Introductory Chemistry:
some comments and strategies regarding problem-solving

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The facts:
- The courses are very fast-paced. Most students in the course are freshmen, and nearly all of them plan to major in something other than chemistry. Even most of those with high school chemistry will have only covered chapters 1-4, which is covered in three weeks at Duke.
  - The lectures are totally one-way. The professor usually speaks and writes on the board at the same time, filling up the board with terms and derivations but rarely including moments of reflection or definitions. If you attempt to write everything down, you are unlikely to actually hear most of what the professor says.
  - There is simply no time to process the lecture during the lecture-period if you have never seen the information before.
  - The class size is very large (~200 students in each section) and anonymous. Many students sleep, read the paper, talk, or otherwise fail to pay attention. It can be very easy to fall prey to those distractions.
  - The class is not designed to test critical thinking or to place the concepts into a unified framework. However, you are unlikely to be able to remember all of the material unless you have some sort of construct for how the information is assembled within the field of chemistry.
  - The class is a good primer for organic chemistry, though orgo involves greater use of critical thinking skills.

Some possible solutions:
- Lectures are not places for learning. They are places for evaluating and organizing the information. You must pre-read the lecture material, even if just superficially (we actually recommend reading superficially to save time) so that you can experience the material for the second time in lecture. This approach serves several purposes:
  - You can think about the material more since you’re not seeing it for the first time.
  - You can compare and contrast the lecture presentation with what you saw in the book.
  - You can prioritize the information better.
  - You can evaluate the teaching style and take notes that highlight those topics that the professor deems most important (and least important).
  - You can respond to the material in a manner analogous to seeing a book-based movie….i.e., you can become a “lecture critic”.
- The book is the primary resource for the course, and the lectures follow the book closely. As a result, the book should eventually be studied in detail, regardless of whether you pre-read or not. Thus, it makes sense to pre-read superficially before lectures.
- You should be taking Cornell notes [see “Taking Notes Further” handout], which will force you to take less notes (skeleton outlines are what we recommend). But you will also be able to write more questions and comments about the material and the lectures, and you can leave room for summarizing what you experienced that day. The abbreviated notes will also make it easier to study when reviewing later.
You have to spend some real time doing the problems. You can’t simply verify that you can do the problems you were assigned; instead, you need to understand a lot more about each problem. For example:

- Every problem can be rearranged to become a new twist on the original. You should not only be able to solve the twists, but able to manipulate the problems to twist them personally (see “Science and problem-solving courses: manipulating and understanding the material” handout).

- Every problem has a “purpose”. Why are you doing this problem? What concepts are being explored? How is the problem testing your understanding of those concepts?

- You should be able to explain how you got every answer, right or wrong. If you can’t explain the solution to a problem, even if you got it right, then you don’t understand the problem.

- You should realize that the material is not being taught so you can pass the test. The material is being taught because the professor actually wants you to learn it and believes that the material is important to your lives and your careers. Whether you agree or not, you will find that the class is immeasurably more interesting if you try to understand why people are interested in all of this stuff and what it can be used for.

In addition to the “critical thinking” aspects of the problems, there are a number of strategies that can be used effectively to study for the tests. For example:

- Do as many problems as you can manage in the time you set aside for such purposes, whether they were assigned or not. At least 6 hours per week devoted to thinking about and working on problems is usually necessary. Note that you need additional time to read the book, process your notes, etc.

- Make sure to attempt problems at least once in a time-limited fashion (i.e., race against the clock). It doesn’t matter if you can do all of the problems if you need hours and hours to do it. You have to test yourself in an environment that mimics the exam situation.

- Try making up problems. Quiz each other if you work in groups. You don’t have to make up problems you know the answers to…. you can always explore why you can’t answer problems you’ve posed and then seek to overcome the limitations.

- You have to actually engage in the work. If you simply hunt for a formula, pray that the answer comes out correct, and then move on when it does, you’ll fail on a similar problem in the exam.

- Study at times when you can actually work well. Studying when you’re half-asleep is a waste of time.
- While taking the test, observe the following simple tactics that will increase your chances of answering the problems correctly:

  - Look over the whole test, count the number of pages/problems, and quickly calculate the time-budget you’ll need to follow in order to finish the test.
  
  - When you read a problem the first time, try to put it into the context of what you learned in the previous weeks. You’ll need to have drawn a concept map [see “Concept mapping” handout] or put together some sort of global outline beforehand in order to do this.
  
  - Go with the gut at first, if possible, and try to solve the problem. Then pause and read the problem again with a fresh eye, making sure that you understood what the problem is asking for.
  
  - Read every single possible answer! If you find answers that seem indistinguishable according to the question, look for a choice like “None of the above” or “Need more info”. Otherwise, mark the problem and move on. You’ll have to return to that problem and give it some more thought later.
  
  - If a problem really confuses you or seems particularly difficult, mark it and move on so that you can return to it later. You should always finish all of the problems that you can answer relatively quickly, since those are most likely to be correct.
  
  - Have some scratch paper on hand or work on the back of sheets if possible. You should take notes for yourself and underline key words and phrases in the problems. Anything you can do to identify the heart of the question being asked will make it that much less likely that you’ll make a silly mistake.
  
  - Breathe. Stretch your neck on occasion. You think better if you relax as much as possible.

- In addition to the targeted strategies listed above, introductory chemistry is an ideal course in which to request a tutor. Use your tutor to discuss strategies for approaching difficult concepts, for speeding up response times, and for going over unfamiliar material in a directed fashion. Your tutor should be extra time, not part of your minimum-6-hours study time for problems. You should try all of the problems before you see your tutor.

  - See the professor! Talk to the TAs!

Ultimately the professor and TAs are the best resources for understanding what they want from you in the course. Ask targeted questions about the depth of knowledge that is expected, the key concepts from different components of lecture, etc.

  - Visit an ASIP instructor regularly for guided practice with critical thinking and problem-solving strategies.