Lecture 1.

About this course

① The most common complaint about Chemistry 216 is that there is no good textbook. And that is absolutely correct. Almost all the students in this class took AP chemistry in high school & already know the material in typical freshman chemistry textbooks. This course will therefore go beyond what is typically taught at a freshman level to more (hopefully much more) interesting material.

Unfortunately the textbooks which cover this material are typically taught at too high a level. Although students who are as bright as you can understand the material, the typical upper level text book assumes all kinds of additional knowledge. For example a typical undergraduate inorganic chemistry course is (in this country) taught to college seniors. And so an inorganic textbook writer will assume their audience has had a year of organic and a year of physical chemistry. That's no good for us in Chem 216.

② Instead of a textbook, I propose to prepare for you lecture notes. Where the material overlaps a freshman chem textbook (Zumdahl), I'll let you know. Where it doesn't I'll try to write my notes even clearer. It's the best I can do. I apologize in advance that this will make some people in this class unhappy.

I wish it wouldn't make you unhappy. I hope you can read these notes <u>before</u> the actual lecture; that you ask questions during the lecture; and that you find the problem sets accessible (especially with the additional problem session class which we will run).

③ Think of these lecture notes as a letter, the longest letter you ever read, written by someone who doesn't even know you; someone who believes in you and in your interest in chemistry. For me the measure of success in this course will be the number of students who go on to other chemistry courses and who wind up using chemistry in their daily & professional lives.

