemistry, particularly in "Query 31". More specifically, he argued about matters previously anticipated within a treaty on acids and rigid bodies related to the gravity attraction force, stating a definition of acids "as endowed with a huge Attraction Force; their Activity consists of this Force [gravitational]"[7] [16, 17]. In particular, about hard bodies he observed

> [T]he parts of all homogenous hard bodies which fully touch one another, stick together very strongly. And for explaining how this may be, some have invented hooked Atoms, which is begging the Questions; are glued together by rest, that is, by an occult Quality, or rather by nothing; […]. And therefore hardness may be reckoned the Property of all uncoumpounded Matter. At least, this seems to be as evident as the universal Impenetrability of Matter. For all bodies, so far as Experience reaches, are either hard, or may be hardened; and we have no other Evidence of universal Impenetrability, besides a large Experience without an experimental Exception. Now if compound Bodies are very hard as we find some of them to be, and yet are very porous, and consist of Parts which are void of Pores, and were never yet divided, must be much harder[8] .

Hence, if the phenomenon of Chemistry (a typical one, according to Newton), that is the *affinity*, was interpreted by means of *gravitational force* (considered universal), then the specific principle of the new theory would have been found out; therefore chemistry would have an axiomatic and deductive design based upon the same essential concepts ruling mechanics. Then the universal Newton's design did not just aim at interpreting a specific concept of Chemistry (affinity), but he tended to frame Chemistry likewise mechanics, better say as a *sub-case* of Mechanics. Unfortunately, the gravitational force is weaker than the one effectively linking molecules that is the electric force. So his program was to fail. Anyway, since the great increase of the theoretical Physics, his followers did not have any doubt and started to consider the Newtonian paradigm as the only possible direction for their work: any phenomenon must be related to mechanics[9] .

It is well known that Thomas Khun (1922-1996) in *The Structure of Scientific Revolutions* [19] outlines a historical evolution of science as marked, every now and then by *revolutions*, that is by *alterations* or *changing* of a previous pattern. Unfortunately, differently from the title of his book, he could not witness other revolutions than the birth of the modern science (Newtonian) and of the attempts on the crisis [21-23] at the beginning of the 20th cent. Such matters have already been underlined by some historians [12]. In fact, a recent criticism [12] connoted him with a *weak* historiographical-epistemological quality due to the Khunian paradigm either in considering the *super-mechanical* elements of the chemical theory as essential for the beginning of a revolution or in interpreting the birth of *quantum* that was with no doubt a revolution in theoretical Physics[10] . On the other hand, beyond any question, the authority and authoritativeness of the Newtonian pattern (Table 1) survived almost unaltered and consistently until Pierre-Simon de Laplace (1749-1827) who had wisely widened the Newtonian theoretical model including the short rayed forces, in order to apply it to the microscopic interaction (such as in the theory of capillarity).

Table 1. Newtonian paradigm

Burning items **of the theory**	**Isaac Newton (1642-1727) -** ***Mechanics***
Space	Infinite and absolute
Time	Absolute
Inertia	As a perpetual
Basic-concept	Acceleration
Interaction	Force-cause
Mathematical problem	$\vec{F} = m\vec{a}$
Issuing techniques	Differential Equations
Solutions	All possible motion, for a given force, from $-\infty$ to $+\infty$

Legenda: adapted by [12].

Furthermore, Antoine Laurent Lavoisier' (1743-1794) concentred his later studies on central forces offering the possibility of realizing differential equations

$$\frac{d^2x}{dt} = f(r^{-\alpha}, v, t)$$

with an exponent even different from 2. Following those mathematical speculations, the traditionalist scientist Simeon-Denis Poisson (1781-1840) fully respecting[11] [25] the Newtonian-Laplacian program in his interpretation of all types of celestial and earthly phenomena through cause-forces, that is typically the central forces, applied the scheme to many other cases, in particular to thermal phenomena, getting some laws of gas still valid today.

