Santa Clara University
Department of Chemistry and Biochemistry
General Chemistry II

Lecture Syllabus
Chemistry 12

Summer 2020

Instructor: Dr. Linda S. Brunauer (Office: DS 102 Office Phone 554-6947)
Mail Box: Chemistry Department Office: DS 113
Messages: 554-4799 (Department Administrative Assistant, Ms. Lourdes Barretto)
Office hours: TBA Email: Lbrunauer@scu.edu

Prerequisites: High performance in Chemistry 11 and consent of instructor. 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: Chemistry 12 is the second quarter of a two-quarter sequence in general chemistry. Topics covered this quarter will include: properties of solids, liquids and gases; intermolecular forces; properties of solutions; chemical kinetics; general aspects of equilibria; properties of acids and bases; aqueous equilibria; electrochemistry and a few selected special topics. 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!

Learning Objectives: 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.

Disability Accommodation Policy:
To request academic accommodations for a disability, students must contact the Office of Accessible Education (OAE) located in Benson Memorial Center, Room 216, (408) 554-4109; TTY (408) 554-5445. Students must provide documentation of a disability to OAE prior to receiving accommodations. You MUST complete all documentation with OAE prior to requesting an accommodation for any exam; please make sure to make any exam accommodation requests to me at least 5 business days prior to the exam.

Textbooks and Supplies:
by Nivaldo Tro (Prentice Hall: New Jersey, 2018)
NOTE: The text sold at the bookstore should be bundled with a copy of the student solutions manual featuring solutions to the “odd” end of chapter problems as well as an access code for Mastering Chemistry. I plan on scheduling a number of optional pre-lecture videos from Mastering Chemistry so please make sure that you have access to that program.

(2) A bound notebook is required for laboratory. A simple quadrille-lined composition book is fine.

(3) Chemical splash goggles, a lab coat and appropriate laboratory attire are REQUIRED.
Electronic Devices (allowed and prohibited):

1. A simple electronic calculator is essential for this course. Please make sure that you bring one to all examinations as well as to all lab meetings. You will need a calculator for in-lecture problem solving sessions but you will also need it for doing calculations in lab. While it might be tempting to use a calculator function on your cell phone for lab calculations, this is unwise as it makes it much more likely that you will contaminate your phone! Please invest in a simple, inexpensive calculator like a Ti-30!

2. The use of any electronic communication devices (cameras, cell phones or any smart device) during any in-class graded exercise is prohibited and may result in the loss of all credit for the graded exercise in question or, in extreme cases, failure in the course. All such devices must be turned off and stored in your backpack during any graded exercise.

3. I kindly ask that you refrain from using any electronic communication devices during lecture. “Texting” a friend or playing computer games during lecture may seem innocent but it can distract fellow students from the lecture and thus have a negative impact on the learning environment. Video recording or audiotaping in lecture is prohibited without advance permission from the instructor.

Academic Dishonesty: Academic dishonesty includes looking at another student's test during an exam, allowing another student to copy your work, use of unauthorized materials (e.g., lecture notes, crib sheets, textbooks, prohibited electronic devices) during an exam, copying lab reports from other students, recording laboratory data that was not actually observed ("dry lab"), and plagiarizing the works of others. CHEATING IN ANY FORM WILL NOT BE TOLERATED AND MAY RESULT IN FAILURE OF THE ENTIRE COURSE.

Laboratory Procedures:
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. As required by the Department of Chemistry and Biochemistry, laboratory attendance is mandatory. 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:

<table>
<thead>
<tr>
<th>Lab “grade”</th>
<th>How this influences your overall course grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pass</td>
<td>A bonus equal to 2% will be added to your lecture point total (20 points)</td>
</tr>
<tr>
<td>Pass</td>
<td>A bonus equal to 1% will be added to your lecture point total (10 points)</td>
</tr>
<tr>
<td>Low Pass</td>
<td>No change in lecture point total</td>
</tr>
<tr>
<td>Fail</td>
<td>Failure in the entire course</td>
</tr>
<tr>
<td>One unapproved absence</td>
<td>A deduction will be made from your lecture point total (10 points)</td>
</tr>
<tr>
<td>2+ unapproved absences</td>
<td>Failure in the entire course</td>
</tr>
</tbody>
</table>
Lecture Procedures:

Handouts:
There will be one or more PDF handouts used for each textbook chapter we cover this term. These will be available on Camino in the handout module; be sure to check for the new handouts after 7 pm the day prior to each class. It is your responsibility to come to class with a hard copy of the handout or with the file downloaded onto a tablet or computer to use in class. Each handout may feature figures, diagrams, and sample problems as well as some basic definitions and concepts, organized with a “fill-in-the-blank” style. Following completion of the handout in class the “Filled in” version of the handout will also be posted on Camino provided that attendance in the class does not drop below 90%.