④ Chemistry is typically divided into three main subfields

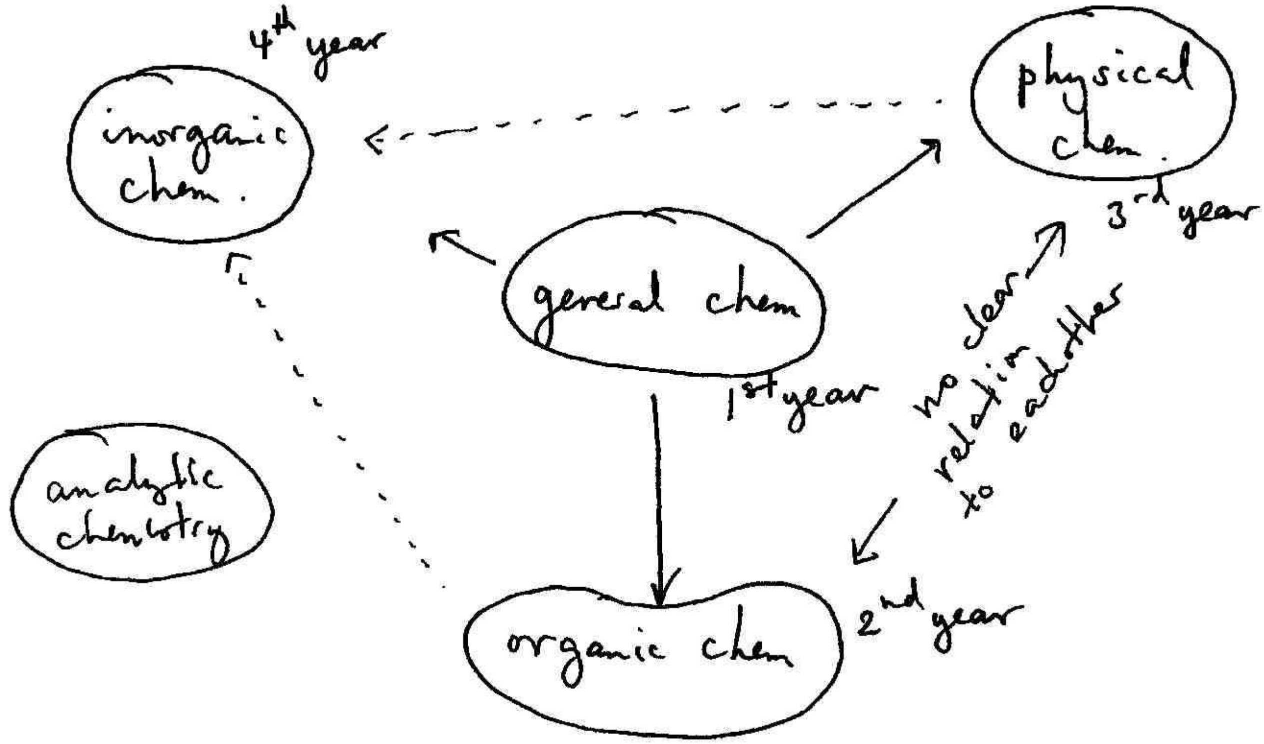
① Organic

② Physical

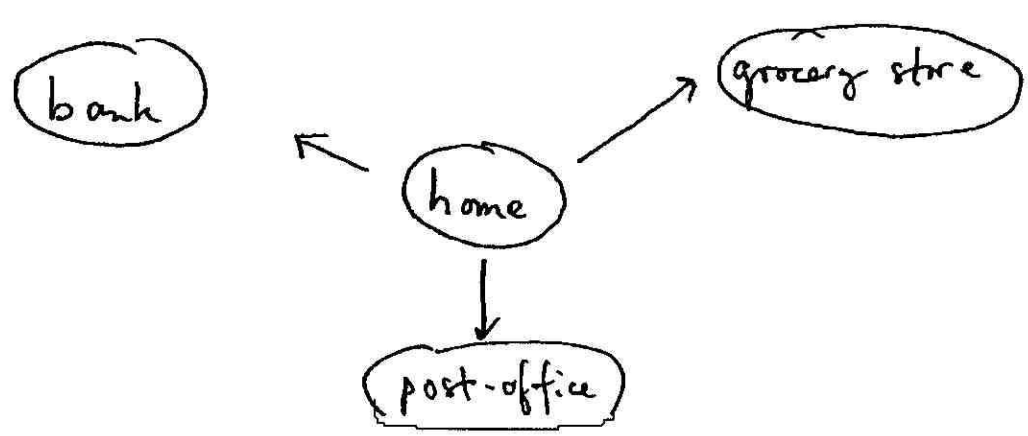
③ Inorganic

They are each taught in their own subfield and sometimes when I think about organic, physical and inorganic chemists I have a hard time seeing how these 3 subfields are related.

The undergraduate syllabus looks a bit like this:

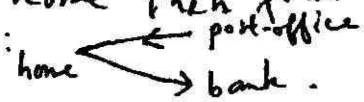


⑤ This overall situation reminds me of the book/movie The Accidental Tourist & of my mother-in-law



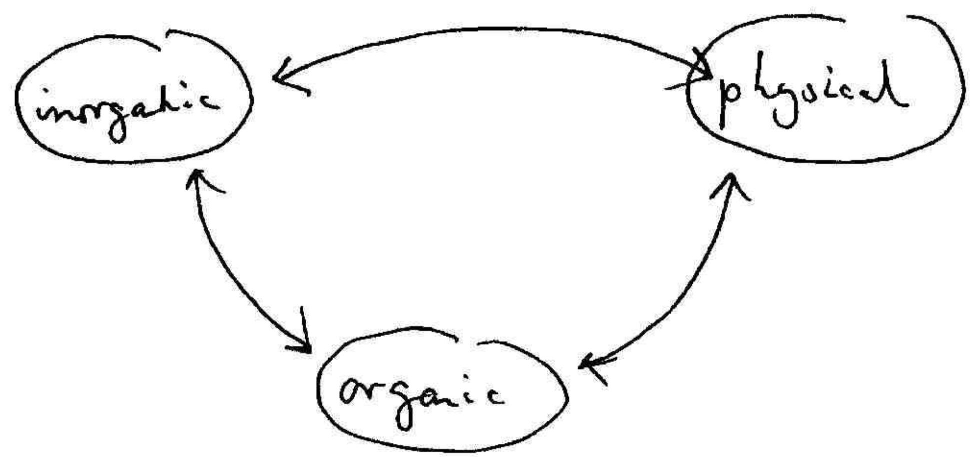
(and my mother-in-law)

The people in this movie/book know how to get from home to the bank; home to the post-office; & home to the grocery store. If they are at the post-office & need to go to the bank they drive from the post-office first to home then from home to the bank. Even though the route looks like this:



...

⑥ The goal of this course is to learn a better way of driving around



Our goal is to develop a unified picture which can be used in all sub-fields in chemistry. Our goal will be to understand

① bonding

② chemical reactions

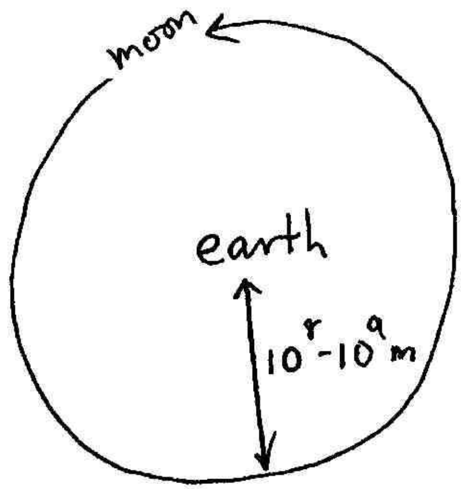
w/ a unified language useful to all 3 subfields.
Where we can we will explain how the language of our course translates to the language of these sub-fields.