The history of the classical chemistry [26, 27] is characterized by two burning aspects. In 1970, Arnold Thackray in *Atoms and Power* ([27] later referred to as *Atoms*) introduced a history of the birth of the classical Chemistry, characterizing it according the above two basic aspects. The first one concerns with intellectual and fundamental contrast between Lavoisier' new theory [28-30] and the prevailing view conceiving a scientific theory as well as typically considered in a Newtonian context. The second aspect is based on John Dalton' two essential choices (1766-1844): an organization evidently problematic (PO) of the theory and a mathematics with the only use of the potential infinite (PI)[12] [31]; that is to say the research of the solution to the problem of the atomic weights through a kind of mathematics discriminating the matter. According to those really bold choices the British physicist and chemist built up his new concept of the world; the title of his famous work A N*ew System of Chemical Philosophy* (1808) [32, 33], already suggested an intellectual revolution. In *Atoms*, Thackray clearly expresses his categories of historical interpretation:

> [T]he theory [Newtonian chemistry] has two essential components-belief in the inertial homogeneity of all matter and its possession of an "internal structure", and acceptance of attractive and repulsive forces as proper categories of [interpretation] explanation [historical]". […] A third and more ambiguous Newtonian category, the ether, thought often referred to or hinted at, did not feature prominently before 1740's[13] .

The "inertial homogeneity of matter", quoted by Thackray, is referred to the Newtonian conviction of a matter hierarchically ordered and strictly structured. Whereas the second category, the admission of "short-rayed forces", is referred to the fact that (according to such a view of science), for chemistry as well as for the celestial and earthly mechanics, a quantifying method is necessary. This goes through the measurement of those cause-forces (metaphysical) which are typical of the Newtonian theory; for what concerns Chemistry and the measurement of the short-range forces, the theory of the chemical affinities should be considered. Of course, in

Newtonian mathematics, these forces include the differential equations. By those categories, Thackray interpreted the application of the Newtonian theory to the pre-Lavoisier Chemistry. Though he later on points out that:

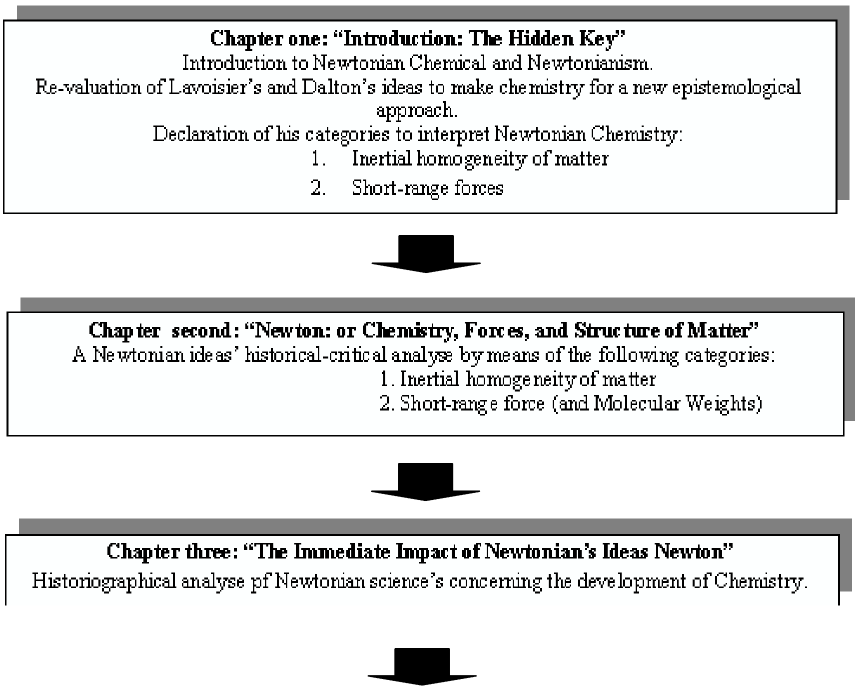
> [T]he Enlightenment's vision of a fully predicative Newtonian chemistry, based on mathematical laws and empirically measured forces, was not fulfilled[14] .

So Thackray's categories well suit the study of the Newtonian chemistry; moreover they can show very well the difference of that theory from Lavoisier' and Dalton' theory. He ends up his book this way:

> [T]he [chemical] theory was profoundly antiphysicalist and antiNewtonian in its rejection of the unity of matter, and its dismissal rejected the short-rayed forces[15] .

