

**Chemistry 1B: General Chemistry****Fall 2019**

Dr. Brophy



**CHEM 1B01 CRN 21582** Lecture: MWF 9:30 am – 10:20 am in SC1102  
Lab: MW 11:30 am – 2:20 pm in SC2204

**CHEM 1B02 CRN 21583** Lecture: MWF 9:30 am – 10:20 am in SC1102  
Lab: MW 2:30 pm – 5:20 pm in SC2204

**Instructor:** Dr. Megan Brunjes Brophy  
**E-mail:** [brophymegan@fhda.edu](mailto:brophymegan@fhda.edu)

**Office:** SC1220 (dial 8338 from door phone)  
**Phone Number:** 408-864-8338

Please note that **e-mail and Canvas** are the most reliable ways to get in touch with me outside of class and office hours.

**Course Webpage:** Canvas.

*Turn on Canvas notifications to receive class announcements.*

**Office Hours:**

Tu 12:30 am – 2:10 pm in S43  
Th 12:30 am – 2:10 pm in S43

*And by appointment*

**Zoom:** <https://cccconfer.zoom.us/my/drbrophy>

*Please e-mail to schedule a meeting in-person or over Zoom.*

**Important Dates**

<b>Add Day</b>	October 5, 2019	Last day to <i>add</i> .
<b>Drop Day</b>	October 6, 2019	Last day to <i>drop</i> the course without a withdraw being recorded.
<b>Withdraw</b>	November 15, 2019	Last day to <i>withdraw</i> from the course.

**Exam Dates**

*There will be three midterm exams and one cumulative final exam. The date of the final exam is determined by the college and cannot be moved.*

October 11, 2019	Midterm Exam 1
November 1, 2019	Midterm Exam 2
November 22, 2019	Midterm Exam 3
December 9, 2019	Final Exam

**Mandatory Lab Days**

September 22, 2019	Safety lecture
September 24, 2019	Safety quiz
December 4, 2019	Lab checkout day. <i>If you drop or withdraw from the course, you must check out of your lab locker during the designated lab check-out day and time.</i>

**Required Materials: Lecture**

- **Computer and printer access** You will require internet access and a printer throughout this course. The Library West Computer Lab is located on the lower level of Learning Center West in LCW 102. Printing can be found around campus: <https://www.deanza.edu/students/printing.html>
- **Textbook** *Chemistry: The Molecular Nature of Matter and Change*, 8<sup>th</sup> edition by Silberberg and Amateis, available at the De Anza College Bookstore or from multiple online retailers. Chemistry 1A, 1B, and 1C all use the same textbook.  
*We will **not** use online homework in this class, and you will not require access to McGraw-Hill Connect. You may use any edition of the textbook in any format.*
- **Calculator** A scientific calculator with natural log functionality is necessary and sufficient for this class. If you have already purchased a graphing calculator for another class, you may use it on exams and quizzes; however, *we will not use the graphing functionality*. Recommended models:  
<https://www.amazon.com/Texas-Instruments-MultiView-Scientific-Calculator/dp/B000PDFQ6K>  
[https://www.amazon.com/dp/B005QXO8J0/ref=dp\\_cerb\\_3](https://www.amazon.com/dp/B005QXO8J0/ref=dp_cerb_3)
- **Index Cards** A pack of 100 3x5 index cards. *Bring these with you to every class.*
- Stapler and staples (*recommended*).

### Required Materials: Lab

- **Lab Manual** Lab procedures and assignments for Chemistry 1B will be posted on Canvas.
- **Lab Notebook** A dedicated bound composition notebook to use as a laboratory notebook. Notebooks with metal spiral binding are *not* permitted. *You do not require a lab notebook with carbon copies for this quarter.*
- **Personal Protective Equipment**
  - Approved laboratory safety goggles (not safety glasses), available from the De Anza College Bookstore. Safety goggles must be ANSI-rated. If you purchase safety goggles from another retailer you must present the packaging with verification of ANSI rating to your instructor.
  - Disposable latex or nitrile gloves.
  - A lab coat or lab apron (*optional*).

