Chapter 20
Kant’s Conception of Chemistry in the Danziger Physik

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1 Introduction

In the preface to *Metaphysical Foundations of Natural Science* (1786), Kant famously asserts that chemistry is not likely to ever become a proper science. It must, Kant says, be instead called a ‘systematic art’ or an ‘experimental doctrine’ (MAN 4: 470). In this chapter, I will show why, for Kant, chemistry is as it were ‘less scientific’ than physics. I will refer in particular to the “Danziger Physik” lecture notes, since they offer important complementary claims and are also often more explicit on statements that are a bit obscure in *Metaphysical Foundations*, although strictly speaking the latter could in principle suffice for a reconstruction of Kant’s argument.

In the literature, the question why Kant thought that physics is a proper but chemistry an improper science mostly gets a fairly simple answer: whereas mathematics can be applied in physics, in chemistry that is impossible and that is why the latter is not a science in the proper sense. That is indeed what Kant asserts himself in *Metaphysical Foundations*. On the one hand, Kant famously claims there that “in any special doctrine of nature there can only be as much proper science as there is mathematics therein” (MAN 4: 470).[1] On the other hand, he states that “the principles [of chemistry] are merely empirical, and allow of no a priori presentation in intuition, and thus they do not in the least make conceivable the possibility of fundamental laws of chemical appearances, because they are not suitable for the application of mathematics” (MAN 4: 471).

There is a problem with this standard reply, however, for it supposes that we all know that and how mathematics can be applied in physics. Now, with respect to *Metaphysical Foundations*, the claim that it is possible to apply mathematics in physics seems to be based on some kind of proof that the fundamental characteristics of the object of physics can be constructed in a priori intuition. Indeed, Kant writes: “in order to make possible the application of mathematics to the doctrine

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1 For Kant, both physics and chemistry are special doctrines of nature (see section 4 below).

of body, which only through this can become natural science, principles for the *construction* of the concepts that belong to the possibility of matter in general must be introduced first" (MAN 4: 472) I think that this rather complex claim has not been well understood in the literature.[2] Note that Kant does not speak about the possibility to construct the concept of matter, but about the possibility to construct "the concepts that belong to the possibility of matter in general." Thus, the task of *Metaphysical Foundations* is to provide evidence for the claim that the concepts that belong to the possibility of matter in general can be constructed, by introducing the principles for such construction. But even then, the quoted passage stays obscure because it is not clear what these "principles for the construction of the concepts belonging to the possibility of matter" should look like. It is also unclear how these principles relate to the fundamental determination of matter, i. e., the concept of motion. And what are the concepts that belong to the possibility of matter in general? So it seems that much has to be explained in order to understand why Kant thought that chemistry is not a proper science.

Because these questions have less to do with history of science than with Kant's philosophical approach to the relation between metaphysics and empirical sciences, I will not discuss in detail the chemical knowledge that is treated in the Danziger Physik, nor will I make an extensive comparison between the lecture notes and the textbook that Kant used for these lectures. This means that I also will not provide an overview of what Kant took in 1785 to be the most important teachings of chemistry. This has been discussed elsewhere: fellow scholars and I have written on that topic, and have included references to the Danziger Physik (e. g., Carrier 1990, 2001b; Friedman 1992a, 2013; Blomme 2015). However, we need a minimum of history of science in order to be able to situate Kant's declarations on chemistry in the scientific context of the seventeenth and eighteenth centuries. In the following sections, I first offer a succinct history of the theories of elements and principles (section 2) and situate the Danziger Physik with regard to contemporaneous chemistry (section 3). Next, I explain what, for Kant, turns a doctrine of nature into a proper science (section 4), whereas in the fifth section I describe Kant's conception of a special metaphysics of corporeal nature. In the sixth section, I ask why it is that Kant needs a fundamental determination of matter. The seventh section then offers a reconstruction of Kant's conception of empirical affection and its role in *Metaphysical Foundations*, which in my view has to take into account Kant's theory on the predicables of change and movement or motion (*Bewegung*) (section 8). In the concluding section, I

2 Plaaß (1965) is perhaps the most ambitious in trying to understand this claim, but I do not follow his analysis or conclusions.

consider whether Kant would have considered modern chemistry to be a proper science.

2 A very short history of chemistry: Elements and principles

The first chemical theories coincide with the ancient Greeks, who searched to determine the basic element(s) of the universe. The oldest theories proposed one element as first principle of everything: Thales (640–546 BCE) water, Anaximenes (550–480 BCE) air, and Heraclitus (576–480 BCE) fire. It was Empedocles (490–435 BCE) who first said that the basis of the universe is constituted of four elements: water, fire, air, and earth. Aristotle later took up this theory of four elements and stated that they form two pairs with contrary characteristics: fire was hot and dry, water was cold and humid, air was hot and humid, and earth was cold and dry.