In the following Thackray's scientific though exposition from his *Atoms:*

Diagram. A synthesis Thackray's *Atoms and Powers*



Chapter four: "The Spread of Newtoniannism: A Tradition Established"
Study of Newtonianism and chemical-physical Newtonian theory in the Europe.
The British Newtonian chemical-physical theory interpreted by the following categories:

1. Inertial homogeneity of matter
2. Short-range forces
3. Ether (after 1740)

↓

Chapter five: "Speculative System"
History of European scientific though during the development of Newtonian ideas.
Chemical-physical theory of 18th cent.

↓

Chapter six: "The Problem of the Elements"
Epsistemological study about the problems of the indivisibility and primitive elements.
Lavoiser's, French school.

↓

Chapter seven: "Quantified Chemistry: The Newtonian Vision"
Criticism to chemical Newtonianism and research of a new paradigm for understanding the birth of Chemistry.
Lavoisierian and Daltonian school

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Chapter eight: "British Popular Newtonianism and the Birth of the *New System*"
Inadaptability of his [Tackray's] categories to determine the birth of Lavoisier's and Dalton's Chemistry.
The relevance of a *mathematizzation* of chemical theory proposed by J. Dalton.

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Chapter nine: "Conclusion"

- "The success achieved by chemical research in the nineteenth century from striking contrast to those of the previous hundred years. The chemical theory was fundamental to these success" [27, p. 279, l. 16]
- "The chemical theory was profoundly antiphysicalist and antiNewtonian in its rejection of the unity of matter, and its dismissal of short-range forces". [Ibidem, l. 23]

2. Lavoisier' and Dalton' revolution to achieve a new view of science

In 1789 Chemistry produced a real revolution[16] and Lavoisier, as well as the chemists of his time, searched for the basic principles of this new theory in a revolutionary fashion[17]. Nevertheless those *principles* were not the same as in Newtonian Mechanics; neither were they self evident property of truths (in the Aristotelian sense). Moreover Lavoisier' revolution started with the rejection of the traditional system of the principles of the four elements. Let's think of the dissociation of water in *H* and *O* which was particularly a matter of contrast with the old Aristotelian theory and enabled Lavoisier, i. e., to start up a *battle* against the *phlogiston theory* as an explanation of phenomenon of the fire; he replaced it with the combination with oxygen (and on the whole two new elements, *calorique et lumière*). Therefore, with Lavoisier, the number of the *principles* is not more set *a priori* according to metaphysical causes (four, one, or *n*), but it must be found out through experimentation *a posteriori*, that is by the moment the instruments would have explored all the possible ways of dissociating substances. Nonetheless the fashion of *establishing* the process of the scientific knowledge is clearly in contrast with the idea of the axiomatic principles of a theory (for example, the principles of the prevailing mechanics then). That is, in chemistry the word *principles* outlined *methodological principles*[18], either for dissociating or for combining substances. The theory was defeated on the ground of the experimentation to manage the matter, following not so much rational processes, but more effective ones, checked by man. So, according to Lavoisier' theory the method used for the measurement of the masses of the reagents (and of the compounds in a chemical reaction) became the reliable basis for going ahead towards knowledge; in other words, the Galilean method of experimentation to test a scientific law, always conceived as deductive, tended now to become a global method when building up a new theory [13].

This new way of considering science appeared similar to a *mental illusion* [34-36], that is like the impossibility of actually theorizing: because, according to the scientists of that time the lack of *real principles* made it impossible the process of making the theory out of a mathematical model and consequently the building up of what was then considered a *true theory* (i.e. *à la* Newton). Nonetheless the final result got by Lavoisier was amazing: the first table of the chemical elements; a table arranged in experimental symbols only is a completely unusual device in a Newtonian-Aristotelian thought of the theory. Even today it is stressed the dramatic difference of Chemistry from the nomological-deductive model, though not tracing its origin and nature [37, 38]. It must be said that Lavoisier set elements such as light and heat and classified them first. Furthermore his definition of element, allowing the chance of an unlimited breakdown (decomposition) of substances, was logically unsatisfactory and gave way back to the infinitesimal matter, *à la* Newton. That is, the by-*deduction* and *by-axioms* postulates were still not defined, decoding them respectively through generalization and chemical principles.