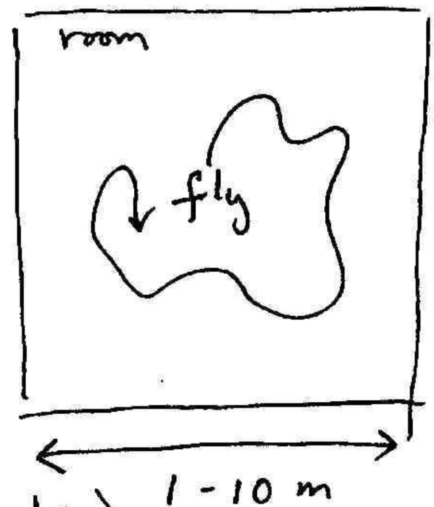
Lecture I proper — Electrons & Atoms

Zumdahl p.540 - 545 (p.537)

Atomic orbitals

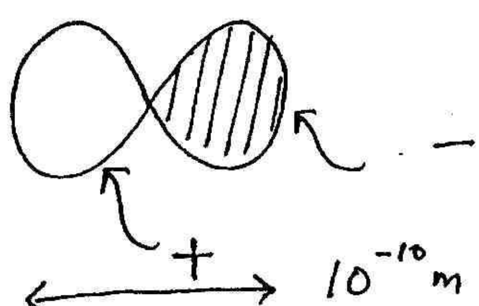
① Analogies





Electrons move around nucleus (nuclei) in a motion somewhere inbetween that of the motion of the moon around the earth and a fly in a room. Electrons lie in orbitals.

② eg.,



ψ_p

10^{-10} m = 1 Ångstrom = 1 Å

To describe electron motion we have discovered we need to describe a sign to the orbital.

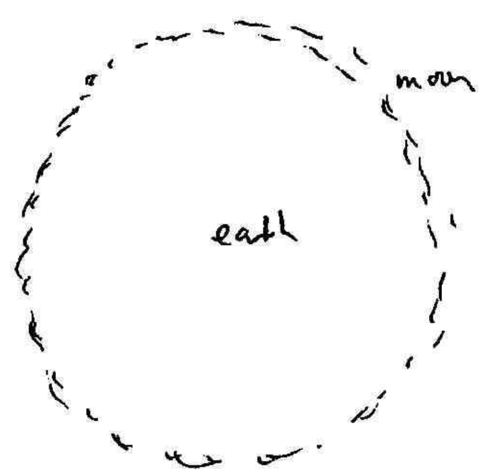
(I remember when I learned this material in school, it made absolutely no sense. Now that I know what all the picture means, I know it is correct, but it is hard to make sense of) All I can say is that we will spend several weeks in this course making sense of this picture)

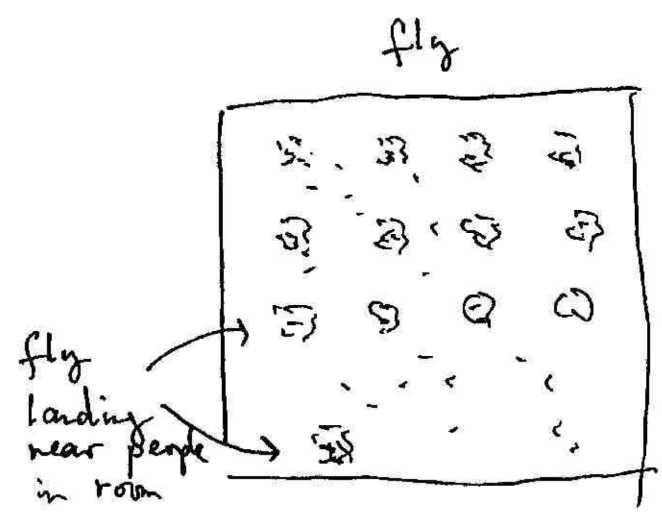
③ Some chemistry textbooks are so weirded out by the + & − signs that they get rid of them altogether. They point out that

$$\psi_p^2 \propto \text{electron density}$$

ψ_p^2

This picture can be compared to the moon density & fly density



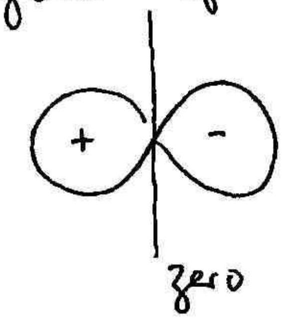


④ Let's make a list of the questions we have:

① What do (+) & (−) signs mean?