### Supplemental Texts

- *Calculations in Chemistry an Introduction*, 2<sup>nd</sup> edition by Dahm and Nelson. Available at many online retailers ([https://www.amazon.com/Calculations-Chemistry-Introduction-Donald-Dahm/dp/0393614360/ref=dp\\_ob\\_title\\_bk](https://www.amazon.com/Calculations-Chemistry-Introduction-Donald-Dahm/dp/0393614360/ref=dp_ob_title_bk))
- *OpenStax Chemistry*, 2<sup>nd</sup> edition. Available **free** online at <https://cnx.org/contents/f8zJz5tx@9.18:DY-noYmh@9/Introduction> or on the OpenStax app (iPhone/iPod).

### Campus Resources

- **Math, Sciences, and Technology Resource Center (MSTRC) Tutoring.** The MSTRC offers tutoring for the Chemistry 1 sequence and is located in room S43 in the S-squad. Furthermore, I will hold office hours in S43 this quarter.  
<https://www.deanza.edu/studentssuccess/mstrc/>
- **Disability Support Programs Services** The mission of DSPS is to ensure access to the college's curriculum, facilities, and programs. In particular, DSPS can help you get extended time on examinations.  
<https://www.deanza.edu/dsps/>
- **De Anza College Library** The library houses the Library West Computer Lab and group study rooms that may be reserved online.  
<https://www.deanza.edu/library/index.html>
- **Resources for Students** Additional resources may be found at <https://www.deanza.edu/services/>
- **Office Hours** Instructor office hours are the best time to ask questions related to course content in-person. This time is *for you, the student*.

***I expect you to use the resources available to you, share resources with your classmates, and ask for help when needed.***

## Syllabus Statement

This course syllabus is a contract. Please read it carefully and completely in its entirety before asking me any questions regarding the course schedule, content, requirements, grading, etc. You are expected to adhere to the De Anza College Student Code of Conduct Administrative Policy 5510 at all times. **All corrections and changes to this syllabus will be announced through Canvas.**

This class is divided into two separate instructional periods: a lecture period devoted to the primary course material and a lab period for conducting lab experiments. Everyone will have the same lecture period, but a different lab period depending on which section you are enrolled in. At De Anza College, the lab and lecture may not be taken as separate courses under any circumstances.

## Course Description

Chemistry 1B is the second quarter of a year-long introduction to the principles of general chemistry, and a direct continuation from Chemistry 1A. Chemistry 1B will constitute an investigation of intermolecular forces and their effects on chemical and physical properties, investigation of reversible reactions from the standpoints of kinetics, thermodynamics, and equilibrium, as well as investigation and application of gas laws and kinetic molecular theory.

## Prerequisites

Chemistry 1A with a grade of C or better. EWRT 211 and READ 211 (or LART 211), or ESL 272 and 273.

## Hours

Three hours lecture and six hours laboratory will be spent in class. **Expect to spend an additional 8-12 hours a week studying and working on class assignments.**

**Honors Sections** There are two honors sections of Chemistry 1B. Successful completion of the honors course will require participation in an additional lab project worth 10% of your final grade.

## Attendance Policy

Your punctual attendance is expected at all lecture and laboratory sections of the course. *Plan to arrive 5-10 minutes early.* If you will have to miss lecture or lab for any reason, let me know by e-mail or phone as soon as possible. Notifying your instructor of absences or tardiness shows that you take your responsibility towards your fellow students seriously.

The De Anza College Chemistry Department does not offer make-up labs under any circumstances. If you miss 3 or more lab periods you will automatically fail the course.

## Study Tips

1. Complete the assigned reading before coming to class. Review 1A topics that are unfamiliar. Write down any vocabulary words that you do not understand as well as their definitions.
2. Take *handwritten* notes during class and review your notes regularly. Write down any questions you have and bring them to office hours or e-mail your instructor.
3. **Do a little bit every day.** After every lecture, review the reading assignment and complete in-chapter and end-of-chapter exercises.
4. Join a study group. Work on problem sets together. The best way to learn the material is to teach it to somebody else.
5. If you feel that you are a poor test-taker, **complete and turn in all assignments on time** in order to pass the class.
6. Take care of yourself! Stay well-rested and drink water.

### Grading Breakdown and Grade Scale

To succeed in this course, you will need to exhibit consistent and sustained effort throughout the quarter. This will be demonstrated through in-class practice problems, laboratory preparation and data analysis, and examinations. Assignment types are assigned a weight; not all points are created equally!