A few years later, Dalton' contribution [32] to the matter was crucial; thanks to him the chemical science was not more a theory simply opposite to the AO. He applied the mathematical model to Chemistry. The result was so simple, not to be either considered a step really fundamental in the history of Chemistry. Nonetheless it was able to shape chemists' mind: not introducing infinite magnitudes or infinitesimal ones in chemistry, Dalton set a close operating link between Mathematics and Chemistry; and he did not allow any siding at all between experimental and theoretical chemistry. For instance, the mathematical relation between *H and O* in H_2O has got an exact operating sense, whereas Physics, since Galileo Galilei (1564-1642), with $s = 1/2\ gt^2$, for example, had used continuous magnitudes, infinitely divided, that is beyond any physical measurement operations.

Thanks to Dalton, atoms, till then one of the greatest expressions of metaphysics, turned into entities operatively concrete and mathematically simple. Since *simplicitas sigillum veri*, Dalton considered atoms at last scientifically real [32]. This mathematical process or an atomic discretization process of the matter brilliantly matched an arrangement of the theory of problematic kind (PO) aimed at building a new theoretical organization of the fundamentals of chemistry. But the real innovation in Dalton's book consisted of dealing but with an only problem, either in the form of a program.

> [B]y elementary principles, or simple bodies, we mean such as have not been decomposed, but are found to enter into combination with other bodies. We do not know [by experimental means] that anyone of the bodies denominated elementary, is absolutely in-decomposable, but it ought to be called simple, till it can be analyzed[19] .

Coherently with the individuation of this central problematical view of Chemistry, Dalton goes on pointing out a method, either an ideal one, to combine elements among themselves. Such a singular method (for the science at that time) consists of a clearing illustration and by the well known series of the seven rules[20] . He suggested atoms combining only in the simplest forms. In order to apply his rules Dalton used, more than a mathematical device, some models (made out of wood) of the combination of the atoms. This formulation of theory PO gave relevance to mathematical machines to be kept on an instrumental level:

> [W]hen an element A has an affinity to another B, I see no mechanical reason why it should not take as many atoms of B as are presented to it[21] .

Obviously, science matured its knowledge and many of Dalton' observations changed up to now. Nonetheless what he maintained is enough for evaluating Dalton, not only as a former pupil of Lavoisier, but sometimes more important than Lavoisier himself, as well as Newton is to be considered more relevant than Galilei for his creation of the post-medieval mechanics. In this sense, I think that Dalton inaugurated a real *Daltonian paradigm* (chemistry-mathematics theory) in chemistry and in the scientific theory, in opposition or alternative) to the Newtonian program (Physics-Mathematics theory).

3. A Koyréan program for the history of chemistry?

The Historiography of Chemistry is mainly tangled up and complex to be illustrated due to so many discoveries of substances, of more or less valid ideas, of labels, nomenclatures; especially when theory converged in different fields of application of scientific knowledge or not. In particular, biographies do not contribute more than a good chronology; just a few chemists determined real cultural turning points [39-43]. Both the histories of an idea (for instance, the atom) really contribute to clear up and they too often date back: the modern knowledge. Surely Partington' encyclopaedic Opera marked a milestone, since it stimulates to go ahead in the search for a better understanding of the cultural thread of the theory [44, 45]. In the cultural history of fundamentals (or epistemological) of chemistry, some contributions tried a connection between the theory of Chemistry and the chemists' guidelines This view of the science as a whole is similar to what occurred in the history of Physics that could rely on the contribution (though ignored and then rejected as idealistic for long, in the end neglected as too much dated) by Alexandre Koyré (1892-1964) who was able to find out a relation between the physical and the mathematical theoretical process in the birth of modern science.

It is well known that Koyré brilliantly examined the birth of the modern science and its historical categories which he summed up with two phrases: "destruction of the cosmos" and "geometrization of space". Recent studies marked those two phrases as *intuitive expressions of the two basic choices made by Newton*. A derived translation has been used for the theories developing alternative choices to the Newtonian ones. They represent "the evanescence of force-cause and discretization of matter". Considered as historical categories inquiring straight on primary book, as well as original manuscripts, they have already interpreted history and the fundamentals of several scientific theories that have been built actually according to the two Dalton's choices. A clear sign of it is Sadi-Carnot's thermodynamics (1796-1832) in *Réflexions sur la Puissance Motrice du Feu* [46-51]. More than others, even more than Ernst Mach (1838-1916), Alexander Koyré considered above all that, among the intellectual factors, a basic role would have been played by the choice of what kind of infinite in Mathematics. As a student of Edmund Husserl (1859-1938) [52] who well knew mathematics and logics, Koyré wrote about the importance of the concept of infinite in the field of science. Differently from the ones who wrote about the same topic, remarking the artisans' work, considered, together with their inventions, the only responsible of the birth of the XVII century science, Alexander Koyré suggested the opposite thesis, according to which even laying upon a perfect artisan work the result will be always determined by the inaccuracy of measurements [53]:

> [T]he new science, we are told sometimes, is the science of craftsman and engineer, of the working, enterprising and calculating tradesman, in fact, the science of rising bourgeois classes of modern society. There is certainly some truth in this descriptions and explanations […]. I do not see what the scientia activa has ever had to do with the development of the calculus, nor the rise of the bourgeoisie with that of the Copernican, or Keplerian, astronomy theories. […] I am convinced that the rise and the growth of experimental science is not the source but, on the contrary, the result of the new theoretical, that is, the new metaphysical approach to nature that forms the content of the scientific revolution of the seventeenth century, a content which we have to understand before we can attempt an explanation (whatever this may be) of its historical occurrence[22].

Hence, Koyré grasped that the birth of the modern science cannot be explained just through the human works, but conceptual factors are needed[23]:

> [I] shall therefore characterize this revolution [the birth of the modern science] by two closely connected and even complementary features: (a) the destruction of the cosmos and therefore the disappearance from science - at least in principle, if not always in fact - of all considerations based on this concept, and (b) the geometrization of space, that is, the substitution of the homogeneous and abstract - however now considered as real - dimension space of the Euclidean geometry for the concrete and differentiated place-continuum of pre-Galilean Physics and Astronomy[24].

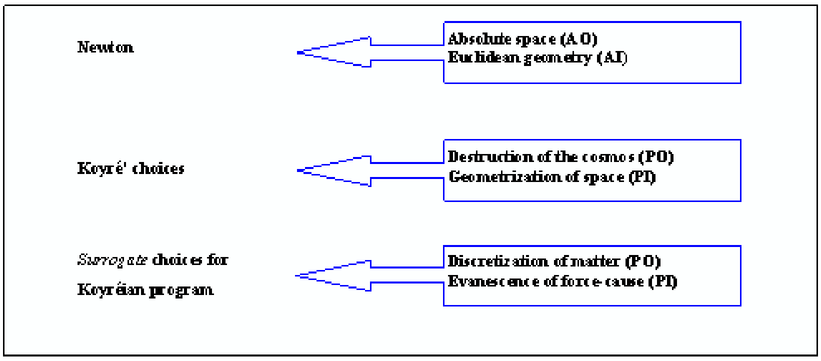
Through the intuition that the fundamentals of scientific theories contain two basic choices, Koyré' intellectual matrix has been cleared up (Table 2):

Table 2. Explaining of Alexandre Koyré' choice for the history of science

1. "*The destruction of the cosmos*" that is a replacement of the finite world, as it had been hierarchically classified by Aristotle, with the infinite universe. (That is, an AO organization).
2. "*The geometrization of space*": that is a replacement of Aristotle' physical (concrete) space with the abstract space of the Euclidean geometry. (That is, a choice of actual infinite - AI).

Koyré underlined the logical and intellectual step ahead performed by just a few of the luminaries by that time, such as Galileo [54, 55] and Newton; thanks to them science, *modern* by then, provided the basis for the next theories, so honourable for physicists and mathematicians. Koyré' choices about the modern science put in relation *sub-surrogate* concepts of the two basic choices made by Newton (Table 3).