By taking Aristotle as an authority, the later alchemists could think that all observed transformations of matter only concerned alterations of formal properties, while matter stayed basically the same. Hence there were, e. g., the attempts to transform lead into gold, which were motivated by the conviction that the material essence of these two kinds of metals was the same basic matter. The art of the alchemist was then to manipulate kinds of matter in order to bring about a change of the formal characteristics. The alchemists distinguished between two principles: sulphur and mercury. Sulphur was taken to be 'male', 'active', 'hard', 'hot' and 'stable', whereas mercury was taken to be 'female', 'passive', 'soft' (malleable), 'cold' and 'volatile'. Mercury was defined as the metallic principle and explained why metals can melt. It was supposed to be liquid at normal temperature. Sulphur was defined as the principle of combustibles.

Paracelsus (1493–1541) added a third principle: salt or arsenic. The function of salt was to unite mercury and sulphur and assure their cohesion. When, e. g., salt was applied to meat, Paracelsus took it to block the separation of sulphur and mercury and thus to prevent the meat from rotting. Because salt blocks the separation of the other two principles also in living beings, it was defined as the principle of life as such.

Now the theory of the elements and the theory of principles gave rise to convenient relations of correspondence between them. As the principle of combustibility, sulphur corresponds both to earth, which is solid, and to fire, which is subtle. Water, which is liquid in its normal state, and air, which is gaseous, take on the form of the recipients in which they are stored. This passivity makes them belong to the feminine kinds of matter and thus they correspond to mercury. The third principle, salt, as mediating instance between sulphur and mercury, was associated with a fifth element: the ether or quintessence (literally 'fifth essence'). However, in the alchemic tradition the ether was never given the same importance as the other elements.

As we will see, until 1781 at least, the tradition of the elements survives in Kant's conception of matter and chemistry. He does not take over the doctrine of principles, however. The elements are completed with a number of 'instruments' – Kant thought there were three – which are the media in which chemical reactions take place.

3 The scientific context of the Danziger Physik

For over 30 years Kant lectured on physics: from 1755 until 1788. We know of exactly 21 physics courses that he actually held during this period. For the first 15, held between 1755 and 1770 when he was still a Magister, Kant used as a textbook the *Erste Gründe der Naturlehre* (1753) of the physician Johann Peter Eberhard (not to be confused with Kant's later opponent, Johann August Eberhard). Kant's promotion to *Ordinarius* in 1770 marked the beginning of a pause of six years. Between 1776 and 1788 then, Kant delivered another six courses on physics, for which he used the *Anfangsgründe der Naturlehre* (1772) by Johann Christian Polycarp Erxleben (1744–1777). But there is one exception: for his penultimate physics lecture in the summer semester of 1785, Kant used the recently published *Anleitung zur gemeinnützlichen Kenntniß der Natur, besonders für angehende Aerzte, Cameralisten und Oeconomen* (1783) by Wenceslaus Johann Gustav Karsten (1732–1787). The reason for this textbook change was Kant's interest in chemistry (Lehmann, AA 29.1,1: 650) – a discipline that received indeed a much more extensive and up to date treatment in Karsten's *Anleitung* of 1783 than in Erxleben's *Anfangsgründe* that Kant possessed in its first edition of 1772 (Warda 1922).

In the preface to the second edition of his *Anfangsgründe der Naturgeschichte*, Erxleben had written that he would have preferred to include more chemistry, because he offers a section on mineralogy and cannot "imagine mineralogy without chemistry" (Erxleben 1773). Karsten quotes this passage both to argue for the necessity of his new handbook and to utter a critique of Erxleben's undertaking: in the latter's "little handbook," "mineralogy … is not at all what it should be. It supposed that the future scientist had first to visit lectures on the history of nature and only then lectures on chemistry" (AA 29.1,1: 175; my trans.). Karsten's *Anleitung* indeed includes discussions of recently made discoveries in chemistry, particularly those concerning the so-called pneumatic chemistry, i. e., the study of the properties of different kinds of air. The most prominent representatives of pneumatic chemistry at the time were, Stephen Hales (1677–1761), Joseph Black

(1728–1799), Joseph Priestley (1733–1804), Henry Cavendish (1731–1810) and Carl Wilhelm Scheele (1742–1786). Although informed by the discoveries of these scientists, and although a century before Boyle had already highlighted the inadequacies of the old theories of the four elements (earth, water, fire, air) and three principles, Karsten's chemical considerations are still based on a theory of four elements (earth, water, salt, phlogiston).

For his last course on physics, held during the winter semester 1787/88, Kant returned to the textbook of Erxleben, though in its third edition. Erxleben had died in 1777, but his famous student Georg Christoph Lichtenberg took care of extending and actualizing his teacher's textbook and published a new edition in 1784. In a passage of the Danziger Physik, Kant refers to this book when he says:

> Some savants have tried to connect chemistry with physics, so for example Erxleben, who started a chapter on chemistry, although it leaves much to desire: because he only speaks about solutions and condensations [*Niederschlägen*]. Lichtenberg has presented it already a bit more extensively. (29.1,1: 98; my trans.)

