General Chemistry II
The University of Toledo
College of Natural Sciences and Mathematics
Department of Chemistry and Biochemistry
CHEM1240 – Lecture and Recitations L1 (1) & Hon-(88); R2 – 12, -89, -90

Instructor: Dr. Cohen
Email: claire.cohen@utoledo.edu
Office Hours: M, W, Th, F: 2:15pm – 3:00pm, Tues. 1:00pm – 3:00pm and by appointment
Office Location: BO2096H
Office Phone: 419-530-4071

Term: Spring, 2018
Lecture Location: WO1201
Lecture Day/Time: MWF 8:30am – 9:25 am
Recitation Day/Time/Location:

<table>
<thead>
<tr>
<th>Section</th>
<th>Day</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Thursdays</td>
<td>8:00am – 8:55am</td>
<td>BO2047</td>
</tr>
<tr>
<td>4</td>
<td>Thursdays</td>
<td>9:10am – 10:05am</td>
<td>BO2047</td>
</tr>
<tr>
<td>6</td>
<td>Thursdays</td>
<td>10:20am – 11:15am</td>
<td>BO2047</td>
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<tr>
<td>7</td>
<td>Thursdays</td>
<td>11:30am – 12:25pm</td>
<td>BO2047</td>
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<td>9</td>
<td>Thursdays</td>
<td>12:40pm – 1:35pm</td>
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<tr>
<td>10</td>
<td>Thursdays</td>
<td>1:50pm – 2:45pm</td>
<td>BO2047</td>
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<tr>
<td>12</td>
<td>Thursdays</td>
<td>3:00pm – 3:55pm</td>
<td>BO2047</td>
</tr>
<tr>
<td>89</td>
<td>Thursdays</td>
<td>1:00pm – 1:55pm</td>
<td>FH2920</td>
</tr>
<tr>
<td>90</td>
<td>Thursdays</td>
<td>1:00pm – 1:55pm</td>
<td>FH2680</td>
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</tbody>
</table>

Credit Hours: 4

REQUIRED TEXTS AND ANCILLARY MATERIALS

Required Textbook: Chemistry, 7th Ed, 2015, McMurry /Fay/Robinson, Pearson

Required Online Homework Access Code: There is a Mastering Chemistry code sold at the bookstore with the book package or separately.

Required Clicker with access/license code: LCD clicker with 1 or 4 year access*

*Access/license codes may be purchased without a clicker if you already have one. You also have the option of buying the access code with no clicker, and using your phone or iPad in place of the clicker.

Optional Materials (all are part of the package sold by the UT Bookstore):
Solutions Manual for Chemistry, 7th Ed, 2016, Topich for McMurry/Fay/Robinson, Pearson. We strongly recommend that you have this book either by buying or sharing.

Study Guide for Chemistry, 7th Ed, 2016, Zubricky for McMurry/Fay/Robinson, Pearson. There will not be any assignments from this book, but you may find it helpful to your studying.

COURSE/CATALOG DESCRIPTION
An introduction to solutions, equilibrium, acid-base theory, energy relationships and structural concepts. This sequence is for students who major in science, engineering or other fields which require chemistry as a prerequisite subject. Three hours lecture and one hour discussion per week.
COURSE OVERVIEW
CHEM1240 is the second course in the General Chemistry sequence. CHEM 1290 is the appropriate lab course to go with CHEM 1240. This sequence is intended for majors in the natural sciences, science education, pharmacy, chemical engineering or bioengineering, and allied health fields.

TEACHING STRATEGIES
Lecture: Attendance is required, please arrive on time, clicker questions for points will be included in lecture. You are responsible for all material, experiments, and problems covered in class. You will be provided with partial lecture outlines of the course material via Blackboard.

Writing Assignments (WA)/ Clicker Points will be given in lecture or recitation or for out of class work.

Textbook We urge you to read the text before the lecture so you are familiar with concepts before hearing about them during the limited time of each class session.

