Santa Clara University
Department of Chemistry and Biochemistry
General Chemistry II (Chemistry 12)

Lecture Syllabus — Summer 2022

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Prerequisites: Chemistry 11 or the equivalent. You should have a **working** knowledge of topics covered in Chemistry 11 as well as basic algebra; you will be using logs very frequently this quarter so make sure to review the use of common and natural logs.

Course Topics: Chemistry 12 is the second quarter of a two-quarter sequence in general and analytical chemistry. Topics covered this quarter will include: properties of gases, properties of solids and liquids, intermolecular forces, properties of solutions, chemical kinetics, general aspects of equilibria, properties of acids and bases, aqueous equilibria, and electrochemistry. Special emphasis, in both lecture and laboratory, will be placed on the application of chemical principles. We will cover these topics at a very brisk pace; it is therefore essential that you do your very best to not fall behind. If any subject covered in lecture is unclear, please see me ASAP!

Textbooks and Supplies:

(**1**) **Required: Chemistry: Structure and Properties, 2nd edition**
by Nivaldo Tro (Prentice Hall: New Jersey, 2018) available from the SCU Bookstore. Note that this text was used for Chemistry 11 and 12 during the 2021-22 academic year and will be used again in 2022-23. Please also note that we will not be using Mastering Chemistry in class this term.

(**2**) **Highly recommended: Student Solutions Manual for Chemistry: Structure and Properties, 2nd edition**. This is also offered through the bookstore and various online outlets. This will give you access to full solutions for most of the odd-numbered end-of-chapter problems in the text. Although the Bookstore may list this as recommended, I feel that it is essential to assisting you in preparing for the various exams we will have this term. ***I HIGHLY RECOMMEND THAT YOU PURCHASE THIS MANUAL***

(**3**) **Required: Laboratory Manual for General Chemistry II, Summer 2022 Edition**
This is available in electronic format via the Camino page for your laboratory section.

(**4**) **Required:** A **notebook** is required for laboratory. This should be a bound notebook with quadrille lined pages. A simple quadrille-lined composition book is an excellent inexpensive option.

(**5**) **Required: Chemical splash goggles, a laboratory coat** and appropriate laboratory attire are **REQUIRED** for all in-person lab sessions. Please note that safety glasses are **not** adequate eye protection.

(6) A simple **electronic calculator** (Texas Instruments **TI-30X** or **TI-30Xa** or equivalent) is essential for this course. Please note that the use of any **smart** device is **strictly prohibited during any graded exercise**; your cell phone is not a substitute for the calculator requirement when it comes to exams!

Lecture Procedures:

Handouts: A significant percentage of the core information for lecture will be delivered in class using a set of interactive "fill in the blank" style PowerPoint slides. The slides will be available in two formats: one with blanks ready for you to fill in during class, and a second version with the blanks already populated (Handouts vs "Filled In" Handouts). You should choose the format that best fits your learning style. The handouts will be posted each week in the appropriate weekly module on Camino. It is your responsibility to come to lecture with either a printed hard copy of the appropriate handout(s) or with an electronic copy that you can annotate during class using a tablet or laptop. Instructor-printed hard copies will not be available. Please make sure to also bring notebook paper as most of the sample problems we will do in class will not be on the slides—we will do those together on the whiteboard!

Class attendance: Students are expected to attend all class sessions. Formal attendance will not be taken however as long as at least 90% of the students enrolled in the class attend class each day, I will post instructor-narrated YouTube video micro-lecture videos of the lecture topics covered that day so that you may use them as you review course material. If we drop below 90% attendance 2 days in a row, the micro lecture video posting will be eliminated for the remainder of the course so please make sure to come to class!

Tentative Lecture Schedule

The chapter topics and number of lectures per chapter listed below are approximate. Key sections for each chapter are noted below. The organization listed below is approximate; a more specific detailed "weekly roadmap" will be published each week with information regarding suggested pacing of your studies for the week.

