Introduction

This online learning system been created specifically to support you in Chemistry 109 at the University of Wisconsin-Madison. It is more than a textbook and includes more than chemistry. We hope that it helps you learn chemistry and learn how to succeed in this and other challenging courses. For a 15-minute overview of what one aspect of chemistry is all about, take a look at this video.

Before proceeding further, make sure you have a course notebook in which you can write about what you are learning. Your notebook can be pencil-and-paper, a tablet, a laptop, or some other device, but it needs to be with you whenever you are studying and learning chemistry and it needs to be easy for you to write and draw in. Writing will help you to learn and to record important information so you can review what your have learned. Writing about what you are learning should become a useful habit in your career.

> **?** Activity 1: How Do You Study?
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> Think about how you have studied in courses you have taken in the past. For example, you have almost certainly taken high school chemistry. How did you study in that course? In your course notebook, write a few sentences describing your study habits. What did you do each day? Each week? Before each exam? What seemed to work well? What did you not do, but think you should have? (Don't go further until you have written something.)

We asked you to think about how you study because an important goal of this course is that you learn better ways to learn. One of those better ways is to make certain you are engaged and active as you learn. Another is to prepare your own set of notes about the topic you are studying. The activity you just did should be the first entry in your learning notes for this course; we will ask you to refer to it after you have more experience in Chem 109. Many scientists carry with them at all times a notebook in which they write about what they learn from seminar presentations, conversations, and journal articles. Scientists also jot down questions that occur to them—sometimes these become research topics. We strongly encourage you to do the same thing.

Let's begin by building on what you just wrote in your course notebook. We often hear from students that "Chemistry 109 was the course where I learned how to learn." That's great. It means that we helped students learn how to learn more effectively. In today's rapidly changing job market, it's crucial to be able to learn something new every day. Another important goal is that you learn lots of chemistry, because most biological/medical/engineering disciplines are based on solid understanding of chemical principles. We assume that you want to learn chemistry and want to be able to use what you learn in your future endeavors. So how do you do it?

Learning Requires Your Effort

The secret to successful learning is that learning does not just happen: *Learning is something you do to yourself*. Nobody can learn for you or force you to learn. Learning is not just attending class, reading books, viewing videos, or even studying. Learning requires specific activities and repetition of those activities over an extended period.

Neuroscience has revealed a lot about the best ways you can learn. Learning is a biochemical process that enhances signals among neuron cells in your brain. (This four-minute video summarizes how this works: https://www.youtube.com/watch?v=U8Eieult80U.) To learn a new idea you first need to make sense of it (understand it), which means connecting it with things already in your memory. For example, when studying acids and bases try to connect what you are learning with household products you are familiar with such as vinegar and ammonia. The more connections you can make the better you will remember. You can strengthen the connections through recall—the more often you bring a new idea back to mind the easier you can retrieve it later.

When you try to understand something your brain is working hard to establish the right connections among neurons to link the new idea to what you already know. Sometimes this happens quickly—an "Aha!" moment, but it may take several tries with the same new idea before the right connections happen. Either way, understanding requires highly focused attention and active brain work on your part. It cannot be done if you are multitasking or distracted. You have to be actively concentrating on the new idea. (Multitasking while learning will hurt your grades: see this study.)

Remembering also requires your active participation. Memories are not imprinted in your brain—neurons are not permanently linked—so memories must be reconstructed. The more often they are reconstructed the easier the next reconstruction becomes. In neuroscience lingo, a pattern of synaptic activity can produce a long-lasting increase in signal transmission among the neurons involved. Thus, using an idea helps you remember that idea and makes the idea easier to use later. Mental practice is important.

Knowledge Involves More Than Information

Information is available everywhere; you can Google almost anything. But "just the facts" is not enough. Knowledge involves understanding something well enough that you can recognize connections among facts, evaluate information to decide which facts are useful (and which are fake), and think creatively. Knowledge involves those connections among neurons that will fire when you are trying to solve a problem.

Unfortunately, neuroscience has found no method for transferring knowledge from a teacher's brain to a student's. A teacher can lead you to information, provide useful insights, and inspire you to do the necessary work, but it is your job to convert that information into knowledge. The information will mostly be symbolic—words, numbers, diagrams, videos—so you will need to know what those symbols mean. New knowledge depends on previous knowledge to which you can make connections. And, once you have made those connections, you need to practice using them as often as possible so you can remember. You may understand everything that you hear in a lecture, but if you don't practice applying your understanding to new but related situations, you won't be able to use your understanding (or even remember it) when it really counts: on an exam, in a different course, or in real life situations.

? Activity 2: Section Summary

- Summarize in two sentences (in your course notebook) what you have learned from this section. What is the important take-away?
- Refer to what you wrote earlier about study habits. Based on what you have learned here, write in your course notebook changes you will make in how you will study for this course.

How Will This Course Help Me Learn?