Table 3. Historiographical choices: Newton, Koyré, Koyré-surrogate choices



It is particularly remarkable that each of the two Koyré' clauses relate the two choices to each other: the first phrase (Table 2) connects Newton's two positive choices, whereas the second phrase connects the two choices negated by Newton (The same scheme could be re-used for Dalton's choices). Therefore it is possible to propose the program of re-interpretation *à la* Koyré of the birth and the development of Chemistry by means of two basic ideas, analogous- opposite to Koyré' ones: "The discretization of matter and evanescence of Newtonian force-cause" [12]. Now if we translate all that in terms of historiography [56], it must be noticed that these interpreting categories are stimulated from one hand by the problem of the choice of infinite in a theory (highlighted by Koyré as far as the origin of the modern science is concerned); on the other hand, by the choice about the traditional organization of the Aristotelian scientific theory [57, 58]. It must be noticed that these phrase can be applied to any other theory of PO and PI type. As a matter of fact, in 1700 matter was already considered in analytical terms,[25] that is assuming the possibility of disassembling it at infinity. The AI brought to consider atoms as infinitesimal parts of the matter; on the contrary the PI made the atoms thought as elements only fictitiously last. It was just Dalton who made the basic choices of the chemical theory, opposite to Newton's ones. Thus, since chemistry is an example of PO theory and provides a clear choice of the PI, it represents actually the most evident example of the alternative model to the Newtonian one [62].

4. Conclusive (?) notes

On stating incommensurability as the property of two theories based at least upon one different choice out of the basic two, it has already been noticed that, with regards to the Newtonian Mechanics and to Lazare Carnot' (1753-1823) Mechanics [63-65], a large amount of concepts implied in the theory change in meaning . Similarly, comparing the classic chemistry with the mechanistic Newtonian Chemistry, space, time and force, (Table 4) which are essential concepts in Newton's Mechanics, are not more useful from a theoretical point of view in Chemistry; the deriving concept of fluid too from physical (phlogiston) turns from physical into not physical (calorique). The atom, the last element of the matter, conceived as an infinitesimal part of it, becomes a plurality of elements. The mass only seems to keep the same value for Newton and Lavoisier. Actually the Newtonian mass is above all the inertial one, while Lavoisier' mass is gravitational. Those variations in meaning are so many that chemists can even use the word principle, typical of Newton's theory and of the AO ones, but with a completely different meaning (Table 4):

Table 4. Newton' chemistry and Lavoisier' chemistry

Burning items of the theory	**(Mechanicist) Newtonian chemistry**	**Lavoisierian Chemistry**
Space	Infinite and absolute	Assumed as volume on the whole
Time	Absolute	Assumed as a measure to mark a before and an after; with regard to the rate reactions).
Atom	Infinitesimal part of matter	Plurality of elements.
Fluid	Phlogiston (corporeal)	Caloric (incorporeal).
Mass	Inertial	Gravitational.
Interaction	Force-cause	Reaction and balance.
Problem of the theory	Nature of the matter. Molecular theory: attractive and repulsive forces	Indivisibility *Chemical affinities* theory through the accomplishment of the nomenclature and chemical elements.
Arguing techniques	Differential equations	Arguing *by absurdum* proof and elementary mathematics.
Solutions	Any possible motion, for a given force, from $-\infty$ to $+\infty$	Oxygen's saturation degrees; variation of some acids names endings.

Legend: adapted by [12].

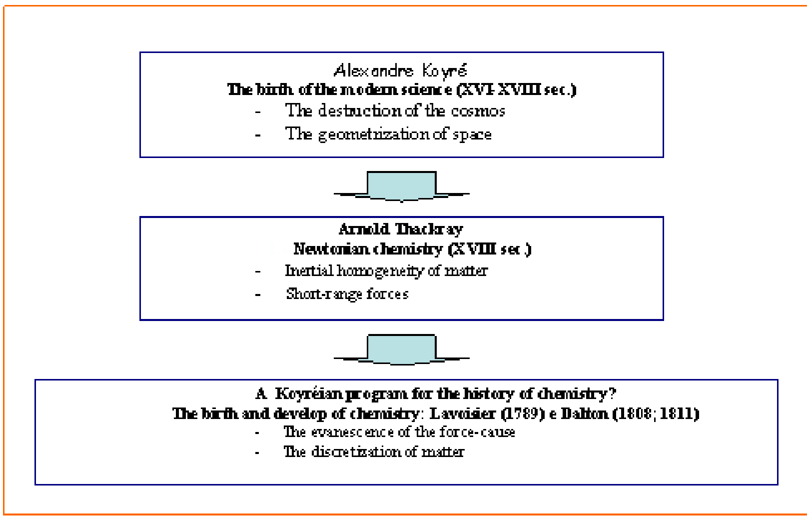
Those variations in meaning are so many that chemists can choose to use the word principle as well, typical of the Newtonian theory and of the AO theories, though with a completely different meaning. Therefore, here more than usual, the problem arises whether two not measurable theories are incompatible, too. As a matter of fact, the history of chemistry proves its historical incomparability, to the point that physicists (mechanicists) still underestimate completely the classical chemistry as the true theory [66].