Chapter Topics

Tentative Lecture Schedule: Listed below for each chapter are the major topics we will cover for each chapter as well as the approximate # of lecture hours we will spend on each chapter and textbook section numbers associated with these topics. Topics in parenthesis will be covered in less depth or covered as guided assigned reading:

Week #1: Ch. 10: Gases: Gas laws; Dalton's law; volumes of gases in chemical reactions; kinetic molecular theory; deviations from ideality (approx. 2-3 hrs); Sec 10.1, 10.2, 10.4, 10.5, 10.6, 10.7, (10.9)

Week #1: Ch. 11/12. Intermolecular forces; solids and liquids; changes of state; vapor pressure; (approx. 3 hrs); Sec11.1, 11.2, (11.3), 11.4, 11.5, 12.1

Week #1/2: Ch. 13. Concentration conventions for solutions, solution thermodynamics, ideal and non-ideal solutions, colligative properties, electrolyte solutions (approx. 5 hrs); Sec 13.1, 13. 2, 13. 3, 13. 4, 13. 5, (13. 6)

Week #2: Ch. 14. Kinetics: rate laws, half-lives, mechanisms, Arrhenius theory, catalysis (approx. 4-5 hrs); Sec 14.1, 14. 2, 14. 3, 14. 4, 14. 5, 14. 6, 14. 7.

Week #2: Ch. 21. Radioactive decay rates and detection of radioactivity (approx. 1 hour); Sec (21.1), 21.4, 21.5.

Week #2/3: Ch. 15. Chemical equilibrium, Kc, Le Châtelier's principle; common-ion effect (approx. 4-5 hrs); Sec 15. 1, 15. 2 (we will not cover Kp); 15. 3, 15. 4, 15. 5, 15. 6, 15. 7.

Week #3: Ch. 16. Aqueous equilibria part I: Acid-base equilibria (definitions, impact of structure on acid strength, pH scale and pK, pH calculations for acids, bases, and salt solutions) (approx. 3-4 hrs); 16. 1, 16. 2, 16. 3, 16. 4, 16. 5, 16. 6. 16. 7, 16. 8, 16. 9, 16. 10, (16. 11)

Week #3: Ch. 17. Aqueous ionic equilibria: Acid-base equilibria involving common ions; composition of buffers, Henderson-Hasselbalch equation, amino acids (approx. 2-3 hrs), 17.4 (pH indicators), 17.5, 17.6 (if time permits)

Week #3: Ch 19: Electrochemistry: Balancing redox reactions, galvanic cells, standard electrode potentials, cell potential/free energy/equilibrium constant, Nernst equation Tentative sections:19.2, 19.3, 19.4, 19.5, 19.6 (approximately 3 hours)

Recommended End-Of-Chapter Problems: The following is a list of some suggested exercises to get you started. The answers to most of these problems are in the text solutions manual; the manual also gives a guide to HOW each problem was solved. You should to do as many of the textbook in-chapter and **recommended** end-of-chapter problems as possible (I have tried to avoid assigning problems that are very unlikely to be directly related to work that we will do in class or problems that might appear on exams). Extra practice problems and sample exam questions will be available prior to each of the major exams. These will help you to gain a better understanding of the lecture material. In addition, some of the questions on exams may be derived from problems found in the text or the sample problem sets.

