

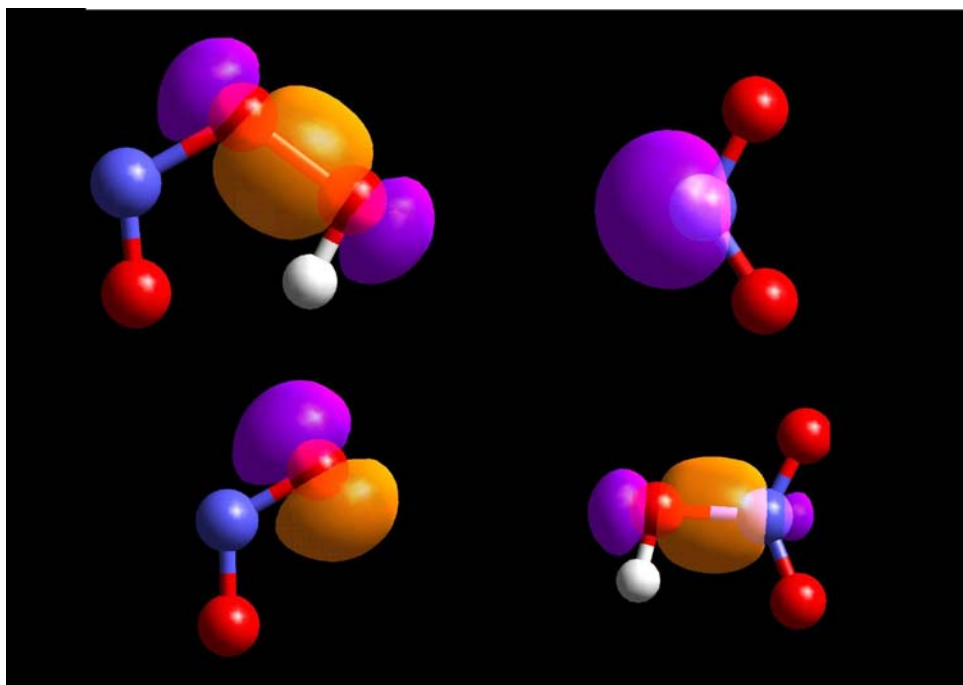
Atoms, Ions, Molecules and Function I:

First Part:

Basic Chemical Principles

Ursula Röthlisberger

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How to use this script

These *lecture notes* contain all the material required for the part '*Basic Chemical Principles*' of the course '*Atoms, Ions, Molecules, and Function I*'. You can download this script in English or French as a pdf from the site:

<http://lcbpc21.epfl.ch/Course/aimf>

At the same web site you can also download electronic versions of the copies of the powerpoint slides that are used during the course that illustrate and summarize the different chapters and that often contain *animations*.

The symbol  is used to indicate that an animation is available for a given topic.

You can also download the electronic version as a zipped WORD document that contains *hyperlinks* and *animations*. The information that is given by the *hyperlinks* is meant as an additional help for supplementary explanations and illustrations but is not part of the final exam!

If you prefer to work with a book, you can use either

- Peter Atkins, Loretta Jones, ***Chemical Principles, the Quest for Insight, 3rd Edition, W.H.Freeman, NY (2003)*** (in English)
<http://www.whfreeman.com/chemicalprinciples/>

or:

- Peter Atkins, Loretta Jones, ***Chimie. Molécules, Matière, métamorphoses, 3ième Edition, DeBoeck Université, Paris (1998)*** (in French)
<http://www.whfreeman.com>

1. Introduction

Chemistry is the science of the properties and transformations of matter¹. In this course, we will discuss the basic physical and chemical principles that determine the chemical properties of matter and govern its transformations.

To this end, we first have to answer some fundamental questions about the nature and structure of matter, a question that has occupied the mind of people since the early beginnings of mankind. Already the ancient Greeks posed the question of what happens if we divide a substance into smaller and smaller pieces. Is there a minimum size at which matter has still its characteristic properties or is matter something continuous that keeps its features even in an infinitesimal small piece?

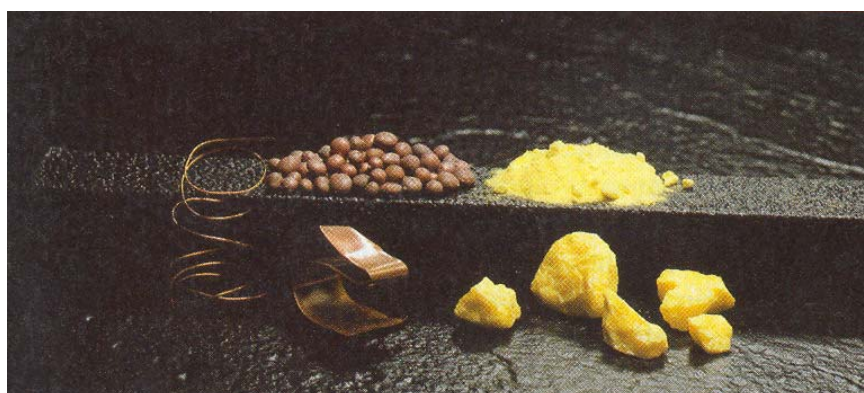


Fig. 1.1 What is the smallest size of matter that keeps its characteristic chemical properties?²

The Greek philosopher [Democritus](#) suggested that matter is defined by tiny no longer dividable entities, the **atoms** (from Greek 'atomos' = undividable). It took almost 2000 years until this idea was also supported by experimental evidence. It was the English school master [John Dalton](#) who performed careful measurements to show that chemical substances always combine in well defined ratios. Such behaviour cannot be explained if matter is something continuous but is easily reconcilable with the existence of atoms that have to combine into well defined groups with given stoichiometry to form new chemical compounds.