For Kant, it is Stephen Hales who may have been the most important source of the new discoveries in pneumatic chemistry. Kant owned a German translation of Hales' work *Vegetable Staticks* (1727), in which it is shown that air as such is not an element but that there are different kinds of air, all with their own chemical properties. But in the *Critique of Pure Reason*, Kant writes: "one reduces all materials to earths (mere weight, as it were), to salts and combustibles (as force), and finally to water and air as vehicles (machines, as it were, by means of which the aforementioned operate), in order to explain the chemical effects of materials in accordance with the idea of a mechanism" (A646/B674). This passage indicates that, in 1781, Kant still held on to a chemical theory of three elements and two instruments, which brought him closer to Stahl, van Helmont, and Boyle.[3] Jan Baptista van Helmont (1577–1640) and Robert Boyle (1627–1691) are considered to be at the origin of pneumatic chemistry. Both studied gases and their effects, but still thought of air as an instrument.[4] These indications may suffice to bear in mind that, when Kant states that chemistry will probably never be a proper science, he is not referring to organic chemistry (of which Lavoisier is generally

3 The Danziger Physik proves that, at the time of the publication of the second edition (1787) of the *Critique of Pure Reason*, Kant already knew that air is not an element, but he left the passage as it was in the first edition.

4 Van Helmont introduced the concept of "gas," following the Dutch pronunciation of the Greek χάος. Kant was perhaps a bit too patriotic when he taught his students that 'gas' was derived from the German *Gescht* (29.1,1: 163).

considered to be the father).[5] He has in mind the so-called *phlogistic* chemistry, founded by Johann Joachim Becher (1635–1685) and popularized by his much more famous student, Georg Ernst Stahl (1660–1734). In fact, Kant's adoption of three elements and two instruments in the first *Critique* perfectly corresponds to the theory of Stahl (Carrier 2001b).

Now, the Danziger Physik proves that, by 1785, Kant had adopted at least the new conception of air from the pneumatic chemists, perhaps by reading Karsten's handbook. But, in line with the reaction of most chemists of his time (and also with Karsten), this did not turn him away from Stahl. Hence the very telling passage in the lecture notes: "Air is not an element because it seems to be a certain form into which everything can be transformed. Instead of air it is better to put phlogiston [as an element]" (29.1,1: 162; my trans.). A bit later, Kant explains: "Phlogiston or pure elementary fire has been first introduced in chemistry by Stahl, who proved it to be an element that is of the same kind in all combustibles .... As a kind of air, it is called phlogistic air" (29.1,1: 163).

Becher proposed to distinguish between five fundamental substances: air, water, and three kinds of earth – first, the *terra pinguis* (also called "fat" earth or sulphur), second the *terra lapidia* (the principle of sand, stone, and metal), third the *terra mercurialis* (a principle that is present in metals, but not in sand or stones). Becher believed that, during the process of combustion, the *terra pinguis* was expulsed in the form of fire. It is this *terra pinguis* that Stahl would give the name 'phlogiston', derived from the Greek verb φλογίξειν ('phlogidzein'). Stahl managed to gather experimental evidence for the existence of phlogiston by transforming metals into calces[6] and these calces again into metals. This reversible transformation is explained by phlogiston: when a metal is intensely heated and transformed into metallic calx, the phlogiston that was linked to the metal is expulsed. That is why, when one introduces phlogiston to calx by heating the latter with coal, oil, or other matters from which Stahl asserts that they are rich in phlogiston, the metal reappears. During the process of combustion, the air absorbs the expulsed phlogiston, but no fusion of air and phlogiston can occur. Moreover, the air can only absorb a certain quantity of phlogiston and when that limit is reached, combustion is not longer possible.

5 Hence the question whether Kant would have considered Lavoisier's chemistry to be a proper science – which I discuss in the final section.

6 In the terminology of phlogistic chemistry, the calx (plural 'calces' or 'calxes') is what is left of a metal once its phlogiston has been driven off. Lavoisier later discovered oxidation and declared that 'phlogiston' was an unnecessary scientific hypothesis.

It is Stahl's experimental transformation of metals into calces that Kant refers to in a famous passage of the preface to the second edition of the first *Critique*:

> When Galileo rolled balls of a weight chosen by himself down an inclined plane, or when Torricelli made the air bear a weight that he had previously thought to be equal to that of a known column of water, or when in a later time Stahl changed metals into calces and then changed the latter back into metal by first removing something and then putting it back again, a light dawned on all those who study nature. They comprehended that reason has insight only into what it itself produces according to its own design, that it must take the lead with principles for its judgments according to constant laws and compel nature to answer its questions, rather than letting nature guide its movements by keeping reason, as it were, in leading strings; for otherwise accidental observations, made according to no previously designed plan, can never connect up into a necessary law, which is yet what reason seeks and requires. (Bxii f.)

In this passage, praise goes as much to Stahl as to Galileo and Torricelli. One would thus expect that Kant does not make any fundamental distinction between physics and chemistry and that he takes the latter to be a proper science just as much as the former. Yet we know that this is not the case: physics is a proper science, but chemistry is not. What, then, is a 'proper science'?