Suggested Tro Textbook "End of Chapter" Problems and Exercises
Chapter 10: 25(a, b), 31, 33, 35, 37, 39, 41, 45, 49, 51, 57, 59, 61, 67, 69, 81, 83
Chapter 11: 35, 37, 39, 41, 43, 45, 47, 49, 55, 65, 69
Chapter 12: 39, 41
Chapter 13: 25, 27, 29, 37, 39, 41, 45, 47, 49, 51, 55, 57, 61, 65, 67, 69, 73, 75, 77, 81, 91
Chapter 14: 41, 43, 45, 53, 55, 75, 7779, 103,
Chapter 15: 21, 23, 35, 37, 43, 47, 49, 53, 55, 57, 63, 65, 67, 69
Chapter 16: 31, 33 35, 37, 39, 41, 43, 45, 49, 51, 53, 55, 59, 65, 67, 69, 71, 73, 75, 77, 83, 85, 87, 89, 95, 97, 99, 101, 113, 115, 117, 121
Chapter 17: 25, 27, 29, 31, 35, 37a, 39, 41, 43, 83, 85, 87, 89, 97, 99, 109
Chapter 19: 41, 49, 53, 57, 59 (this list may be expanded depending on how far we get in class!)

Sample problems: There will be no graded homework this quarter however it is vital that you regularly test your knowledge of the course concepts by doing sample problems; lectures provide the introduction to concepts, but the real learning happens when you struggle with new and challenging problems on your own. You are **STRONGLY ENCOURAGED** to do as many of the in-chapter and *recommended* end-of-chapter problems as time permits; the list of recommended end-of-chapter problems may be found in this syllabus. Text problems, in altered form, may occasionally appear on exams. In addition, sets of additional sample problems (and solutions) will be available on Camino prior to the midterm and final exams. Some of these are taken from exams given in previous terms thus it is to your advantage to try these extra problems as you prepare for your exams.

Evaluation: There will be 3 short quizzes, 2 midterms and a final exam; the schedule for examinations is given below. Frequent testing is a vital part of ensuring that you keep on track during the condensed 3 week summer session. Please note that exams will be given only during the scheduled exam period in our assigned classroom; there are no online options for examinations. It is your responsibility to make sure that you are present and ON TIME for each exam; if you show up late you will have less time to complete the exam. Make up exams will not be available; if you miss an exam for any reason, the weighting of the final exam will be increased accordingly. Please note that the final exam is over conceptually difficult material so you should plan on taking all of the exams and only use this option as a safety net in an extreme case. Also note that the final exam will be given on the last day of class for our term (Friday July 22nd). Please make sure that you consider this when making any travel plans; you MUST be on campus to take the final that day (**no online options** will be available).

Tentative Exam Schedule:

Quizzes (3)	Wednesday July 6th, Wednesday July 13th, Wednesday July 20th
Midterms (2)	Friday July 8th and Friday July 15th
Final exam:	Final Exam, Friday July 22nd

Grading: 1000 total points for the quarter will be tentatively distributed as follows:

Exercise	**points per**	**total points**	**% of grade**
Quizzes	50 each	150	15
Midterm #1	250	250	25
Midterm #2	300	300	30
Final	300	300	30

Note that the final exam will be given in two parts. The first part will be a non-comprehensive midterm-style exam covering material since the second midterm. The second part will be a multiple-choice style standardized exam covering Chemistry 11 and 12 topics; this exam is mandated by the Department of Chemistry and Biochemistry as part of its General Chemistry program assessment.

*The actual letter grade for the course will be assigned using the total scores as a guide, but it remains a subjective decision of the instructor based on general evaluation of the class as a whole. Due to the accelerated nature of the summer course, make up exams will not be possible. If you miss a quiz or a midterm exam, the weighting of the final exam will be increased accordingly.

Exam procedures:

It is your responsibility to bring a calculator to all exams; "loaner" calculators will not be available. Note that smart devices or cameras of any kind (including smart watches, cell phones, etc.) are not permitted during any graded exercise. Use of such devices during in class graded exercises will be treated as a breach of the honor code which may result in course failure.

Prior to starting exams or quizzes, it is your responsibility to ensure that any course materials, such as class notes or study sheets, are stowed completely out of view. Place these, along with any prohibited electronic devices (powered OFF), into your backpack and place the pack in the front of the classroom as indicated by the instructor.