② Flys land near food. Why are e^- landing on regions of empty space?

③



There is a plane passing through the p orbital where $\psi_p = 0$ & $\therefore \psi_p^2 = 0$.

ψ_p^2 means electron density is zero. How did the electron travel from one side to the other side?

(For now all we can do is ask questions. The answers will come later in this course.)

⑤ Zumdahl goes on to tell us about quantum numbers

principal quantum # : n
orbital angular momentum # : l
orbital directional angular momentum # m_l
(directional spin) quantum number m_s

Rules
n is an integer $(1, 2, 3, 4, \ldots)$
l is an integer (in value less than n)
m_l is an integer $(-l \leq m_l \leq l)$
m_s is $+\frac{1}{2}$ or $-\frac{1}{2}$

Example:

	n	l	m_l	m_s	
e^-	4	3	-2	½	acceptable quantum #
	4	3	-4	½	not acceptable

(6) These names are cumbersome so we give some of these orbitals names

$l = 0$ s orbital

$l = 1$ p orbital

$l = 2$ d orbital

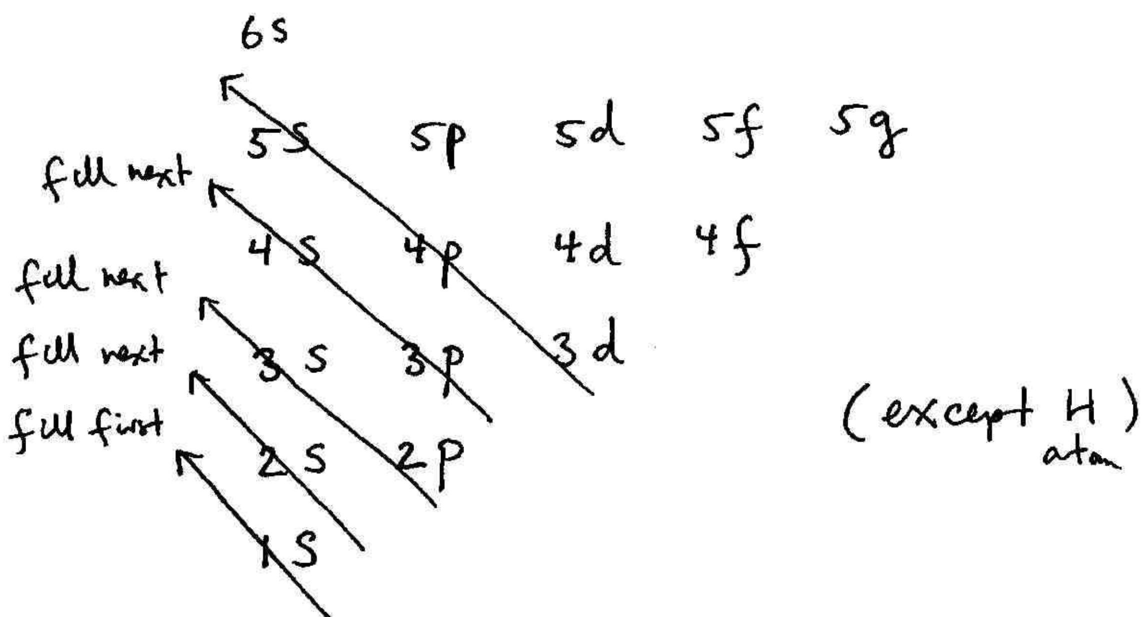
$l = 3$ f orbital

We call the $n=1$ s orbital 1s; the $n=2$ s orbital 2s & so forth. Thus 3d means $n=3$, $l=2$. Note as $l < n$ the 3d is the d orbital with the smallest possible n value.

(7) Pauli exclusion principle: Only one e^- can have a given n, l, m_l & m_s set of values at a time (around 1 nucleus)

(Exercise 1) What question does the n, l, m_l & m_s raise in your mind? We will read & hope to answer these questions in this course.

⑧ Energy order of the atomic orbitals.
Zumdahl p. 550 - 557. (approximate)



Energy order of orbitals

$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p \ldots$

⑨ Rule is that the stable configuration fills the lowest energy orbitals before higher energy orbitals.

FIGURE 12.28

The orbitals being filled for elements in various parts of the periodic table. Note that when we move along a horizontal row (a period), the $(n + 1)s$ orbital fills before the nd orbital. The group labels indicate the number of valence electrons (ns plus np electrons) for the elements in each group.