4 Kant's conception of proper science

Before discussing Kant's conception of proper science, one should know which conditions must be fulfilled, in Kant's view, for a doctrine of nature to be called 'science'. For Kant's conception of what it is to be a science radically differs from our contemporary understanding. In *Metaphysical Foundations of Natural Science*, Kant writes: "Any whole of cognition that is systematic can, for this reason, already be called *science*, and, if the connection of cognition in this system is an interconnection of grounds and consequences, even *rational* science" (MAN 4: 468). Chemistry can be systematic ("a systematic art") and its cognition is built on the interconnection of grounds and consequences that experience (chemical experiments) teaches. But because the principles of this interconnection are merely empirical, chemistry is not a proper science. This is a short answer to the question why, for Kant, chemistry is not a proper science. But it leaves aside the question why the principles of physics would be less empirical then the principles of chemistry; so this reply is unintelligible as long as we do not know more about the deeper reasons for Kant's distinction between physics and chemistry.

In the Danziger Physik, Kant teaches that research concerning nature can be divided into four parts (29.1,1: 97–100; cf. MAN 4: 468–70): mathematical physics, chemistry, description of nature, and history of nature. Below I present a succinct representation of these disciplines and their characteristics, based on what he taught in his physics lecture and completed with claims from the *Metaphysical Foundations* preface.

A. Natural Sciences
1. Mathematical Physics:
- presents the laws of the interaction of bodies (effect of a body on another body)
- has a priori principles; these principles are metaphysical – "presupposes metaphysics of nature" (MAN 4: 469)
- contains proofs that concern only a very little part of nature
- is a proper science

2. Chemistry:
- presents the laws of the interaction of matters (effect of a matter on another matter)
- has a posteriori principles that are adopted during chemical practice: "laws of experience" (MAN 4: 468)
- is an improper science

B. Historical Doctrines of Nature
3. Description of Nature ('natural description'):
- presents the diversity of things in nature, as given together in space
- has no principles: it is built on observation
- provides us with a system of classes on the basis of similarities between species (MAN 4: 468)
- is a historical doctrine of nature – no science

4. History of Nature ('natural history'):
- presents the diversity of things in nature, as the latter are present through time; "presentation of the effects and the many states of things as they follow on each other in different times" (29.1,1: 99; my trans.)
- is a systematic presentation of things of nature, "in different times and different places" (MAN 4: 468)
- is a historical doctrine of nature – no science

The criterion that is important to understand the distinction between physics and chemistry directly concerns the possibility of a metaphysics of corporeal nature. In Kant's view, in order to be called proper science, a scientific doctrine needs an a priori part that serves as the metaphysical foundation of that doctrine. Only then will we be able to attain systematicity and apodicticity. In the following passage, taken from the *Metaphysical Foundations* preface, Kant develops this view and connects it with his distinction between physics and chemistry:

> Natural science would now be either *properly* or *improperly* so-called natural science, where the first treats its object wholly according to a priori principles, the second according to laws of experience. What can be called *proper* science is only that whose certainty is apodictic; cognition that can contain mere empirical certainty is only *knowledge* improperly so-called. Any whole of cognition that is systematic can, for this reason, already be called *science*, and, if the connection of cognition in this system is an interconnection of grounds and consequences, even *rational* science. If, however, the grounds or principles themselves are still in the end merely empirical, as in chemistry, for example, and the laws from which the given facts are explained through reason are mere laws of experience, then they carry with them no consciousness of their *necessity* (they are not apodictically certain), and thus the whole of cognition does not deserve the name of a science in the strict sense; chemistry should therefore be called a systematic art rather than a science. (MAN 4: 468)

This passage gives us the means to say something more about systematicity and apodicticity – criteria of a proper science that can be distinguished yet are interconnected: there is no real or strict systematicity without apodicticity, and vice versa.

So, in order to be called a proper science, a doctrine must first be articulated as a system. Kant uses the concept 'system' in a strict and in a loose way. When taken in the strict sense, to talk of an empirical system would entail a *contradictio in terminis*. Thus, in the strict sense, systematicity is both a necessary and a sufficient condition for a doctrine to be called science proper. But Kant's strict comprehension of the term 'system' was not widely accepted: his contemporaries would use the concept to refer to any well-ordered presentation of knowledge (empirical or not), for example Linnaeus's classification of the species of nature. In *Metaphysical Foundations of Natural Science*, there are instances where Kant also uses this looser meaning, for example when he speaks of the historical doctrine of nature, which contains only "facts of things of nature, ordered systematically" (MAN 4: 468), or when he calls chemistry a "systematic art." When used in this broader sense, systematicity is only a necessary, not a sufficient condition for a doctrine to be called proper science. Now systematicity in the strict sense is the mark of a proper science because, for Kant, a theory of nature in general[7] does not in the first place investigate empirical things. A theory of nature in the

7 'Theory of nature' is here to be taken in a broad sense: it includes both inner and outer nature, is a priori, and is to be situated at a higher level than 'physics'.