Please take a moment to visit the restroom PRIOR to starting your exam. It is expected that you will remain in the classroom during the entirety of the exam/quiz. In extreme cases, if excusing yourself to use the restroom is unavoidable, ask the instructor's permission to take a brief restroom break. Taking course materials or your phone with you to the restroom is a breach of academic integrity and will result in sanctions, which can include course failure. If you leave without permission your exam will be collected for grading and you will not be allowed to make any alterations to the exam copy if you return

to the classroom. Exams in this class are individual exercises; giving or receiving assistance to/from any individual, group, or outside resource is strictly prohibited and is grounds for failure in the course.

Laboratory Procedures: Your laboratory instructor will discuss lab procedures in detail. The following is a brief overview.

You must successfully complete and pass the laboratory section of the course in order to pass the class. Carefully review the schedule for the laboratory section provided in the Laboratory Manual (available at the SCU Bookstore or on your lab section's Camino page). The Chemistry 12 laboratory will be graded on a modified pass/no pass basis. Students must show proficiency in the laboratory portion of the course and fulfill the minimum attendance requirement as indicated below:

(1) In order to be eligible for a course grade of D- or higher you **must not accumulate** more than one unapproved absence or two total absences (for any reason excused or not) from lab. In rare cases make-up labs may be possible but this is left to the discretion of your laboratory instructor. If you accrue an **UNEXCUSED** absence, **A DEDUCTION OF 1% (10 POINTS)** WILL BE MADE FROM YOUR LECTURE POINT TOTAL. To be an approved absence, you must provide your laboratory instructor with a valid, written excuse, within one week of the absence. Valid excuses are sickness (doctor's note required) and family EMERGENCY (verification required).

(2) The final course grade in Chemistry 12 will be determined by your accumulated points in lecture only since lab is pass/no pass. However, as an added incentive to do your very best in lab, points will be added to or deducted from your lecture total according to the following schedule:

Lab "grade"	**How this influences your overall course grade**
High Pass	A **bonus** equal to 2% will be added to your lecture point total (20 points)
Pass	A **bonus** equal to 1% will be added to your lecture point total (10 points)
Low Pass	No change in lecture point total
Fail	Failure in the entire course
Unapproved absence	A 1% **deduction** will be made from your lecture point total (10 points)
>1 unapproved absence	Failure in the entire course
> 2 total absences	Failure in the entire course

Tips on How to Study Chemistry

1. **If time permits, skim the chapter before it is covered** in lecture; this will help to familiarize you with some of the terms associated with each topic. Skim to become familiar with some of the vocabulary terms.

2. **Get the most out of lecture** (e. g., take good notes, don't skip classes, ask questions). If you are unclear about something we talked about in class, come to office hours or watch the YouTube micro lecture video(s) on the subtopics in question. As long as class attendance does not dip below 90%, I will post these videos at the end of each week.

3. **Read each subsection of the chapter** in the textbook after it is covered in class. Try the in-chapter solved exercises. Try your best to do this the SAME DAY that we cover the subsection in class—it will really help!!!

4. **Do the recommended end-of-chapter problems**; they are designed to help you to increase the depth of your understanding of specific concepts and to give you practice in problem solving. Try not to look at the solutions manual answer to a problem until you have worked on it for a bit. You won't have a solutions manual to look at during exams!!!

5. **If you need extra help** with a topic or a problem, be sure to seek out that help ASAP. Do NOT wait until the "night before the exam" to study chemistry; it does not work. Come to **office hours** to get concepts clarified.

6. **Exams are also a learning exercise**: detailed exam keys will be available about a week after each major exam is graded and returned. Be sure to consult these keys to get additional feedback. Please see the instructor in office hours if you have questions about how to improve your performance on graded exercises.

Academic Integrity

The Academic Integrity pledge is an expression of the University's commitment to fostering an understanding of—and commitment to—a culture of integrity at Santa Clara University. The Academic Integrity pledge, which applies to all students, states:

> I am committed to being a person of integrity. I pledge, as a member of the Santa Clara University community, to abide by and uphold the standards of academic integrity contained in the Student Conduct Code.