Nowadays, there is ample experimental evidence for the existence of atoms and we know that all matter in all its diverse forms of appearance (water, air, wooden tables, plastic chairs, teddy bears, our bodies etc.) is constituted by a mere hundred of different kinds of atoms. These atoms can interact with each other and form groups (chemical compounds) that are bound together by strong **inter-atomic**³ forces (ionic, covalent, metallic, or coordination bonds).

¹ We call 'matter' all substances that have some mass and occupy space.

² Very small groups of atoms can exhibit physical and even chemical properties that differ from their macroscopic analogues. It is due to these intriguing effects that the recent fields of nanoscience and nanotechnology have emerged. Nevertheless, the smallest entity that still bears the chemical identity of an element is the atom.

³ *Inter-atomic, intermolecular: between atoms, molecules*

The molecules that are formed in this way interact with each other via **intermolecular forces** (dipole-dipole interactions, hydrogen bonding, van der Waals forces) that are usually much weaker than the **intramolecular⁴ forces** between chemically reactive atoms but these weaker forces are responsible for such properties as melting and boiling points of a substance and the three dimensional structure of proteins, to name only a few.

In this course, we will first discuss the composition of atoms (*Chapter 2*) and in particular the structure of the electron cloud that is responsible for the chemical properties. To do this, we will have to know some basic principles of quantum mechanics (*Chapter 3*) that govern the electronic structure of atoms (*Chapter 4*) and determine their chemical properties. On the basis of the properties of each atom we will be able to predict how atoms will react with each other and form chemical compounds (*Chapter 5*). In the last Chapter of the first part of the course (*Chapter 6*), we will focus on the intermolecular forces, i.e. the physical interactions that molecules exert between each other. Figure 1.2 gives an overview of all the material of this subjects in a graphical representation to help you guide through the different subjects.

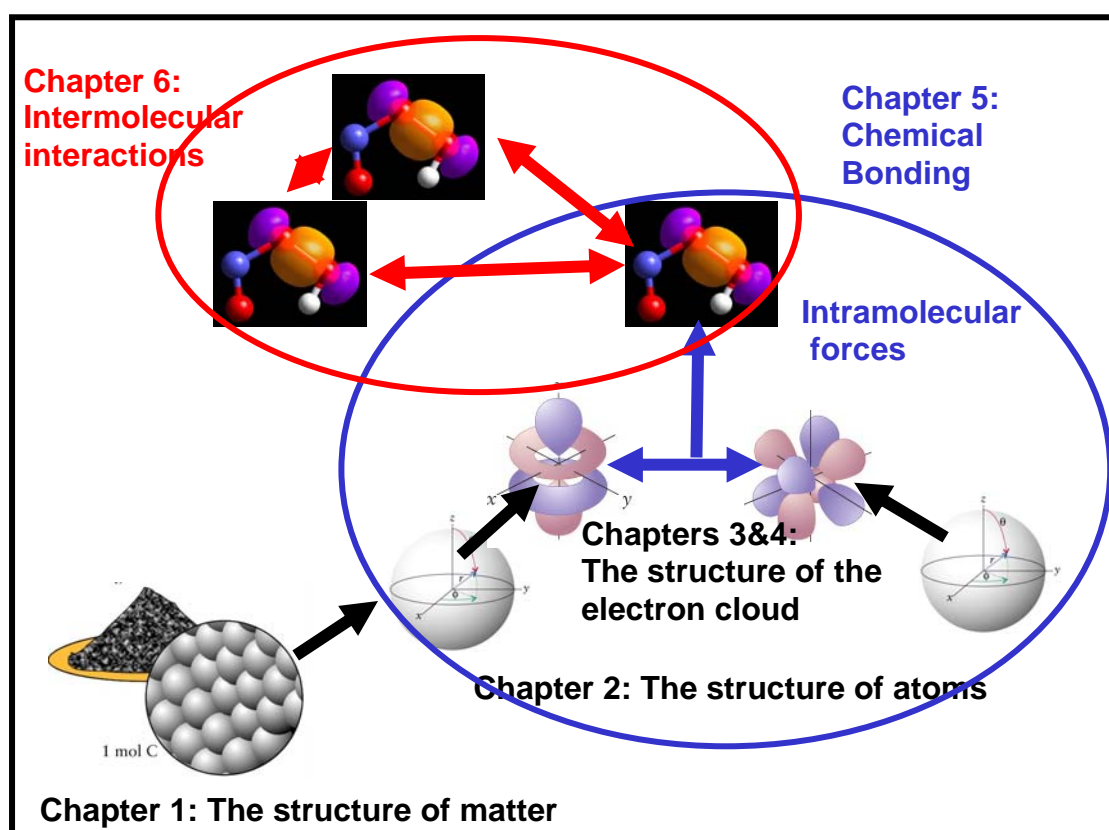


Fig. 1.2 Overview of the structure of the course.

⁴ *Intramolecular* forces: forces that act *within* a molecule