Kantian sense will present us with everything that pertains to the existence of a thing insofar as it can be derived from the internal principle of that thing. As a result, a theory of nature will only be called systematic (in the strict sense of the word) when the connection of the things within this system is known a priori through reason alone.[8]

A second condition of proper scientificity is, for Kant, that the certainty that we (seem to) meet with in a doctrine of nature has to be apodictic. It is this condition that makes that every science proper has to be either totally pure, or contain at least a pure part on which its apodicticity can be grounded. If we take for example geometry, its purity is guaranteed by its exclusive use of the pure intuition of space. Indeed, because geometry tries to give the laws of that which pertains to the essence of concepts that are constructed a priori in pure intuition, it can proceed wholly a priori. But natural science does not seek the laws of what pertains to the *essence* of a concept: it wants to present the laws of that which pertains to the *existence* of a really existing thing. Now, in the first *Critique* Kant's major claim against dogmatic metaphysics is that the existence of a thing cannot be presented in an a priori intuition. In the case of a doctrine of nature, to be called proper science therefore means that it must contain a pure part that gives us a priori the concepts of what pertains to the existence of its object considered in its generality. These fundamental concepts will a priori specify the object of physics, but they will not depend on construction in intuition a priori, i. e., they will not be generated through construction. Nonetheless, these concepts will have to be such that they can in principle be constructed, by showing how they can be presented as instances of the general concept of motion that Kant claims to be the fundamental determination of matter (see section 6). This pure part of physics as natural science proper will be provided by Kant's metaphysics of nature.

5 Metaphysics of corporeal nature

We have to specify what Kant means when he refers to a 'metaphysics of nature'. From the author of the *Critique of Pure Reason*, we cannot of course expect that he would provide us with but another 'dogmatic metaphysics'. So here we will have to speak of a *Critical* metaphysics of nature. But what is that?

8 Kant develops this view of systematicity already in the Architectonic chapter of the first *Critique*. He there claims that systematicity (in the strict sense) is only guaranteed when the system has been constructed following the indications of the idea of the whole of a science. This idea is an idea of reason that commands a priori the systematic divisions that have to be made.

When the concept 'nature' is taken in its purely formal sense, where it refers to the first principle of everything that pertains to the existence and lawfulness of a thing in general, the metaphysics of nature is a part of the system of transcendental philosophy, of which the first *Critique* is the propaedeutic. Indeed, even in Kant, transcendental philosophy is not in the first place concerned with the conditions of the possibility of experience but with the a priori concepts that determine the unity of an object in general. As Kant states, the concept of an object in general is still problematic with regard to its empirical reality and needs further determination to be classified as something rather than nothing (A290/B346). When it is determined as something and the mathematical categories are positively realized, the object in general becomes the thing in general, and this latter concept is the only one that can express a priori the empirical but still undetermined content of appearances (A729/B748). The thing in general thus is the object in general that is positively determined with respect to quantity and quality. Now, a metaphysics of nature in this formal sense has been provided by the first *Critique*, where Kant discussed the synthetic a priori characteristics of the thing in general (see the axioms of intuition and the anticipations of perception).

When one takes the concept 'nature' in its material sense, it refers to the totality of things that constitute the object of our senses (29.1,1: 100). If we talk of metaphysics of nature taken in this sense, it is a particular or special metaphysics, as opposed to the general metaphysics that is concerned with the object in general. Following Kant's indications in the Architectonic chapter of the first *Critique*, the special metaphysics of nature contains two divisions: a metaphysics of corporeal nature that is devoted to the object of the outer senses, and a metaphysics of thinking nature concerned with the object of inner sense (A846/B874). But since the *Critique* has shown that a special metaphysics of thinking nature cannot have objective validity (the so-called rational psychology of the metaphysicians is, for Kant, a doomed project), the Critical philosopher will only need to say more about the special metaphysics of corporeal nature. It is this metaphysics that Kant develops in *Metaphysical Foundations of Natural Science*.

The first task of the special metaphysics of corporeal nature is to provide us a priori with concepts that, on the one hand, can lend themselves to mathematical construction and, on the other hand, are synthetic a priori determinations of the empirical concept of 'matter'. Indeed, "although a pure philosophy of nature in general, that is, that which investigates only what constitutes the concept of a nature in general, may indeed be possible even without mathematics, a pure doctrine of nature concerning *determinate* natural things (doctrine of body or doctrine of soul) is only possible by means of mathematics" (MAN 4: 470). *Metaphysical Foundations* will thus isolate the empirical concept of 'matter' and present us with all concepts and principles that are in fact a priori determinations of the object in general of corporeal nature. In order for this presentation to be complete, *Metaphysical Foundations* will show how the content of the concept of 'matter' ("object of the outer senses") and the intension of the elementary concepts of transcendental philosophy – i. e., metaphysics of nature in its formal sense – specify and determine each other.

