Chapter 10. Cracolice, 2/e. Chemistry X11.

Emphasize Sections 3-5.

Ch 10 builds on Ch 5, and develops the modern understanding of atomic structure. Ch 10 focuses on electrons -- their energy levels, and their orbitals; this leads to understanding chemical bonds (Ch 11). Unfortunately, some of this chapter is quite abstract, and some involves rather fancy physics.

Sect 1 is historical background, discussing ideas prior to the current model. The idea of quantized energy levels is important.

Sect 2 presents the current model. Since the underlying physics is so complicated, the presentation is largely "here it is", and is not satisfying intellectually. (That is still substantially true in "Chem 1" type courses.)

I hope that many of you will find some of Sect 1-2 (including the questions) helpful, but do be careful not to get bogged down here. The chapter becomes more "practical" as it proceeds.

Sect 3. The <u>key</u> <u>goal</u> is to see the relationship between electron configurations and the PT, as shown in Fig 10.8. With this Fig, you should be able to write the electron configuration for any element, determine the valence electrons -- and talk at length about the chemical properties of the element based on that information. Without such a Fig, you should try to write the electron configurations for the elements of periods 1-3. If you can do this, you have the idea. (There are complications and special cases after period 3.)

Sect 4 introduces two ideas that we will use in upcoming Ch. The idea of <u>valence</u> <u>electrons</u> (VE) is important. You can read VE from the PT; Ch 10 provides a reason. <u>Lewis</u> <u>symbols</u> (electron dot symbols) are particularly useful in showing the structure of nonmetal compounds, with covalent bonds (Ch 11, 12).

Sect 5 discusses a number of patterns in the PT, and relates them to electron configuration.

Fig 10.13 shows the family names for some major groups.

Problems 20, 21, 25 (Ca), 30, 37 are representative of the priority issues.

Errata

p 274. Fig 10.8 appears to show three 1s electrons! The 1s block should not extend into group 2. (There is no group 2A element in period 1.)

Further reading (Also see Ch 5 handout; the material for these chapters overlaps.)

C J Humphreys, Electrons seen in orbit. Nature 401:21, 9/2/99. News. Discusses work that allowed orbitals to be directly visualized. The cover of this issue shows one of the pictures, which clearly shows a d_{z^2} orbital (see Fig 10.7 of Cracolice). (That language is a little rough, since orbitals are not "things"; what they observed was an electron density, which corresponds to that of the d_{z^2} orbital.)

R F Jarrell, A brief history of atomic emission spectrochemical analysis. J Chem Ed 77:573, 5/00, plus four accompanying articles. In Fig 10.3 Cracolice introduces the idea that different elements have different spectra associated with them. Numerous analytical methods make use of this. The simplest is the flame test, in which a sample is simply heated and the flame color is compared to those for known elements. For example, a bright yellow flame (with certain specific spectral features, if examined in detail) is characteristic of sodium; this is also the color of sodium vapor lamps. Quantitative techniques include atomic absorption and atomic emission spectroscopy.

S M Condren et al, LEDs: New lamps for old and a paradigm for ongoing curriculum modernization. J Chem Educ 78:1033, 8/01. Interesting article on LEDs, both how they work and how they are used. For more on lighting, see my web page.

J L Marshall & V R Marshall, Rediscovery of the elements: Ytterby Gruva (Ytterby Mine). J Chem Educ 78:1343, 10/01. The authors visit the site that was the source of several of the lanthanides, and after which four elements are named. Includes maps.

P J Karol, The Mendeleev-Seaborg periodic table: Through Z = 1138 and beyond. J Chem Educ 79:60, 1/02. We introduced the PT in Ch 5, but Ch 10 presents the basis for it in terms of electron configuration. Here, with considerable whimsy but also exploring real issues, Karol extends the PT through the 17th period, which ends with a "noble gas" -- presumably a not very noble solid in this case -- at Z = 1138. Beyond? Discussion continues, and continues, as he addresses issues that affect nuclear stability. He ends up at $Z = 10^{21}$. Fun and instructive.

R N Zare, Visualizing chemistry. J Chem Educ 79:1290, 11/02. We have talked about various levels of making models of the atom. In this amusing commentary, the noted Stanford chemistry professor Richard Zare tells how he once helped his young daughter build a model of a gold atom -- a model that was far more complicated than either the daughter or her teacher understood.

T C Beers, Astronomy: The first generations of stars. Science 309:390, 7/15/05. News, about the elemental abundances in the very first stars. This will become part of the story of how the elements came to be.

R C Albers & J-X Zhu, Solid-state physics: Vacillating valence. Nature 446:504, 3/29/07. News, about the unusual nature of plutonium metal, and an attempt to explain it in terms of the electronic behavior. "Electrons in one particular solid phase of plutonium are complex characters: while bound to atoms, in a quantum-mechanical mixture of two different valence states, they also roam freely throughout the crystal." Quite readable -- if you just avoid too much detail.

A Turler, Nuclear chemistry: Panning for ununbium. Nature 447:47, 5/3/07. News. How do you measure the chemical behavior of elements whose atoms last only seconds -- at most? With great difficulty! And why would you care? The trends of the PT become less clear near the bottom. Substantial deviations from simple predictions were found for Rf and Db. More complex theories, involving relativistic effects, accommodate the results. The work discussed here explores the chemistry of ununbium (Uub; Z=112). Speculations varied that it might behave like Hg, just above it in the periodic table, or that it might be more like the noble gas Rn. Using only two atoms of Uub, they showed that it behaves like Hg, about as expected for its group. A paper on the chemistry of hassium (Z=108) is listed on the web page of Old Articles.

Computer resources

> There are several items on the web page for Intro Chem Internet Resources that are relevant to this Chapter. A couple are explicitly marked for Ch 10, but most of those marked for Ch 5 are also relevant here.

Among the relevant web site sections:

Atomic force microscopy. There are some nice pictures on pp 272-3. (Also recall Fig 2.1, which mentions the method.) For the originals of these, and much more, see the section on atomic force microscopy at my web site. Good pictures and a good introduction to an important new technology.

Orbitals. Lots of pictures, and more.

Lighting. Mentioned above.

Nucleosynthesis; astrochemistry; nuclear energy; radioactivity. Astrochemistry discusses the chemicals found "out there", and nucleosynthesis discusses how atoms (nuclei) are made in stars. Nuclear energy and radioactivity are discussed in Ch 21, which is beyond our course.