I apologize to the reader for using notes as a conclusion of but an epistemological and historical introduction to the problem. However, Thackray's categories aiming at the study of a development of chemistry can be distinguished into:

√ Koyré' categories for the interpretation of the chemical Newtonianism.
√ Categories *à la* Koyré for the interpretation of Lavoisier' and Dalton' chemistry

A diagram (Table 5) follows summing up the whole of the problem:

Table 5. A history of chemistry à la Koyré (generalised point of view)



Koyréian program for the history of the chemistry express by means of categories *à la* Koyré (surrogated by two Dalton' fundamental choices), results applicable both to Lavoisier' theory that Dalton one; but it seems applicable also later chemical scientists up to Cannizzaro (1826-1910), and Mendeleev (1834-1907) [12, 56]. The first one, in fact, conducted to conclusion the Daltonian paradigm introducing the distinction between atoms and molecules, making stronger and surer the past tentative to include mathematics in chemistry. Dmitrij IvanoviæMendeleev, instead, playing inside this clarity of ideas and empirical facts concern the problem of constituents of matter, it reached to formulate a model of reasoning, the cycle, that has been typical of a problematic theory, the Carnot's thermodynamics (1824 and) that - as the chemistry - it does not use the infinitesimal analysis; on the contrary the cycle became a technique of alternative reasoning. Well, if the chemical revolution were delayed of one century so much, it is not owed to Newton, but also to the scientific authority that Newton represented after his death: that is, says *à la* Kuhn, to the continuity of a Newtonian paradigm, only.

In conclusion, going up again to the fundamental choices of Newton (mathematics with the endless one in action and Aristotelian organization), never doubted by his successors, one can only explained why the birth of the chemistry was born after one century of failures.

"Thought does not respect national frontiers. Yet scientific ideas are far from stateless citizens". (Arnold Thackray. *Atoms and Powers. An Essay on Newtonian Matter and the development of Chemistry*, Harvard University Press, 1970, p. 4, line 4).

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NOTES

[1] Obviously I do not exclude ancient and Renaissance (embryonic-scientific) theories: i.e., studies on *centrum of gravity*. [1-8].

[2] Cfr.: [9]. The essay on *Optics* is part of his most famous opera *Le Monde*, in which he deals with his mechanicist and rational observations: i. e., *La Dioptrique* (1634), *Les Météores* (1635) and *la Géométrie* (1636) in *Discours de la méthode* (definitive, March 1637). In these works, particular study about some natural phenomena appears (i.e light) connect to the human senses; follow an profound mathematical interpretation.

[3] [10]. According to Koyré, the best scientific exposition is: Rosenberg [11].

[4] In the history of science we encounter both *axiomatically organised* theories (AO theories), as well as, theories whose organisation requires non-axiomatic principles suggesting a method for solving a given problem for a theory which is thus *problematically organized* (PO theory). In brief, an AO theory is developed by "self-evident" principles and it is generally followed by the use of advanced mathematics (e.g., in Newton's theory). A PO theory is based on methodological principles which indicate a direction for the development of the theory. For a deep reading see [12, 13].

[5] Cfr.: [14].

[6] The 31 *queries in Optiks*, are the last Newton's opera and they have been thought about and delayed in publishing for long; this was due to the theoretical of the problem, according to which mechanics could explain anything, from mechanics to chemistry, biology, to ethics itself, even beyond the four cardinal virtues "followed by the primitive peoples". Cfr.: Newton I., "Queries", *Optiks*, [15].

[7] Newton I. "De Natura Acidorum", in *Lexicon Technjcum*, [16]. It also printed in Horsley S. (ed.).

Isaaci Newtoni opera quae existant omnia, [17]. This *Query* is burning either because Newton attempts to set some elaborated theoretical fundamental to the later theory of the short-rayed inter-particles forces to motivate cohesion and reactive phenomena (that will represent the basis of the new-born theory of the chemical affinities), or because the questioning (*doubtful*) nature of his general view of mechanic science in other fields of knowledge, in progress by then, comes out. I remark his opinion concern with particles-compound: "If the particles of the first [composition] or perhaps of the second composition of gold could be separated; that metal might be made to become fluid, or at least softer. And if gold could be brought once to ferment and putrefie, it might turn'd into any other body whatsoever". (Quoted in Thackray A. *Atoms and Powers. An Essay on Newtonian Matter and the development of Chemistry*, [27, p. 24, l. 21]).