6 The fundamental determination of matter

As we have seen, Kant considers 'matter' to be an empirical concept. This means that when we take matter as given to us, we must also presuppose an empirical affection of the outer senses. In the literature, this is seen as the reason why Kant takes *motion* to be the fundamental determination of matter (Carrier 1991; Kötter 1991; Kerszberg 2001; Friedman 2013; McNulty 2014). Although this seems correct, it is not entirely clear why Kant needs such fundamental determination in the first place. Indeed, Kant repeats in the *Metaphysical Foundations* preface that the scheme to obtain completeness of a metaphysical system, whether it concerns nature in general or corporeal nature in particular, is the table of categories, because there are no other pure concepts of the understanding that concern the nature of things (MAN 4: 474). Now the structure of *Metaphysical Foundations* will indeed follow the synthetic order of the categories. But why then the need for a fundamental determination of matter, that has to precede the determinations following quantity, quality, relation, and modality? I think that this problem has not yet received a convincing answer in the literature. It is indeed not enough to state that, since matter is an empirical concept, we need to presuppose empirical affection and thus also motion. I think that the only convincing answer is more complex, and I also think that we need this complex explanation to fully understand why, for Kant, chemistry will probably never be a proper science.

As we saw above, the fact that Kant speaks about matter as an empirical concept means that its objective reality cannot be proved a priori but has to rely on empirical intuition. But it seems better to speak of a metaphysics of material bodies instead of a metaphysics of matter, because matter is not sensed as such: we are not affected by "*the object* of the outer senses"; we are affected by material bodies.[9] Nonetheless, *Metaphysical Foundations* will start with the analysis of

9 It is important to distinguish between the general object of outer sense and the general object of the outer *senses*. The general object of the outer senses is 'matter' and it is with this general object that *Metaphysical Foundations* is concerned. The object of outer sense is simply an intuition in space and this can be an a priori or empirical intuition. Only in the second case will the

matter as such, without making a distinction between different material bodies. The reason is that *Metaphysical Foundations* is meant to provide us with a *metaphysics* of corporeal nature and cannot thus be built on experience (empirical cognition). We learn from experience that outside of us there is not only matter, but also several material bodies. Speaking from the start about material bodies would suppose more empirical input than just introducing the empirical concept of matter in metaphysics.[10] Now, just because *Metaphysical Foundations* is concerned with metaphysics and because empirical cognition about matter thus falls outside their scope, the empirical nature of matter must itself be integrated in the complete presentation of synthetic a priori determinations that specify the concept of matter. But metaphysics of corporeal nature is a part of physics and if the latter is to be a science proper, Kant has to find an expression for the empirical nature of matter that is nonetheless constructible in a priori intuition – only then will it be proved that mathematics is not only applicable in physics, but that this application is valid. Finding a fundamental characteristic of matter that fulfils these conditions is thus the first task for *Metaphysical Foundations*, and that explains the importance of its preface. Again, this fundamental characteristic will have to be an integral part of the synthetic a priori content of the concept of matter; it will have to express the empirical nature of the concept of matter and it must be constructible in a priori intuition.

The analytic content of the concept of matter is to be the general object of the outer senses. Thus, the proposition "a material body is an object of the outer senses" is analytic. Now, one of the results of the first *Critique* was the insight that all cognition of empirical outer objects has to be based on an intuition that is delivered by a perception. A perception is the effect of an empirical object that

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object of outer sense also be an object of the outer senses. This is mostly neglected in the relevant literature, but whether one will be able to understand the project of Kant's *Metaphysical Foundations* as opposed to the section of the *Critique of Pure Reason* that presents the transcendental principles of the understanding depends on grasping that kind of detail in Kant's theory. To give one recent example, McNulty (2014) fails to distinguish between 'object of outer sense' and 'object of the outer senses'.

10 The Danziger Physik states: "the mathematical part of physics presents the laws governing the effects of bodies on bodies and has a priori principles and that is what distinguishes it from chemistry, which presents the laws governing the effects of matter on matter" (29.1,1: 97; my trans.). It seems thus that *Metaphysical Foundations*, as the a priori part of mathematical physics, should be concerned in the first place with material bodies and not with matter as such. Matter is everything that occupies a (portion of) space, whereas a body must have a certain figure. But *Metaphysical Foundations* starts from matter as such and does not presuppose material bodies, because the question how they are generated out of matter is partly a question of empirical research.

affects us. Cognitions that are based on such perceptions are therefore empirical, although any system of empirical cognition will of course also contain realizations of all the elementary concepts (categories) and principles of the understanding. In the following section, I will show that Kant gets at the fundamental determination of matter by analyzing what it means to be affected by an empirical outer object.