This course has many features designed to help you learn chemistry. It is organized into units, each of which ends with an exam. Within each unit there is a weekly schedule. Within each week there are whole-class meetings where lecture and group work will be done, a discussion section for group work, and a laboratory session. Each of these meetings has a pre-class activity that will make sure you have the background needed for the class session. There are post-exam activities that will ask you to reflect on your study habits and what you have learned. There will be activities during each class period, and there is homework each week. Laboratory work enables you to learn techniques and apply what you have learned in class. All course information is available in a course management system called Canvas. An online system called Piazza allows you to post questions anytime and get responses quickly. Your course instructor will have office hours during which difficult material can be discussed and explained: make use of them!

How Should I Use These Pre-class Materials?

This pre-class learning system is different from a typical textbook. It is online. It is interactive. Sometimes it asks you to discover things for yourself, instead of reading about them. To use it effectively you must participate in all interactive components. For example, so far there have been two "Activities" in blue-shaded boxes. Did you do what these activities asked you to do? There will also be "Exercises" in purple-shaded boxes and opportunities for "Applying Core Ideas" in green shaded boxes. Much of what you need to learn is in these boxes. The boxes will ask you to do something, to answer a question, or to think about ideas. These processes are essential to your learning. *Do not skip them!*

In this course you will encounter many facts and concepts. These are like stones that might be assembled to build a home or even a cathedral. Part of what we hope you will learn is how to select appropriate facts and concepts and build them into larger structures that help you address important unsolved problems. Learning how to select appropriate building stones, fit them together, and add mortar to hold them in place is an important goal—one that we will do our best to help you achieve. We want you to depart this course with beautiful mental structures that will serve you well in the future. Your active participation and intellectual involvement in the pre-class materials and all other aspects of this course is a cornerstone for building toward that goal.

What Does This Mean for Me?

There is no way round the fact that learning is work—very rewarding work, but work nonetheless. You need to make sure that you align your efforts with what is known about brains, information, and knowledge. Here's how to do that most effectively.

- Assign yourself at least one regular time each day when you will concentrate on learning chemistry without interruptions or distractions.

- Schedule those times so that you can prepare for each class meeting: during classes we will assume that you know what you were assigned to learn and without that prior knowledge you will have a hard time learning more.
- Arrange your schedule so that you get a good night's sleep every night–this really helps!
- Make sure you get plenty of exercise–don't just sit and study.
- Participate actively in group work in whole-class and discussion sections: if you don't understand something, ask; if someone else has a question, practice what you have learned by explaining the idea to them.
- Write in your course notebook about the important concepts during each whole-class and discussion section; fill in gaps in your notes by consulting this online learning system, Piazza, other resources, or your lecturer during office hours.
- If you are not sure you understand a chemistry problem or concept, post a question on Piazza and participate in the online discussion; go to Piazza often to see what others are asking.
- Begin studying for the first exam the first day of the semester: learning requires repeated practice over an extended period, so cramming for an exam doesn't yield long-lasting results.
- At least once a week spend 5-10 minutes thinking about which topics you have mastered and which you need to work on more; exams in this course allow you to select among several questions and you need to be able to recognize which ones you will be able to answer best.
- Constantly test yourself to make sure you can apply what you have learned; believing you know something is not the same as actually knowing it.
- Form or join a study group that meets regularly to work on homework, discuss difficult concepts, and helps each other prepare for exams.

? Activity 3: Study Schedule

- Write a two- or three-sentence summary of this section.
- Set up a weekly study schedule and write it in your course notebook; you will probably need to change this schedule later, but get it written now.

What Will I Learn in Chemistry 109?

When you complete Chemistry 109 you will be able to

1. Describe fundamental chemical concepts and principles. These include structure and properties of atoms, models for bonding and molecular geometry, intermolecular forces, organic molecules and functional groups, biomolecules and polymers, kinetics and reaction mechanisms, equilibria and thermodynamics, acid-base chemistry, and electrochemistry.
2. Invoke models of atoms, molecules, and their interactions to qualitatively explain observed macroscopic phenomena, including the organization of the periodic table, chemical and physical characteristics of organic compounds, the rates of chemical reactions, equilibrium concentrations, and electrical currents generated by electrochemical cells.
3. Apply quantitative chemical models to predict thermodynamics, equilibrium concentrations, rates of reaction, and voltages of electrochemical cells.
4. Design, conduct, and analyze experiments pertaining to chemical concepts included in the course while developing fundamental skills in safe laboratory practices, accurate chemical measurements, and sample isolation and analysis techniques.
5. Demonstrate abilities as reflective, self-directed learners who can assess their work, identify their misconceptions, and critically evaluate information from a variety of sources.
6. Articulate the rationale behind experimental observations and the answers to conceptual problems using clear, concise, and scientifically appropriate language.
7. Solve a wide variety of integrative chemistry problems that connect several concepts and their applications to real world situations.

? Activity 4: Goals

Think about how your personal goals mesh with these course goals. If you are aiming for a certain major or a particular career, how will the outcomes listed above help you achieve your career goals? Write a few sentences about this in your course notebook