[8] Newton I. "Query 31" *Opticks*, pp. 388-389, [15].

[9] Let's think, for example, to the birth of electricity introduced by Charles-Augustin de Coulomb (1736-1806) by means of (mechanicist) experiment based on torsion balance (1777) to investigate the torsion moment impressed exerted exactly by the gravitational forces.

[10] Fortunately the historical study of fundamentals and of change of minds and theories allows comparing the scientific thought, properly of the physic-mathematics sciences with other fields of knowledge.

[11] See Lavoiser' biography: Duveen D.I. and H.S. Klickstein *A bibliography of the works of A.L. Lavoisier* [24,25].

[12] PI: potential infinite; AI. Actual infinite.

[13] Thackray, A. *Atoms and Powers. An Essay on Newtonian Matter and the development of Chemistry*, [27], p. 122, l. 9.

[14] [Ivi, p. 5, l. 32].

[15] [Ivi, p. 279, l. 23].

[16] The birth of Chemistry proved really a revolution within the revolution. It looked like a stronger result and more evident than the first Jacobin program ("Society of friends of the constitution", 1789).

[17] Some years before, with Claude-Louis Berthollet (1749-1822), Antoine-Francois de Fourcroy (1755-1809) and Louis-Bernard Guyton de Morveau (1737-1816) published *Méthode de nomenclature chimique* (1787), a first revolutionary point of view about language of Chemistry which he dealt with even better in *Traité élementaire de Chimie* including Etienne Bonnot de Condillac (1714-1780) logics teachings (*Logique*, 1780).

[18] For a historical inquiry of Sadi Carnot theory (please, see [13]) we used the term "methodological" to indicate the particular role played by principles in theory: Sadi Carnot built his thermodynamics on principles (as well as on the impossibility of a perpetual motion) which are really different from the axiomatic-principles, which were "auto-evident" i.e, Euclidean geometry ones or idealized ones in mechanics Newtonian theory. In my opinion, Thackray uses the term *principle* in this work with the same meaning it assumed in Sadi Carnot' theory.

[19] Dalton, J. *A New System of Chemical Philosophy*, Manchester-London, 1808 (and 1810) [32], pp. 221-222.

[20] The seven rules concerned combinations and weights that were to represent the quantitative foundation of the modern Chemistry.

[21] Dalton, J. "Inquiry Concerning the Signification of the Word" [33], pp. 143-151.

[22] Koyré, A. *Newtonian Studies*, [53], pp. 5-6, r. 25.

[23] Koyré, A. *From the Closed World to the Infinite Universe*, Baltimore, Johns Hopkins UP, 1957

[24] Id., [53], p. 6, l. 17.

[25] In that period the experimental progress about the chemical elements of the matter were not understood. Paradoxical conclusions were admitted and a great theoretical confusion was caused. It was necessary to give account of the existence not only of atoms but also of molecules, that was out of any previous analytical standard scheme. The crisis was such that Amedeo Avogadro' (1776-1856) solution was not taken into account for fifty years; Cfr.: [59-61].

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ИСТОРИЯ НА ХИМИЯТА ПО KOYRÉ. ВЪВЕЖДАНЕ И АНАЛИЗ НА ЕДИН ЕПИСТЕМОЛОГИЧЕН ПРОБЛЕМ

Резюме. Alexandre Koyré сумира по брилянтен начин раждането на модерната наука чрез две исторически категории — „деструкция на космоса“ и „геометризация на пространството“. Целта на това изследване е разбирането в каква степен раждането на химията между XVIII и IX век може да бъде обяснено чрез подходящи исторически и интерпретационни категории. Такъв подход е предложен от Alexandre Koyré. Настоящето изследване е развито чрез две категории в историческата интерпретация: 1) йерархията на идеите като елемент на разбирането на еволюцията на научната мисъл и 2) използването на логиката като елемент за сканиране и контрол на организацията на науката.

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