Lecture	70% of total grade
Lecture assignments (collected)	10%
Midterm exams (three total)	45%
Final	15%
Lab	30% of total grade
Lab assignments	16%
Lab quizzes	12%
Clean-up	2%

Final %	Grade <sup>1,2</sup>
>100.0	A+
>90.0	A
88.0 – 89.9	A–
85.0 – 88.9	B+
80.0 – 84.9	B
78.0 – 79.9	B–
75.0 – 77.9	C+
68.0 – 74.9	C
63.0 – 67.9	D+
55.0 – 62.9	D
<55%	F

<sup>1</sup>If your average in either the lab *or* lecture portion of the course is less than 55%, you will receive an F as a final grade.

<sup>2</sup>A+ grades will be given to students who demonstrate excellence in the following three areas: lecture, lab *and* class participation.

#### Academic Integrity

Students are expected to adhere to the policy on academic integrity that is outlined in the De Anza College manual (<https://www.deanza.edu/studenthandbook/academic-integrity.html>). ***I expect all submitted work to represent your own understanding of the material and to be written in your own words.*** Cheating, copying, plagiarizing, etc. will not be tolerated, and the minimum consequence will be receiving a zero on that assignment and the incident will be reported to the Dean of Student Services. All laboratory data used in calculations and reported in lab reports must be collected by each student. Multiple instances of academic dishonesty may result in failing the course.

**Lecture (70%)**

Your attendance and active participation is expected at every lecture period. **Due to the high number of students wishing to enroll in the course, any unjustified absences during the first two weeks of class will result in you being dropped from the course.** Absences may be excused in case of a verified emergency (e.g. doctor's note or police report). If you know that you will not be able to attend lecture for any reason, let me know by email right away (even if only 5 minutes before class). Late arrivals and early departures are distracting for the whole class (and me!), so arrive on time and stay for the whole class period. I strongly encourage taking your own notes in lecture. Computers are not necessary during lecture. Do not use your computers for non-course related activities during lecture. Put your phone on silent or Do Not Disturb while you are in class. If you must take a phone call in case of emergency, quietly leave the room before answering the phone.

**Recommended practice problems (0%)**

Consistent practice is an essential component of learning, and homework questions will often be similar to exam questions. Recommended practice problems from the textbook will be posted for each chapter; however, homework will not be graded. In general, the answers to these questions may be found in the back of the textbook and solutions are readily available online. It is your responsibility to keep up with suggested practice problems every day. **Collaboration with classmates is expected and encouraged.**

**Collected lecture assignments (10%)**

Lecture assignments will be collected and graded for completion. Bring loose leaf paper and a writing utensil to class with you.

**Exams (45%)**

There will be three midterm exams, each worth 15% of your final grade. Early and late exams will not be administered, and **missing an exam will result in a zero without documented proof of a medical or legal emergency** (e.g. hospitalization or car crash). If you require any accommodations for exams, you must be approved by DSPS.

Exams will consist of short answer questions with the opportunity for partial credit. You must show your work in order to receive credit for any answer. I am more interested in how you think about a problem than your final answer. You will be asked to demonstrate your conceptual understanding of the material and apply those concepts in an algebraic context and solve quantitative problems.

**Final (15%)**

The final exam will be cumulative. The final exam will be administered on **Monday, December 9<sup>th</sup> from 9:15 am – 11:15 am**. This date and time are determined by De Anza College and cannot be moved under any circumstances. If you cannot take the final at this time, you should not enroll in the class. The final will not be administered at an alternative time under any circumstances.

**Lecture Schedule and Assigned Readings**

Chemistry 1B will cover material presented in chapters 5, 12, 16, 17, 18 and 20 of Silberberg. We will also review Chemistry 1A topics presented in chapters 10 and 6 throughout the quarter.

Detailed reading related to each lecture will be announced in class. In the schedule below, chapter reading is given for the required Silberberg text as well as the OpenStax free textbook.

Every effort will be made to keep to the lecture schedule below. If we fall significantly behind this schedule, the content of the exams will be adjusted to reflect the material that we covered in class. Exam dates will not be modified except in cases of *force majeure*.