7 An analysis of empirical affection

Matter or bodies cannot be sensed as such. We can feel certain effects on our own body, but it is only our understanding that will give us the concept of substance to grasp the unity of a series of sensations. In order for the affection by an empirical object to lead to a perception, the affecting object must be thought of as the cause of changing receptive states in the perceiving subject. It would not be possible to gain knowledge of different external objects if the effect they had on our senses were always the same, just as a quality that pertains to every object cannot be empirically perceived. The fact that the concept of matter is to be linked with empirical affection, i. e., with matter or material bodies affecting our outer senses, means that the change of receptive states in the subject is a change of outer relations. For Kant, every real change has to occur in time and each outer relation is *per definitionem* a relation in space. Empirical affection thus basically means: change (in time) of outer relations (in space). Now the only concept that can express a priori a change of outer relations and is at the same time constructible in a priori intuition is the concept of motion. This is the hidden context behind that seemingly innocent remark of Kant in the preface to *Metaphysical Foundations*, that the fundamental determination of a something that is the object of the outer senses has to be motion, because it is only by motion that these senses can be affected (MAN 4: 476). 'Motion' is thus the only concept that can at once a priori "schematize" empirical affection (and thus also the empirical nature of the concept of matter) and be mathematically constructed (namely, as a description in the a priori intuition of space).

8 The predicables 'change' and 'motion'

For Kant, the logical content of the concept 'motion' can be derived a priori from the predicable 'change', namely, when the latter is brought together with the a priori forms of intuition. On the other hand, Kant holds that we do not need the concepts of space and time to express the logical content of the concept 'change'.

As a predicable, the concept of 'change' is generated by bringing together the relational couple "substance – accident" with the modal couple "existence – non-existence." Although the predicable of change can be defined without reference to the form of time (the analytic content of the concept of change does not include the statement that it occurs in time), Kant also says that we (humans) cannot understand its possibility *without* representing the concept of change as occurring in time (B48 f.). Formal logic does not involve time, and the concept of change there only leads to contradiction. Indeed, the concept of time cannot be realized in formal logic because the conjunction of *opposita* generates analytical impossibility. As a consequence, the concept of change is entirely empty when considered apart from all content of intuition. Time as the form of all representations is thus for us humans an absolute condition of the objective validity of the concept of change. When we speak about change of our inner state, this means that we attribute to our soul (thought as a substance) mutually exclusive predicates and such attribution is only possible when we are in possession of the pure manifold of inner sense that is delivered by its a priori form: time.

Now, as we have seen, when it comes to the analysis of empirical affection, through which alone an object of the outer senses can become an object of cognition, change has to be understood here as occurring in time and in space. When one now links the predicable of change (as realized in time) with space as the a priori form of outer sense, one gets the predicable of motion. But the predicable of motion can be objectively realized in two ways: either as a priori motion or as empirical motion. A priori motion is realized within the manifolds delivered by the forms of intuition and thus takes place in pure space and pure time, without any reference to experience. One can thus realize the predicable of motion when executing a geometrical construction in pure intuition, by moving a point in geometrical space (space as a quasi-object or formal intuition) in order to create a line. The predicable of motion is then a priori realized as geometrical description. But the predicable of motion can also be objectively realized within the empirical manifold delivered by experience: it is then realized as physical motion.

The analytic content of the predicable of motion does not change as a result of its realization as geometrical or physical motion. The analytic content is indifferently characterized through the formula 'real change of outer relations'. Thus all change in the empirical world of physical bodies and all change in geometrical space must be motion if it has to be grasped by the understanding. When Kant states that motion has to be the most fundamental determination of matter, we must take motion as a predicable and thus as meaning 'real change of outer relations'. In the phoronomy chapter, matter is then further determined as the movable in space, and Kant will show how the fundamental determination is specified by the a priori construction of the properties that pertain to it as an extensive magnitude: speed and direction. The motion of the movable in space is then studied without presupposing any quality of the movable. Because of the fundamental determination of matter by the predicable of motion, chemistry will not be a proper science of nature as long as chemical reactions cannot be represented a priori as motions. Only then would mathematics find an objectively valid application in chemistry, and the a posteriori principles of the latter could then be preceded by a pure part on which the necessity of real chemical laws could be grounded. Because chemical reactions cannot be presented as motions in space, they cannot be grounded on the metaphysical principles that *Metaphysical Foundations* provides by taking motion as the fundamental characteristic of matter.

> So long, therefore, as there is still for chemical actions of matters on one another no concept to be discovered that can be constructed, that is, no law of the approach or withdrawal of the parts of matter can be specified according to which, perhaps in proportion to their densities or the like, their motions and all the consequences thereof can be made intuitive and presented a priori in space (a demand that will only with great difficulty ever be fulfilled), then chemistry can be nothing more than a systematic art or experimental doctrine, but never a proper science, because its principles are merely empirical, and allow of no a priori presentation in intuition, and thus they do not in the least make conceivable the possibility of fundamental laws of chemical appearances, because they are not suitable for the application of mathematics. (MAN 4: 470 f.)

If chemical reactions could be grounded on the metaphysical principles of matter, chemistry's basic concepts would be expressible through a priori constructions, because they would then be reducible to a kind of motion that could be presented in intuition. Chemistry would then be a proper science because one could show that the possibility of the application of mathematics in chemistry is very well conceivable, by providing the principles for the construction of the chemical concepts that pertain to the possibility of matter in general. Such principles would be metaphysical principles of chemistry.