Academic integrity is part of your intellectual, ethical, and professional development. I expect you to uphold the principles of this pledge for all work in this class. I will clarify expectations on academic integrity as needed for assignments and exams. If you have questions about what is appropriate on any assignment, please let me know **before** you start a graded exercise hand. For more resources about ensuring academic integrity in your work, including the appropriate use of course sharing sites such as Chegg, see this site created by the SCU Library at https://libguides.scu.edu/academic-integrity or visit www.scu.edu/academic-integrity.

Please note that a breach of academic integrity includes looking at another student's test during an exam, allowing another student to copy your work, working with other individuals or groups (including Chegg!) on exercises that are listed as individual exercises, use of unauthorized materials (e.g., lecture notes, crib sheets, textbooks, inappropriate electronic devices) during an exam, copying lab reports from other students and recording/submitting laboratory data that you did not actually observe ("dry labing"). **CHEATING IN ANY FORM WILL NOT BE TOLERATED AND MAY RESULT IN FAILURE OF THE ENTIRE COURSE.**

Discrimination, Harassment and Sexual Misconduct (Title IX)

SCU faculty are committed to helping create a safe and open learning environment for all students. If you (or someone you know) have experienced any form of discrimination, harassment or sexual misconduct, including sexual assault, dating or domestic violence, or stalking, know that help and support are available, I encourage you seek support and report incidents to the Director of Equal Opportunity and Title IX Coordinator, Belinda Guthrie, at 408-554-3043, bguthrie@scu.edu. For more information about reporting options and resources at Santa Clara University and in the community, please visit https://www.scu.edu/title-ix/. If you wish to speak with a confidential resource, please visit https://www.scu.edu/title-ix/resources/student/.

Office of Accessible Education

If you have a documented disability for which accommodations may be required in this class, please contact the Office of Accessible Education (oae@scu.edu, http://www.scu.edu/oae) as soon as possible to discuss

your needs and register for accommodations with the University. If you have already arranged accommodations through OAE, please be sure to request your accommodations through your myOAE portal and discuss them with me during my office hours within the first two weeks of class.

To ensure fairness and consistency, individual faculty members are required to receive verification from the Office of Accessible Education before providing accommodations. OAE will work with students and faculty to arrange proctored exams for students whose accommodations include double time for exams and/or assistive technology. Students with approved accommodations of time-and-a-half should talk with me as soon as possible. The Office of Accessible Education must be contacted in advance (at least two weeks notice recommended) to schedule proctored examinations or to arrange other accommodations.

In light of shifting health advisories related to COVID-19, exams may be administered online. Students with approved testing accommodations should contact me (at least two weeks notice recommended) prior to an exam date to notify me of their intent to use their testing accommodations on the upcoming exam to ensure their accommodations are effectively implemented.

Safety Measures

In order to meet our learning objectives, we will adhere to the highest standards for safety and mutual respect. I expect everyone to adhere to current university mask mandates at all times; to make their best attempt to make themselves heard when asking questions or contributing to discussions; and refrain from eating or drinking in class. It is expected that everyone will follow university guidelines about health and public safety measures; these are updated frequently via email from the COVID-19 Operations Team.

In-Class Recordings: The Student Conduct Code prohibits students from "making a video recording, audio recording, or streaming audio/video of private, non-public conversations and/or meetings, inclusive of the classroom setting, without the knowledge and consent of all recorded parties," except in cases of approved disability accommodations. The Student Conduct Code also prohibits the "falsification or misuse, including non-authentic, altered, or fraudulent misuse, of University records, permits, documents, communication equipment, or identification cards and government-issued documents." Dissemination or sharing of any classroom recording without the permission of the instructor would be considered "misuse" and, therefore, prohibited. Violations of these policies may result in disciplinary action by the University. At the instructor's discretion, violations may also have an adverse effect on the student's grade. ***Please ask permission before taking any photographs in class—even of materials posted on the board.***

Copyright Statement

Materials in this course are protected by United States copyright laws. I am the copyright holder of the materials I create, including notes, handouts, slides, and videos. You may make copies of course materials for your own use and you may share the materials with other students enrolled in this course. You may not publicly distribute the course materials without my written permission.