Week	Date	Day	Lecture Topic Readings
1	9/23	M	Chemistry 1A Essentials <i>Silberberg Chapters 1 – 4, 6 – 11</i> <i>Labs A1 and A11</i> <i>OpenStax Chapters 1–8</i>
	9/25	W	Introduction to Kinetic Molecular Theory and Properties of Gases Gas Laws: Boyle's Law, Charles' Law, Avogadro's Law and the Ideal Gas Law <i>Silberberg Chapter 5</i> <i>OpenStax Chapter 9</i>
	9/27	F	Gas Law Applications: How do airbags work? <i>Silberberg Chapter 5</i> <i>OpenStax Chapter 9</i>
2	9/30	M	Kinetic Properties of Gases and the Refinement of Uranium <i>Silberberg Chapter 5</i> <i>OpenStax Chapter 9</i>
	10/2	W	Intermolecular Forces and Properties of Water <i>Silberberg Chapter 12</i> <i>OpenStax Chapter 10</i>
	10/4	F	Intermolecular Forces and Properties of Water <i>Silberberg Chapter 12</i> <i>OpenStax Chapter 10</i>
3	10/7	M	Phase Changes and Review of Enthalpy <i>Silberberg Chapter 12</i> <i>OpenStax Chapter 10</i>
	10/9	W	Phase Changes and Review of Enthalpy, continued <i>Silberberg Chapter 12</i> <i>OpenStax Chapter 10</i>
	10/11	F	<b><i>Exam 1: Gases, Intermolecular Forces, and Phases of Matter</i></b>
4	10/14	M	Chemical Kinetics, Reaction Rates, Reaction Mechanisms and Transition States <i>Silberberg 16.1-16.2, 16.6, 16.7</i> <i>OpenStax Chapter 12</i>
	10/16	W	Chemical Kinetics, Reaction Rates, Reaction Mechanisms and Transition States <i>Silberberg Chapter 16</i> <i>OpenStax Chapter 12</i>
	10/18	F	Chemical Kinetics, Reaction Rates, Reaction Mechanisms and Transition States <i>Silberberg Chapter 16</i> <i>OpenStax Chapter 12</i>
5	10/21	M	The Rate Laws and Integrated Rate Laws <i>Silberberg Chapter 16</i> <i>OpenStax Chapter 12</i>
	10/23	W	The Rate Laws and Integrated Rate Laws <i>Silberberg Chapter 16</i> <i>OpenStax Chapter 12</i>
	10/25	F	Kinetics, Continued <i>Silberberg Chapter 16</i> <i>OpenStax Chapter 12</i>
6	10/28	M	Equilibrium

			<i>Silberberg Chapter 17</i> <i>OpenStax Chapter 13</i>
	10/30	W	Equilibrium <i>Silberberg Chapter 17</i> <i>OpenStax Chapter 13</i>
	11/1	F	<b>Exam 2: Kinetics and Qualitative Chemical Equilibrium</b>
7	11/4	M	Equilibrium: ICE Box Method <i>Silberberg Chapter 17</i> <i>OpenStax Chapter 13</i>
	11/6	W	Equilibrium: ICE Box Method <i>Silberberg Chapter 17</i> <i>OpenStax Chapter 13</i>
	11/8	F	Equilibrium: Le Chatlier's Principle <i>Silberberg Chapter 17</i> <i>OpenStax Chapter 13</i>
8	11/11	M	<b>Veteran's Day NO CLASS</b>
	11/13	W	Proton Transfer and Polyprotic Acids <i>Silberberg Chapter 18</i> <i>OpenStax Chapter 14</i>
	11/15	F	Weak Acids and Bases <i>Silberberg Chapter 18</i> <i>OpenStax Chapter 14</i>
9	11/18	M	Acid-base Properties of Salts <i>Silberberg Chapter 18</i> <i>OpenStax Chapter 14</i>
	11/20	W	Acid-base chemistry <i>Silberberg Chapter 18</i> <i>OpenStax Chapter 14</i>
	11/22	F	<b>Exam 3: Equilibrium Calculations and Acid-Base Chemistry</b>
10	11/25	M	Thermodynamics: Reaction Entropy <i>Silberberg Chapter 20</i> <i>OpenStax Chapter 16</i>
	11/27	W	Thermodynamics: Reaction Entropy <i>Silberberg Chapter 20</i> <i>OpenStax Chapter 16</i>
	11/29	F	<b>Thanksgiving Holiday NO CLASS</b>
11	12/2	M	Thermodynamics: Spontaneous Reactions <i>Silberberg Chapter 20</i> <i>OpenStax Chapter 16</i>  <b>7 days to the final! Start reviewing old material now!</b>
	12/4	W	Review
	12/6	F	Review
12	12/9	M	<b>Final Exam</b> <b>9:15 am – 11:15 am***</b>

**Lab (30%)**

Chemistry is an experimental science, and the laboratory is a major component of the course. De Anza College does not offer make-up labs, and ***you must attend the laboratory section that you are registered for*** to complete the required labs. Everyone gets one excused absence with no grade penalty. A second absence, regardless of the circumstances of your first absence, will result in a zero for the lab and all associated assignments. After a third lab absence, you will automatically receive an "F" in the course.

