INTRODUCTION TO CHEMISTRY

In terms of the four causes, chemistry is the study of substances insofar as they are material causes. Chemistry studies the properties of materials, the different kinds of elemental materials that exist, and the ways that materials combine to form compounds and mixtures. Though chemistry is considered its own branch of science today, this was not always the case. The study of material bodies was grouped with that of motion, the cosmos, and the Earth in particular. In our study of chemistry, we will begin by learning a few key terms commonly used to name the properties of matter. For the first half of our study, we will turn to the Pre-Socratic natural philosophers, some of the earliest thinkers to explore the nature of matter. After this, we will trace the question of how many elemental materials exist – from the classical theory of the four elements all the way to the doorstep of Mendeleev's periodic table. Questions surrounding the nature of the atom naturally intertwine with the study of the elements. We will carefully examine the history of atomic theory from Democritus and Lucretius to the Bohr model of the atom. In exploring the historical progression of these thinkers, we will also come to learn the important foundations of chemical analysis and synthesis.

Note that the word "matter" has the same root as *mater, matris, f.*, which means "mother" in Latin. The matter of a body, then, is in some sense the source or the origin of the body. Just as a mother gives birth to her baby, so also the matter of thing makes possible its existence as a body. Without matter, a body could not be a body. At the same time, it is vital to remember that a body is not a body without both *matter* and *form* together. What we often call "matter" is still *formed* matter, even if our minds are oriented towards its material. Thus, chemistry studies material bodies with an interest in the underlying materials that make bodies bodies, by abstracting from the formal differences that distinguish living from non-living material bodies.

SOME PROPERTIES OF MATTER

Volume	The amount of space a body occupies in three dimensions. A product of its length, width, and depth.
Weight	The heaviness or lightness of a body; the downward tendency exhibited by a body.
Temperature	The degree of hotness or coldness in a body.
Mass	The quantity or amount of matter in a body.
Density	The degree of compactness in a body. The amount of mass per unit of volume.
Inertia	The tendency of a body to remain in its state of resting or moving, or to resist a change in its state.

OBSERVABLE AND MEASURABLE PROPERTIES

It is crucial to remember that properties do not have to be measurable in order to be real properties of bodies. Remember from your study of measurement: measuring involves our attempt to *quantify* the qualities and properties of a thing. Often this means expressing continuous quantities in terms of discrete units. Though the ancient thinkers with whom we begin this section did not take up measurement and experiment as their primary methods, their observations and conclusions are still worthy of our sustained attention and reflection. Chemistry, as it developed, tended to focus more and more on the measurable properties of matter in order to determine the laws of chemical combinations and the essential and differentiating features of materials. The turn from more philosophical, speculative inquiry to an experimental, more mathematical approach will be evident in the progression of readings.

THE PRE-SOCRATIC PHILOSOPHERS

The Pre-Socratics (620 B.C. to 440 B.C.) were a group of thinkers united by their common attempt to understand the nature of the world (*kosmos*) and the ultimate principles of nature. "Principle" in this context means the cause, source, or foundation (*archê*) of a thing, or the reasons that explain the origin and nature of a thing. The Pre-Socratics were therefore in search of material and efficient causes of the whole universe. These questions were common among the Pre-Socratics:

1. What are the first or ultimate principles of the cosmos? Are they material or of some other kind?

2. How many principles are necessary to explain everything in the cosmos?

3. From what material does everything come?

4. How are generation (coming into being) and destruction (passing out of being) possible? How do we explain the appearance of change in the universe?

As you read and reflect on the thought of Thales, Anaximander, Anaximenes, Pythagoras, Heraclitus, Parmenides, Anaxagoras, Empedocles, and Democritus, it will be helpful to refer back to these questions and compare the different answers they propose.

Thales

"Of those who first pursued philosophy, the majority believed that the only principles of all things are principles in the form of matter [*hulē*]. For that of which all existing things are composed and that out of which they originally come into being and that into which they finally **perish**, the substance persisting but changing in its attributes, this they state is the element and principle of things that are… For there must be one or more than one nature out of which the rest come to be, while it is preserved." (Aristotle, *Metaphysics* I.3, 983b6-18)

perish – die

"However, not all agree about the number and form of such a principle, but Thales, the founder of this kind of philosophy, declares it to be water. (This is why he indicated that the earth rests on water.) Maybe he got this idea from seeing that the nourishment of all things is moist, and that the hot itself comes to be from this and lives on this (the principle of all things is that from which they come to be)—getting this idea from this consideration and also because the seeds of all things have a moist nature; and water is the principle of the nature of moist things." (*Metaphysics* I.3, 983b18-27)

Anaximander

"He [Anaximander] says that the first principle is neither water nor any other of the things called elements, but some other nature which is **indefinite**, out of which come to be all the heavens and the worlds in them. The things that are perish into the things out of which they come to be, according to necessity, for they pay penalty and retribution to each other for their injustice in accordance with the ordering of time, as he says in rather poetical language." (Simplicius, *Commentary on Aristotle's Physics*, 24.13-21)

indefinite – not specific, undetermined, formless

underlying nature – first principle, element

boundless – without a limit, limitless

definite –

rarity – how spread out the parts are

density – how close the parts are

Anaximenes

"Anaximenes… like Anaximander, declares that the **underlying nature** is one and **boundless**, but not indeterminate as Anaximander held, but **definite**, saying that it is air. It differs in **rarity** and **density** according to the substances [it becomes]. Becoming finer it comes to be fire; being condensed it comes to be wind, then cloud, and when still further condensed it becomes water, then earth, then stones, and the rest come to be out of these. He too makes motion eternal and says that

CHEMISTRY ETYMOLOGIES

SCIENCE Derivative:	Greek/Latin Root(s)	Translite-ration of root(s)	Relevant Translation of Root(s)	Section in Manual
matter, material	mater, matris, f.		mother; origin, source	Q3: Introduction to Chemistry
corporeal	corpus, corporis, n.		body	Q3: Introduction to Chemistry
volume	volumen, volumenis, n.		book, roll ("volume" developed from the bulk of a book)	Q3: Introduction to Chemistry
density	densus, -a, -um		thick, crowded; cloudy	Q3: Introduction to Chemistry
inertia	in + ers, from ars, artis		unskilled, inactive, (not doing work)	Q3: Introduction to Chemistry
mass	massa, massae, f.		lump, kneaded dough; load, bulk	Q3: Introduction to Chemistry
principle	principium, principii, n.		beginning, origin; foundation, element	Q3: The Pre-Socratics
mutable	muto, mutare, mutavi, mutatus		to move, change	Q3: The Pre-Socratics
cosmos	κοσμος	kosmos	order, beauty, the beauty resulting from order, ornament, world, universe, ordered whole, the order and beauty of the world	Q3: The Pre-Socratics
harmony	αρμονια	harmonia	agreement, concord of sounds	Q3: The Pre-Socratics
element	elementem, elementi, n.		rudiment, first principle, matter in its most basic form	Q3: The Classical Elements
compound/ composite	com + pono, ponere		to put together	Q3: The Classical Elements
atom	α + τομος	a + tomos	not cut, indivisible, uncuttable	Q3: The Atom
particle	pars, partis, f. with a diminutive French ending		little part	Q3: The Atom
solid	solidus, -a, -um		firm, whole, entire	Q3: The Constitution of Matter
liquid	liquor, liqui		to flow	Q3: The Constitution of Matter