Technology Support

SCU can provide you with technology assistance, and you can also reach out to our providers directly for questions. For Camino (SCU's branded instance of Canvas) support, contact caminosupport@scu.edu or call 408-551-3572. You can also use the help button within the Camino platform (on the left hand navigation) for 24/7 support via chat or phone with our vendor.

For Zoom assistance, contact Media Services at mediaservices@scu.edu or 408-554-4520. You can also get support from the Zoom Help Center website.

For SCU network and computing support, contact the SCU Technology Help Desk at techdesk@scu.edu or 408-554-5700. They can provide support for MySCU Portal, Duo, eCampus, hardware and software issues, and more.

Land Acknowledgment

Santa Clara University occupies the unceded ancestral homeland of the Ohlone and Muwekma Ohlone people.

Respect for Diversity

It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, religion, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.

Accommodations for Pregnant and Parenting Students

Santa Clara University does not discriminate against any student on the basis of pregnancy or related medical conditions. Absences due to medical conditions relating to pregnancy and childbirth will be excused for as long as deemed medically necessary by a student's doctor, and students will be given the opportunity to make up missed work. Students needing accommodations can often arrange accommodations by working directly with their instructors, supervisors, or departments. Students needing accommodations can also seek assistance with accommodations from the Office of Office of Accessible Education (OAE) or from the Office of Equal Opportunity and Title IX Office. The following link provides information for students and faculty regarding pregnancy rights. https://www.scu.edu/title-ix/resources/pregnancy/pregnancy.

Gender Inclusive Language

This course affirms people of all gender expressions and gender identities. If you go by a name different from what is on the class roster, please let me know. Using correct gender pronouns is important to me, so I encourage you to share your pronouns with me and correct me if I make a mistake. If you have any questions or concerns, please do not hesitate to contact me. For more on personal pronouns see www.mypronouns.org

Wellness Statement and Mental Health Resources : Jesuit education is grounded in concern for the whole person—mind, body, and spirit— and SCU has many resources and programs to support you. Resources that assist with mental wellness and mindfulness can be found through the Cowell Center and Campus Ministry, to name but a few.

University students may experience stressors or setbacks from time to time that can impact both their academic experience and their personal well-being. These may include academic pressure or challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc.

If you are experiencing difficulties, seeking help is a courageous thing to do for yourself and those who care about you. If you are concerned with your progress in this class, please contact me so that we can find solutions together. Drahmann Center can also offer support with issues regarding your academic progress more broadly. For personal concerns, SCU offers many resources, some of which are listed on the Cowell Center website.

General Learning Objectives for Chemistry 12: The primary objective of the general chemistry sequence is to give you a solid foundation in both theoretical and descriptive chemistry. Special emphasis will be placed on development of problem-solving skills as well as on the application of basic chemical concepts. We will accomplish this goal using a variety of activities. These will include lectures, laboratory experiments, problem solving, examinations, and A LOT of individual effort outside of the classroom. It is IMPERATIVE that you do as many of the end-of-chapter problems as possible.

The laboratory portion of the course will provide you with the opportunity to develop skills necessary for scientific discovery (e.g., critical thinking and observation skills, ability to handle chemical reagents and instruments safely). The laboratory experiments this quarter will include those designed to introduce you to topics not covered in lecture (enrichment) as well as those designed to reinforce or introduce some of the topics discussed in lecture.

Basic Learning Objectives:
The following is a list of specific learning goals and objectives for the course. A small number of additional "special topics", chosen at the discretion of the instructor, may be added during the term. These will be announced in class.