Your timely attendance is expected at every lab. The beginning of each lab period is reserved for lab lecture. The lab lecture is a required component of the laboratory section and will include essential safety information. ***If you miss lab lecture, you will not be permitted to complete that lab and you will receive a zero for all related assignments.***

You must clean up your work area before leaving each lab. Failure to do so will result in a loss of points for that lab. Before you leave lab, check-out with me. You will not receive credit for the lab unless I have signed your data.

**Lab Assignments (16%)**

Lab assignments will consist of pre-labs, completion of laboratory experiments and accurate data collection, and analysis of data.

Pre-lab assignments will vary by lab; however, they will generally include assigned reading, safety preparation, and an introduction to the lab experiment. I expect you to come to lab prepared to complete each experiment with minimal delays.

***Data collected during the lab period must be recorded directly in your laboratory notebook.*** You will not receive credit for any data written on a worksheet or separate piece of paper. Before you leave lab for the day, have me check off on your data in your lab notebook for the available points.

Data analysis worksheets will be posted on the course webpage. The precise nature of the assignment and the number of points available will vary. Due dates will be announced in class and on Canvas.

**Lab Quizzes (12%)**

There will be three lab quizzes in this course.

***Safety Quiz***

The first lab quiz will cover standard safety protocols. You must take and pass the lab safety quiz with at least 80% of the available points before you will be permitted to participate in any lab activities.

***Lab Quiz 1 and Lab Quiz 2***

The lab quizzes will be open lab-notebook, and you may refer to any information that is *handwritten* in your lab notebook. In addition to the required pre-lab assignments, procedures, and data, I encourage you to include lab lectures notes, vocabulary, and example calculations. Extra pages (either printed or handwritten) may not be inserted. The quizzes will cover safety material, background theory, experimental techniques, calculations, and analysis related to your laboratory experiments.

**Clean-up (2%)**

Each student is required to sign up for one lab period in which they will be responsible for after-lab clean-up. This involves staying to end of lab, making sure the common lab areas and balance area is clean, the waste bottles are closed, etc. In addition, each student is responsible for cleaning their own materials and work area.



## Laboratory Safety

All chemistry laboratories inherently come with associated risks and hazards. It is inevitable that some accidents will occur during your chemistry course work. When an accident occurs, **inform your instructor immediately** and **do not attempt to clean-up any broken glassware or spilled chemicals by yourself**. In order to ensure that the lab is as safe as possible, we must (1) **Recognize hazards**, (2) **Assess the risks of hazards**, (3) **Minimize the risks of hazards**, and (4) **Prepare for emergencies**.

From the American Chemical Society Safety In Academic Laboratories Guidelines, 7th Ed., the following mandatory minimum safety requirements must be followed by all students and be rigorously enforced by all chemistry faculty:

- 1) **Chemistry Department-approved safety goggles purchased from the De Anza College bookstore (NOT safety glasses) must be worn at all times once laboratory work begins, including when obtaining equipment from the stockroom or removing equipment from student drawers**, and may not be removed until all laboratory work has ended and all glassware has been returned to student drawers.
- 2) **Shoes that completely enclose the foot** are to be worn at all times; NO sandals, open-toed, or open-topped shoes, or slippers, even with socks on, are to be worn in the lab.
- 3) Shorts, cut-offs, skirts or pants exposing skin above the ankle, and sleeveless tops may not be worn in the lab: **ankle-length clothing must be worn at all times**.
- 4) Hair reaching the top of the shoulders must be tied back securely.
- 5) Loose clothing must be constrained.
- 6) Wearing "...jewelry such as rings, bracelets, and wristwatches in the laboratory..." should be discouraged to prevent "...chemical seepage in between the jewelry and skin...".
- 7) **Eating, drinking, or applying cosmetics in the laboratory is forbidden at ALL times, including during lab lecture.**
- 8) Use of electronic devices requiring headphones in the laboratory is prohibited at ALL times, including during lab lecture.
- 9) Students are advised to inform their instructor about any pre-existing medical conditions, such as pregnancy, epilepsy, or diabetes, that they have that might affect their performance.
- 10) Students are required to know the locations of the eyewash stations, emergency shower, and all exits.
- 11) Students may not be in the lab without an instructor being present.
- 12) Students not enrolled in the laboratory class may not be in the lab at any time after the first lab period of each quarter.
- 13) Except for soapy or clear rinse water from washing glassware, **NO CHEMICALS MAY BE Poured INTO THE SINKS**; all remaining chemicals from an experiment must be poured into the waste bottle provided.
- 14) Students are required to follow the De Anza College Code of Conduct at all times while in lab: "horseplay", yelling, offensive language, or any behavior that could startle or frighten another student is not allowed during lab.
- 15) Strongly recommended: Wear Nitrile gloves while performing lab work; wear a chemically resistant lab coat or lab apron; wear shoes made of leather or polymeric leather substitute.

***Reckless behavior will not be tolerated. If your actions endanger the health and safety of yourself or someone else you will be asked to leave and you will receive a zero for the day. In extreme cases, you may lose your lab privileges for the remainder of the quarter.***

**Lab Schedule**

The expected laboratory schedule for fall 2019 is given below. Pre-lab and post-lab assignments will be posted on Canvas and submitted at the beginning of the lab period.

Week	Monday	Wednesday
1	<p><b>Syllabus and Check In</b> <b>Lab Safety and SDSs</b></p> <p><i>mandatory lab day</i></p>	<p><b>Chemical Hygiene and Safety Quiz</b></p> <p>Setting up your lab notebook Pre-lab for Molar Volume of a Gas</p> <p><i>mandatory lab day</i></p>
2	<p><b>Molar volume of a gas</b></p> <p><i>Perform experiment and collect data</i></p>	<p><b>Vapor Pressure Day 1</b></p> <p>Lewis Dot Structure Review, Polarity, and IMF</p>
3	<p><b>Vapor Pressure Day 2</b></p> <p>Introduction to Excel and Data Analysis Green salt pre-lab</p>	<p><b>Green Salt Lab Day 1</b></p> <p>Synthesis of a green salt</p>
4	<p><b>Green Salt Lab Day 2</b></p> <p>Recrystallization and oxalate quantification</p>	<p><b>Green Salt Lab Day 3</b></p> <p>Iron quantification</p>
5	<p><b>Green Salt Lab Day 4</b></p> <p>Hydrate quantification and determination of the empirical formula</p>	<p><i>Lab Quiz</i></p> <p><b>Kinetics Lab Day 1</b></p> <p>Pre-lab Data collection</p>
6	<p><b>Kinetics Lab Day 2</b></p> <p>Data collection</p>	<p><b>Kinetics Lab Day 3</b></p> <p>Analysis: rate law and mechanism</p>
7	<p><b>Kinetics Lab Day 4</b></p>	<p><b>Equilibrium Lab Day 1</b></p>
8	<p><i>No class</i></p>	<p><b>Equilibrium Lab Day 2</b></p>
9	<p>B5 <i>one day lab</i> <math>K_a</math> / <math>K_b</math> Determination</p>	<p><b>Indicator Lab Day 1</b> Experiment</p>
10	<p><i>Lab Quiz</i></p> <p>Indicator lab analysis Thermodynamics of <math>\text{Ca}(\text{OH})_2</math> Solvation pre-lab</p>	<p><b>Thermodynamics of <math>\text{Ca}(\text{OH})_2</math> Solvation Day 1</b></p> <p><i>***Day before Thanksgiving Holiday***</i></p>
11	<p><b>Thermodynamics of <math>\text{Ca}(\text{OH})_2</math> Solvation Day 2</b></p>	<p><b>Check Out</b></p> <p><i>mandatory lab day</i></p>

**Student Learning Outcome(s):**

- \*Evaluate the principles of molecular kinetics.
- \*Apply principles of chemical equilibrium to chemical reactions.
- \*Apply the second and third laws of thermodynamics to chemical reactions.