9 Conclusion: Post-Stahlian chemistry as science?

We know that Kant was interested in the new discoveries made by British and French chemists and became gradually convinced of Lavoisier's new model. Kant compares the theories of Stahl and Lavoisier in a *Reflexion* that Adickes dates to 1789 or 1790. Kant does not yet express a clear preference for Lavoisier, apparently seeing the two theories as interchangeable:

> Following Lavoisier, when something (following Stahl) is dephlogisticated, then something is added (pure air): if it is phlogisticated, then something (pure air) is taken away, except when it concerns dephlogistication by plants, which is only the removal of combustible air. For him [Lavoisier], the solvents [*Auflösungsmittel*] are themselves replaced. (Refl 14: 489; my trans.)

In the notes associated with Heinrich zu Dohna-Wundlacken, based on a metaphysics lecture that Kant gave in winter semester 1792/93, we find the following passage: "An element is a simple part. Is water an element? No, because it can further be dissolved [*es läßt sich noch auflösen*], it consists of vital air and combustible air and we call something that does not contain species elementary" (V-Met/Dohna 28.2,1: 664). This shows that Kant had definitively rejected Stahl's theory of three elements, but it does not prove that he already adopted Lavoisier's system of chemistry. In a postscript to a letter that Johann Benjamin Erhard sent to Kant on 17 January 1793, we read: "Girtanner still wants to know if you have read his chemistry, and what you think about it" (Br 11: 408). Erhard refers to Girtanner's *Anfangsgründe der antiphlogistischen Chemie*, published in 1792. That Erhard writes 'still' (Girtanner *still* wants to know, etc.) may be an indication that Girtanner sent a copy of his book to Kant and told him in the accompanying letter that he would be happy to know what the sage philosopher thought about it. We know indeed that Kant owned a copy of Girtanner's book (Warda 1922: 34) and given his interest in chemistry, we can at least suppose that he read some of the passages in which the author presents the decomposition of water as one of the most important results of the anti-phlogistic chemistry. In Kant's reply to Sömmering, published in 1796 but written in 1795, we find a passage in which Kant invokes the recent developments in chemistry:

> The pure common water that was until recently considered to be a chemical element is now by means of pneumatic experiments separated in two different kinds of air. Each of these kinds of air contains not only its base, but also the caloric, which perhaps can be in turn decomposed by nature into a light-matter and other matter. (Br 12: 33 f.)

The context of this passage is Kant's argument that chemical division can be done *in indefinitum*. He clearly refers here to Lavoisier's anti-phlogistic chemistry in which it is proven that water consists of hydrogen and oxygen, whereby both gases can be decomposed into their base (respectively hydrogen base and oxygen base) and heat-matter or caloric (see also Friedman 1992a: 288 f.).

With respect to Lavoisier's new systematic model in chemistry, which gave rise to organic chemistry, one can now ask, finally, whether Kant would have considered this to be a proper science. Dussort (1956) takes this to be the case, but I do not agree. As we saw above, in *Metaphysical Foundations* Kant proposed motion as the fundamental determination of matter. We also saw that the ultimate foundation of this determination is an a priori account of empirical affection. Now, following Kant, chemistry is not a proper science because there are no metaphysical principles showing how the fundamental concepts of the actions of matter on matter can be reduced to the concept of motion and thus be presented in a priori intuition. But even in Lavoisier's chemistry, one cannot discover "for the chemical actions of matters on one another" a "concept … that can be constructed" (MAN 4: 470). Indeed, even after Lavoisier's model has replaced Stahl's, the motions that these matters undergo during a chemical (re)action cannot "be made intuitive and presented a priori in space" (MAN 4: 471).

Elsewhere, I proposed that one could perhaps think of another metaphysical schematization and reduction of empirical affection – one that does not refer to the concept of motion, but to the concept of *force* (Blomme 2011: 166–8). When one abstracts from *Metaphysical Foundations*'s project, there is indeed no reason why empirical affection could not be reduced to force.[11] But this does not change anything with respect to Kant's claim about forces as opposed to motions, namely that "the rules for the connection of motions by means of physical causes, that is, forces, can never be rigorously expounded, until the principles of their composition in general have been previously laid down, purely mathematically, as a basis" (MAN 4: 487). Accordingly, the condition of 'constructability by means of reduction to the concept of motion' is a criterion of a rigorous exposition as such. In other words, it is a criterion of proper science.

11 In that same text (Blomme 2011), I argued that Kant tries to develop this alternative conception in his *Opus postumum*. But I see now that that is false. Even if Kant sometimes seems there to oppose the concept of force as the fundamental *dynamical/qualitative* determination of matter to the concept of motion as the fundamental *phoronomic/quantitative* determination of matter (as found in *Metaphysical Foundations*), this is not Kant's point. One should note that, when the *Opus postumum* proposes to anticipate a priori the forces of matter, this concerns far more specific forces than the metaphysical forces of attraction and repulsion that Kant discusses in the dynamics chapter in *Metaphysical Foundations*. Thus, in my opinion the *Opus postumum* does not contain a critique of *Metaphysical Foundations*' phoronomy.