Chapter 3. Cracolice, 2/e. Chemistry X11.

Schedule notes. We will start Ch 3 (Sect 1-4) in class 2, focusing on Sect 3-4 at first. We will "finish" it in class 3. (We cover only parts of this Ch for now; see below.)

WRITTEN ASSIGNMENT #1, due in class 4.
Part 1… Do the problems listed here, including the added problem, showing your work. *Use clear dimensional analysis, even for the simple problems. Be sure to show units as you set up the problems, and in your answers.*
Do: Ch 3 (p 85 ff; that is, pp 85-88): #7, 8, 18 (show work!), first part each of 20 & 27, 40, 46, 51, 53 (a harder problem), 54 (see note below for Sect 3.7).

> Added problem: Based on the data in Tables 1.1 & 2 (p 6), what is the #1 rank chemical overall? Explain; show work.

You should do far more than this for your own practice; I want to see a few, to look at your "form".
Part 2… ask a question. It can be about a homework problem, or some other problem or class issue.

I will return the homework on test night. If you would like it back sooner, include a SASE when you turn in the homework. If you miss class when the homework is due, I encourage you to mail it to me, so I can get it back to you on test night. (My mail address is on the General Information handout.) This is most important if dimensional analysis is new or unclear to you. The main purpose of the assignment is pre-test feedback on dimensional analysis.

⇒ A "**practice quiz**" for Ch 3 is at the web site.

Chapter 3

Ch 3 is a long chapter, with a general theme of problem solving. It introduces some math tools, a problem solving strategy, and some specific applications. The single most important part of this chapter is the use of dimensional analysis as a problem solving tool. Ch 3 also introduces the metric system.

Sect 3.2. This is useful math, but we will spend little class time on it. If it is new to you, give it a try. I am happy to help people with this privately.

> If you want some help with your scientific calculator, see my web page on the topic. It provides information about some models. I will soon ask each of you to fill out such a form for your calculator. Of course, you can also see me for calculator help.

Calculator "tests". Using your scientific calculator…
1) Multiply $2.4 \times 10^{34} * 4.6 \times 10^{-19}$. You should get 1.104×10^{16}.
2) Multiply $2 \times 10^{14} * 10^{12}$. You should get 2×10^{26}.
If you do not get these answers, or otherwise need help using your calculator with exponential notation, please see me.

> Students ask… how do you know when to use exponential notation or ordinary decimal form? There is no right or wrong here; they are two ways to express the same number. Exponential notation is generally most appropriate for numbers with many zeroes at one end (large positive or large negative exponent). Sometimes, it's just a matter of consistency: if most numbers in a set are in one form, it may be most appropriate for your next number to be in that form. Exponential form may allow you to more clearly indicate the number of significant figures (Sect 3.5).

Sect 3.3. This is the heart of the chapter. Dimensional analysis is a tool, a *logical* approach. Dimensional analysis helps guide you through problems, even if you are not quite sure what to do. *It is important that you learn this tool, and that you show clear work in dimensional analysis problems.* Practice!

The goal for class 2 is to get started with dimensional analysis; we will continue it next time, and will use the method throughout the course. I think it will be very helpful if you have read this and tried a few of the Examples yourself. Class will make more sense to you -- and you will know whether you find this an easy or hard topic.

> For more help and practice with dimensional analysis, including multi-step problems, see the supplementary handout on this topic.

> Dimensional analysis is also called unit analysis or the factor-label method. There is an argument that unit analysis is a better name than dimensional analysis; technically, we analyze units (such as inches or meters), not dimensions (the property, such as length). I don't really care what the name is; what is important is using it as a problem-solving tool.

Sect 3.4. You should become comfortable with the basic units, and with the major metric prefixes used in chemistry (highlighted in Table 3.2: kilo-, centi-, milli-). We will tend to cover this material piecemeal as needed; it's a good section to refer to often.

> (Modern analytical chemistry and biotechnology are becoming increasingly sensitive. As a result, the units for smaller amounts are becoming more important to many. A complete list of metric prefixes, from yotta to yocto -- with some fun examples of their use, is at the web site.)

You should be able to do metric conversions by dimensional analysis.

Sect 3.5. Significant figures (SF). This is an important idea; try to see how SF relates to measurement uncertainties. Fig 3.5 is nice. However, it is easy to get bogged down with all the specific rules, especially when zeroes are involved. We will cover it mostly by example as we go along. To some extent it is almost "common sense" that if you multiply or divide three digit numbers, you should express your answer with three SF. As you go through the course, try to be "reasonable" with SF; learn from the feedback.

> I have a web page, Significant figures - a beginner's guide, which may help you sort out the priority ideas on SF.

Sect 3.6. I do not expect you to know metric-USCS conversion factors. However, given the conversion factors, these conversion problems are simply another straightforward application of dimensional analysis.

Sect 3.7. Temperature (T). Most lab work is done with the Celsius T scale. The Kelvin scale is important theoretically (e.g., gas laws, Ch 4 & 13). You are not responsible for the Fahrenheit scale.