1. Goal: Acquire an understanding of the behavior of gases
Objectives:
a. Be able to compare distinguishing characteristics of gases with those of liquids and solids
b. Be able to describe gas pressure, how it is measured and the units used to express it.
c. Be able to relate utilize the ideal gas equation and express the state of a gas in terms of its volume, pressure, temperature and molar quantity.
d. Understand the kinetic-molecular theory of gases and how the average kinetic energy of a gas relates to its absolute temperature
e. Understand how real gases deviate from ideal behavior.

2. Goal: Understand how intermolecular forces influence the behavior of molecules
Objectives:
a. Describe how intermolecular forces between neutral molecules depend on their molecular polarity, size, and shape.
b. Describe the major classes of intermolecular forces that exist between neutral molecules.
c. Understand how many of the properties of solids and liquids (such as boiling point, melting point, surface tension, viscosity) are influenced by the intermolecular forces present in the substances
d. Be able to diagram the various enthalpy changes that accompany the heating or cooling of a substance including enthalpy changes that accompany phase changes.
e. Understand the concept of a dynamic equilibrium, specifically as it relates to the concept of vapor pressure.
f. Be able to characterize solids according to the type of attractive forces between the units in the solid

3. Goal: Develop an understanding of the physical properties of solutions, comparing them with the properties of their components.
Objectives:
a. Describe what happens to a substance, at the molecular level, when it dissolves in a solvent to form a solution.
b. Understand the concept of solubility and the enthalpy changes that accompany the formation of a solution.
c. Appreciate the role of intermolecular forces on the solution process ("like dissolves like").
d. Be able to describe the concentration of a solute in a solution in terms of mass percentage, molarity, mole fraction, and molality.

e. Understand the concept of a colligative property and be able to quantify the extent to which a nonvolatile solute alters vapor pressure, boiling point, freezing point and osmotic pressure of a solution.
f. Understand the difference between a heterogeneous mixture, a colloidal dispersion, and true solution.

4. Goal: Acquire a familiarity with the branch of chemistry concerned with the rate at which a reaction proceeds (chemical kinetics)
Objectives:
a. Describe the four experimental variables that affect reaction rates and understand, within the framework of kinetic-molecular theory, how these factors (concentration, physical state of reactants, temperature and presence or absence of a catalyst) influence reactions rates.
b. Be able to use initial rate data to write a rate law for a given reaction.
c. Be able to manipulate rate laws, as well as the integrated form of the rate law for a first and a second order reaction, to quantify the relationship between reactant or product concentration and time.
d. Be familiar with the concept of a half-life.
e. Be able to utilize basic concepts from the kinetic molecular theory to account for temperature effects on reaction rates (at the molecular level); understand the concepts of activation energy and frequency factor as they relate to the Arrehenius equation.
f. Be familiar with the terms elementary steps, rate determining step, molecularity, and reaction mechanisms.
g. Be able to describe the characteristics of homogeneous and heterogeneous catalysts and explain how they are able to enhance reaction rates.

5. Goal: Understand the concept of a dynamic equilibrium and the factors that determine the relative concentrations of reactants and products present at equilibrium
Objectives:
a. Be able to define the concept of a dynamic equilibrium and to write an equilibrium constant expression for homogeneous and heterogeneous equilibria.
b. Be able to calculate the value of an equilibirum constant from equilibrium concentrations of reactants and products.
c. Be able to use equilibrium constants to predict the equilibrium concentration of reactants and products and to determine the direction in which a reaction must proceed in order to achieve equilibrium.
d. Be able to apply the basic concepts of Le Châtelier's principle to predict how a system at equilibrium will respond to changes in concentration, pressure, volume or temperature.