Homework
One component of the homework for the class is provided with the online system called Mastering Chemistry. There will be weekly assignments with deadlines. You will be provided with handouts on this.

The other component of the homework is of the more traditional type. Within each chapter there are several Worked Examples to show you how to solve problems & answer questions. After each there are Practice and Apply questions/problems which you can use to test your knowledge. In addition, a number of End-of-Chapter (EOC) questions are listed below. These should give you an idea of what you are expected to learn in this course and be able to answer on exams. Full solutions of all in chapter and some EOC questions are in the Solutions Manual which is part of the package sold at the bookstore.

Recitation Homework Problems from the End of Chapter Problems in the Textbook:

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Assigned End of Chapter Questions from the Textbook</th>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>25, 26, 31, 32, 37, 40, 41, 43, 49, 51, 61, 82, 85, 97</td>
</tr>
<tr>
<td>12</td>
<td>31, 51, 57, 59, 61, 73, 75, 77, 81, 91, 95, 97, 103, 109, 124</td>
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<tr>
<td>13</td>
<td>39, 43, 45, 57, 63, 67, 69, 71, 73, 81, 86, 95, 97, 107, 111</td>
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<tr>
<td>14</td>
<td>39, 43, 45, 55, 65, 67, 69, 81, 83, 87, 97, 99, 107, 111</td>
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<tr>
<td>15</td>
<td>37, 49, 51, 57, 63, 71, 73, 77, 85, 91, 103, 105, 107, 113, 116, 121</td>
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<tr>
<td>16</td>
<td>45, 47, 51, 61, 63, 67, 71, 87, 89, 91, 99, 101, 103, 111, 113</td>
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<tr>
<td>17</td>
<td>33, 41, 47, 65, 73, 79, 83, 87, 99, 107, 109, 113</td>
</tr>
<tr>
<td>18</td>
<td>39, 45, 49, 57, 65, 77, 89, 93, 95, 99, 103, 109, 133</td>
</tr>
<tr>
<td>20</td>
<td>37, 58, 69, 79, 81, 83, 87, 97</td>
</tr>
</tbody>
</table>

Recitation: These weekly sessions are a required part of the course. Go to recitation prepared, bring your solved homework with you. Your work will be worth 3 points. Each recitation also has 1 attendance point. You must be present for the entire session to earn these points.

PREREQUISITES AND COREQUISITES
CHEM 1230 with a minimum grade of C is a prerequisite for CHEM1240.

TECHNOLOGY REQUIREMENTS
Blackboard (https://blackboard.utdl.edu/webapps/login/) and Mastering Chemistry will be used on a regular basis in this course. Students need to have access to a properly functioning computer throughout the semester. Student computers need to be capable of running the latest versions of plug-ins, recent software and have the necessary tools to be kept free of viruses and spyware. Updated software is available from the Online Learning Download Center (https://www.utoledo.edu/dl/main/downloads.html).

For exams, students may use an approved calculator. Any calculator that is programmable, whether graphing or non-graphing, and any calculator based on a phone or other device that can receive or transmit data, are prohibited. Students are required to use a clicker (or registered device) in all lecture classes.
UNIVERSITY POLICIES
Policy Statement on Non-Discrimination on the basis of Disability (ADA):
The University is an equal opportunity educational institution. Please read The University’s Policy Statement on Nondiscrimination on the Basis of Disability Americans with Disability Act Compliance.

ACADEMIC ACCOMMODATIONS
The University of Toledo is committed to providing equal access to education for all students. If you have a documented disability or you believe you have a disability and would like information regarding academic accommodations/adjustments in this course please contact the Student Disability Services Office.

ACADEMIC POLICIES
Examinations Make-up exams will not be given. Excused absences will only be given based on conditions outlined below. If an excuse is acceptable, your missed exam score will be replaced with a score equal to the average of the other hour exams. The final exam cannot be excused. For all exams you must show a photo ID card. You may use a non-programmable calculator. You cannot use a programmable calculator or phone.