Be careful to distinguish T and ΔT in doing problems. T is temperature, on a specific scale. ΔT is a temperature change (the Δ, a Greek capital delta, means "change in"; p 34 margin note); only the size of the degree unit matters. For example, to interconvert C and K T values, you must take into account that the scales are offset by 273. T in °C = T in K - 273. But to interconvert C and K ΔT values, all that matters is that the degree size is the same. ΔT in °C = ΔT in K; the 273 offset disappears in subtracting to find ΔT. To convince yourself, try an example.

Sect 3.8. Density is a useful idea; it is a good example of an intensive property -- one that does not depend on how much material you have. The density equation (3.9) is fairly simple. However, I would emphasize using dimensional analysis in doing density problems. Even if you use the equation, be sure to check that the units work out right (p 79).

Sect 3.10. Judging from the title, this sounds important!

Supplementary worksheets

I have posted two supplementary self-help worksheets relevant to Ch 3 at the web site, on the "Chemistry problems" page. They are on Dimensional Analysis and Density. Each of these -- and others posted there -- offers a brief presentation of key points, but mainly consists of extensive sets of practice problems. (I will hand out the Dimensional Analysis worksheet, so you can get a sense of what these are like. But for the others, I will simply mention them in the handouts, and you can check them out at the website as you wish.)

Further reading

F B Salisbury, Standardizing with SI units. BioScience 48:827, 10/98. An extensive discussion of how to use units, aimed at biologists. You may find more here than you want to know, but it can also be delightful reading.

Book. A Linklater, Measuring America -- How an untamed wilderness shaped the United States and fulfilled the promise of democracy. Walker, 2002. ISBN 0-8027-1396-3. A book about why the US should have but did not adopt the metric system from the start. A book about the history of measurements, and of units. A book about surveying -- and about Thomas Jefferson. A book that is surprisingly much more interesting than the short title might suggest, in part because it is well written and in part because it brings together a range of seemingly unrelated topics in an unusual but fascinating way (as the subtitle may hint). This is listed on my web page “Books: Suggestions for general reading”.

Feature section: Fundamentals of Measurement. Science 306:1307 ff, 11/19/04. A set of articles dealing with some fairly advanced issues in establishing standards for measurement. Despite the level, some may find it worth a browse for the general ideas and some bits of history.

D L Hu & J W M Bush, Meniscus-climbing insects. Nature 437:733, 9/29/05. If you thought walking on water was difficult, just wait until you try to climb the meniscus. Small animals, such as some insects, are supported on water by surface tension. However, the meniscus must seem like a “frictionless mountain” to them. Some apparently jump over the meniscus. But some have special wettable appendages, and make use of capillarity to travel on the meniscus.

B C Stoel & T M Borman, A comparison of wood density between classical Cremonese and modern violins. PLoS ONE 3(7):e2554. 7/08. Ch 3 defines and describes density. But why is it important? This article suggests that variations in density through a piece of wood, due to climatic variation, is important to the quality of violins. They use “CAT” scans (at a New York hospital) to measure the density at various spots on the violins, which range from a 1715 Stradivarius to some 21st century violins made by one of the authors. The article is freely available at http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0002554; a link is on the web page of Internet Resources for Intro Chem.

K Jensen et al, An atomic-resolution nanomechanical mass sensor. Nature Nanotechnology 3:533, 9/08. There has been considerable work in recent years on developing nano-balances: balances capable of weighing single atoms or molecules by mechanical means. This one uses the principle that the resonant frequency of an object depends on its mass. It operates at room temperature, and uses carbon nanotubes. A potential use of such balances is weighing individual protein molecules, under gentle conditions. Regardless of use, this is fun! The paper is available at Zettl’s UC Berkeley web site: http://www.physics.berkeley.edu/research/zettl/pdf/345.NatNaotech-Jensen.pdf; a link is on the web page of Internet Resources for Intro Chem.

N Jones, Metrology: The new and improved kelvin. Nature 459:902, 6/18/09. News. I bet many do not know how the kelvin is currently defined -- or what kind of water it takes to define it. This “news feature” tells the story.

Computer resources (See web page for details and links.)

An excellent presentation of unit conversions. Stan Brown emphasizes the importance of “a well-chosen form of 1”. He includes many examples, of increasing complexity, and a few practice problems.

Links to some optional lab activities that you can do on your own. Some of these relate to this Ch.

Have you wondered about the stories -- real or imagined -- behind the names of the units? Read the story of Claude Emile Jean-Baptiste Litre (1716-1778) -- and his daughter Millie.

The kilogram is the only unit that is still defined by a specific physical object, in this case a bar stored in Paris and declared to be the official kilogram. Physicists would love to develop a definition of the kilogram that is more fundamental, but it is proving to be a difficult task. One possibility is to declare a value for Avogadro's number (Ch 7); that would fix the magnitude of the mass unit. The web page lists two articles on this story. A major thrust of their argument is that we should go ahead and make the change, even though not all the underlying questions have been answered yet.

As mentioned above, I have also posted a complete set of metric prefixes, with examples. The page "Significant figures - a beginner's guide" may help you with priorities on this big topic. I also mentioned the practice quiz, the Scientific calculator page, and the supplementary worksheets on the Chemistry practice problems page.

x11\xc3
8/12/12