6. Goal: Examine the behavior of acids and bases in terms of their structure, bonding, and the chemical equilibria in which they participate
Objectives:
a. Be able to define an acid or a base using both the Arrhenius and the Brønsted-Lowry definitions for these substances.
b. Understand the concept of a conjugate acid-base pair.
c. Understand the process of autoionization for water and be able to explain how the equilibrium constant for this process (Kw) defines the relationship between hydronium ion and hydroxide ion in aqueous solution.
d. Be able to use the pH scale to describe the relative acidity or basicity of a solution.
e. Know the names and chemical formulas for the common strong acids and strong bases; understand the difference between a strong acid and a weak acid.
f. Be able to use the acid dissociation constant, Ka, to quantify the extent to which a weak acid will ionize in water and be able to use this information to predict the pH of an aqueous solution of the weak acid.
g. Be able to use the base protonation constant, Kb, to quantify the extent to which a weak base will become protonated in water and be able to use this information to predict the pH of an aqueous solution of a weak base.

h. Understand the mathematical relationship that exists between the Ka and Kb for a conjugate acid/base pair and understand how this may be used to predict the pH of an aqueous solution of a salt.
i. Have an appreciation for how the strength of an acid is influenced by important structural features (such as the size and/or electronegativity of key atoms, the tendency of products to exist as resonance forms, etc.)
j. Be familiar with the Lewis definitions of acids and bases.

7. Goal (tentative, depending on time available): Acquire an understanding of the common-ion effect as it relates to acid-base equilibria in aqueous systems
Objectives:
a. Be able to define the phrase "common-ion effect" and be able to apply Le Chatelier's principle to predict how the presence of a common ion will influence the equilibrium concentrations of a given system.
b. Understand the concept of a buffered solution or a buffer and understand how they are able to resist a change in pH upon addition of small amounts of strong acid or strong base.
c. Be able to use the Henderson-Hasselbalch equation to estimate the pH of a solution or the conjugate base/acid ratio of a buffered solution.
d. Be able to apply Le Chatelier's principle to systems involving solubility of "insoluble" salts or complex ion formation.
e. Be able to predict how the solubility of an "insoluble" salt may be influenced by the addition of a a common ion, an acid, or a base.
f. Be able to predict how the formation of a complex ion may be used to alter the solubility of an "insoluble" salt.
g. Be able to sketch a titration curve for a strong acid titrated with a strong base (or vice versa) or a weak acid titrated with a strong base, or a weak base titrated with a strong acid. Be able to predict the relative pH (above, below or equal to pH 7) at the equivalence point of the titration.
h. Be able to calculate the pH at any point along the titration curve of a monoprotic acid titrated with a strong base.

8. Goal: Acquire an understanding of basic concepts in electrochemistry
a. Be able to recognize an oxidation reduction reaction and balance the chemical equation by the half-reaction method.
b. Be able to describe the functions of the various components of simple voltaic cells.
c. Be able to diagram electrochemical cells, labeling the anode, cathode, and directions of ion and electron movement.
d. Given appropriate reduction potentials, be able to calculate the standard cell potential generated by a voltaic cell and use this to predict if a given reaction will be spontaneous under standard conditions.
e. Understand the relationship between standard cell potential, standard free energy change and the equilibrium constant for redox reactions.
f. Be able to use the Nernst equation to calculate the cell potential or the concentration of a substance under nonstandard conditions.

Natural Science Core Learning Goals and Objectives:
Goal: Scientific Inquiry, Complexity, Critical Thinking, Mathematical and Quantitative Reasoning
Objectives:
a. Demonstrate an understanding of the theory and concepts central to the study of a particular area or topic treated by the natural sciences.
b. Understand how to formulate a testable hypothesis and design an informative experiment to explain phenomena observed in the natural world.
c. Be able to interpret data from scientific experimentation both qualitatively and quantitatively, in order to derive conclusions appropriate to the scope and quality of data.

d. Be able to recognize limitations of experimental and observational methods and understand concepts of probability, causation, and correlation.