Exam Absence Policies: Students who will not be able to take an exam at the scheduled time due to an irresolvable conflict must provide written documentation to verify the conflict. This may occur for students on official university business. The exam will be given at another arranged time before the scheduled test date. Approval must be obtained in advance.

Students who unexpectedly miss an exam due to illness, car accident or similar extreme circumstance should inform their instructor ASAP. Documentation such as a physician’s note, an accident report, etc is required and must be attached to an Absence Report Form (obtained from BO 2022). An email to the instructor and a telephone call within 24 hours is expected. In all other cases a missed exam will result in 0 on the exam.

Academic Dishonesty: Refer to the university’s policy on Academic Dishonesty in the university catalogue. Violation of this policy can result in a course grade of F with additional university sanctions possible. You will be required to print out an Academic Honesty Statement, sign it and submit the statement.

COURSE EXPECTATIONS
1. Attendance is required for the lecture and recitation classes.
2. Read the textbook before the lecture, the schedule is listed below.
3. Print from Blackboard partial lecture outlines and bring them to the lecture class; you are responsible for all material and problems covered in class.
4. Bring your clicker (or registered device) and a calculator to every lecture and recitation class. Correct clickers answer will be worth more than incorrect answers, so be sure to prepare for each class period.
5. You need to come to the recitation class prepared by completing the assigned homework. Each recitation session include is worth 4 WA points: 1 for attendance and 3 for completed homework.
6. Mastering Chemistry online homework assignments have to be completed before the deadline
7. If you need extra help, see your instructor during office hours or use email. You will not be graded or judged based on the questions that you ask! Seek help in the Chemistry Help Center (BO2043) and/or attend Supplemental Instruction (SI) sessions.

GRADING It is a very high priority to your instructor to ensure fairness and equity in all grading aspects of the course. Anyone who has the prerequisites for this course and effectively studies the material can achieve a reasonable level of achievement and therefore an acceptable grade, i.e., a C or above. There is nothing about this class that requires anyone to get a lower grade. We don’t use a curve, so every one of you can achieve the grade that you are willing to earn!
Course Points

The following is the distribution of possible points in the course:

<table>
<thead>
<tr>
<th>Component</th>
<th>Points</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm Exams 3 @ 100 points each</td>
<td>300</td>
<td>43%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>200</td>
<td>29%</td>
</tr>
<tr>
<td>Mastering Chemistry</td>
<td>100</td>
<td>14%</td>
</tr>
<tr>
<td>Participation: Clickers, WA, recitation*</td>
<td>100</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>700</strong></td>
<td></td>
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</tbody>
</table>

*Each correct clicker question is worth more than an incorrect answer. Each recitation is worth 4 points (see above). Additional writing assignments (WAs) may be assigned for 2-4 points per assignment.

Grade Scale

These are the minimum percentages of total points needed to receive the indicated grade.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Minimum Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>88%</td>
</tr>
<tr>
<td>A-</td>
<td>85%</td>
</tr>
<tr>
<td>B+</td>
<td>81%</td>
</tr>
<tr>
<td>B</td>
<td>77%</td>
</tr>
<tr>
<td>B-</td>
<td>73%</td>
</tr>
<tr>
<td>C+</td>
<td>69%</td>
</tr>
<tr>
<td>C</td>
<td>64%</td>
</tr>
<tr>
<td>C-</td>
<td>60%</td>
</tr>
<tr>
<td>D+</td>
<td>57%</td>
</tr>
<tr>
<td>D</td>
<td>53%</td>
</tr>
<tr>
<td>D-</td>
<td>50%</td>
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Drop, Withdrawal and Incomplete Grades

Course drop and withdrawal procedures have been set by the University. Dropped courses do not appear on your transcript. The deadline for dropping is January 30th. You may withdraw from the course and receive a grade of W. The deadline for withdrawal is March 30th. W's do not affect your GPA. If you drop or withdraw from CHEM 1240, you are to drop/withdraw from the lab course CHEM 1290 because you need to know the lecture material to be in lab.