There will be no graded homework turned in this quarter. After one quarter of college chemistry you should be very aware of how important it is to regularly test your knowledge of the course concepts by doing homework problems. You are STRONGLY, VIGOROUSLY, AND ENTHUSIastically ENCOURAGED to do as many of the suggested end-of-chapter problems as time permits; lists of recommended end-of-chapter problems for each chapter may be found at the end of the syllabus. Text problems, in slightly altered form, may appear on exams. Sets of sample midterm problems will be posted on Camino in advance of each exam.

Evaluation:
There will be 3 short quizzes, 2 midterms and a final exam; the schedule for examinations is given below. Please note that graded exercises will be given only during the scheduled exam period. It is your responsibility to make sure that you are present and ON TIME for each exam.

Tentative Exam Schedule:
Quizzes (3) Wednesday July 8th, Wednesday July 15th, Wednesday July 22nd
Midterms (2) Friday July 10th and Friday July 17th
Final exam: Final Exam, Friday July 24th

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

<table>
<thead>
<tr>
<th>Exercise</th>
<th>points per</th>
<th>total points</th>
<th>% of grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes</td>
<td>25 each</td>
<td>75</td>
<td>7.5</td>
</tr>
<tr>
<td>Midterms</td>
<td>300 each</td>
<td>600</td>
<td>60</td>
</tr>
<tr>
<td>Final</td>
<td>325</td>
<td>325</td>
<td>32.5</td>
</tr>
</tbody>
</table>

*total points possible: 1000 points

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.

Suggested Problems and Exercises

Chapter 10: 25(a, b), 31, 33, 35, 37, 39, 41, 45, 49, 51, 57, 59, 61, 6769, 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, 5557, 61, 65, 67, 69, 73, 75, 77, 81, 83, 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 17: 25, 27, 29, 31, 35, 37a, 39, 41, 43, 83, 85, 87, 89, 97, 99, 109

Chapter 19: TBA
Tentative Lecture Schedule: Listed below for each chapter are the major topics we will cover for each chapter as well as the approximate number 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:

Ch. 10  **Gases:** Gas laws; Dalton's law; volumes of gases in chemical reactions; kinetic molecular theory; deviations from ideality (approx. 2 hrs); Sec 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.10, we will NOT be covering sections 10.8 or 10.9 this term and coverage of the van der Waals equation (10.11) will be minimal.

Ch. 11/12  **Liquids, solids and Intermolecular forces:** changes of state; vapor pressure; (approx. 3 hrs); Sec (11.1), 11.2, 11.3, (11.4), 11.5 (skipping Clausius-Clapeyron plots), 11.6, 11.7, 12.4

Ch. 13  **Solutions:** Concentration conventions for solutions, solution thermodynamics, ideal and non-ideal solutions, colligative properties, electrolyte solutions (approx. 4 hrs); Sec 13.1, 13.2, 13.3, 13.4, 13.5, 13.6,

*Ch. 14  **Kinetics:** rate laws, half-lives, mechanisms, Arrhenius theory, catalysis (approx. 4 hrs); Sec 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7, 14.8,

Ch. 20  **Selected topics in Radioactivity:** (approx. 1 hour); tentative; Sec 20.5, 20.6

Ch. 15  **Chemical equilibrium:** Kc, Le Châtelier's principle; common-ion effect (approx. 3 hrs); Sec 15.1, 15.2 (we will not cover Kp); 15.1, 15.2, 15.3, 15.5, 15.6, 15.7, 15.8, 15.9,. We will skip section 15.4 (no coverage on “Kp”)

*Ch. 16  **Acids and bases:** 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); 16.2, 16.3, 16.4, 16.5, 16.6. 16.7, 16.8, 16.9, 16.10, 16.11

*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). Note that a portion of this material (titrations/indicators) will be covered in the laboratory portion of the course.

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)

**Basic Learning Goals for the Lecture:**
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 reaction 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 Arrhenius 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 equilibrium 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.