A course grade of Incomplete is given only to those who have completed all but a small percentage of course requirements for an acceptable reason. The Incomplete must be removed before you take organic chemistry.

All course points and grades will be updated on Blackboard following each exam including a midterm grade. Although this is not your final grade in the course, a midterm grade should be taken seriously with respect to how well you are doing in the course approximately half-way through the semester.

COMMUNICATION GUIDELINES

As your instructor, I am here to help, and will do my best to respond to email within 24 to 48 hours. Students are expected to check their UT email account and blackboard frequently for important course information.

STUDENT SUPPORT SERVICES

Course scheduling assistance: Chemistry Department Secretary, Ms. Samples, is in Room BO 2022, telephone 419-530-2698. If you have further questions or if you need assistance, please talk to her. She takes care of all scheduling changes.

Supplemental Instruction

Advanced students provide several structured study sessions on the material each week. Your participation is optional – though very strongly encouraged.

Chemistry Help Center, Room BO 2043, is where the teaching assistants hold their office hours so it is a great place to receive assistance. It is generally open all day Monday through Friday & evenings Monday through Thursday. A schedule will be posted early in the term. No appointment is necessary.

Tutoring support for all UT students is available through the Learning Enhancement Center located in the Carlson Library.

Instructor Office Hours are times when you can stop by my office (no appointment needed) with questions about the course material, grades, and any concerns with the course. My office hour times and location are listed at the top of the syllabus (page 1). If you have a scheduling conflict with all of the listed times and want to meet with me we can schedule a different time to meet.
**COURSE SCHEDULE** The following table will give you a general idea of our pace throughout the course. Exams will occur on the dates indicated below. Material covered on each exam will be dependent on the pace of the class and will be specified in lecture prior to each exam. Each chapter is consistent with the learning outcomes listed earlier in the syllabus. This material will be assessed through our weekly assigned homework problems due at recitation each week, Mastering Chemistry online homework, and Exams.

**COURSE SCHEDULE:**

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Chapter: Topic</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jan 16 – 19</td>
<td>11: Liquids, Solids and Phase Changes</td>
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<tr>
<td>2</td>
<td>Jan 22 – 26</td>
<td>11: Continued</td>
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<tr>
<td></td>
<td></td>
<td>12: Solutions and Their Properties</td>
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</tr>
<tr>
<td>3</td>
<td>Jan 29 –</td>
<td>12: Continued</td>
<td>Last day to Drop via the web is Tues 1/30</td>
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<tr>
<td></td>
<td>Feb 2</td>
<td></td>
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<tr>
<td>4</td>
<td>Feb 5 – 9</td>
<td>12: Continued</td>
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<tr>
<td></td>
<td></td>
<td>13: Chemical Kinetics</td>
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<tr>
<td>5</td>
<td>Feb 12 – 16</td>
<td>13: Continued</td>
<td>Midterm Exam 1, Fri 2/16, Chapters 11, 12, 13</td>
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<tr>
<td>6</td>
<td>Feb 19 – 23</td>
<td>14: Chemical Equilibrium</td>
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<td>7</td>
<td>Feb 26 –</td>
<td>14: Continued</td>
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<td></td>
<td>March 2</td>
<td>15: Aqueous Equilibria: Acids and Bases</td>
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<td></td>
<td>March 5 - 9</td>
<td>Spring Break</td>
<td>Classes are cancelled</td>
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<tr>
<td>8</td>
<td>March 12 –</td>
<td>15: Continued</td>
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<td></td>
<td>March 16</td>
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<tr>
<td>9</td>
<td>March 19 –</td>
<td>16: Applications of Aqueous Equilibria</td>
<td>Midterm Exam 2, Fri 3/23 Chapters 14, 15, 16 (partial), and review of Exam 1</td>
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<td></td>
<td>March 23</td>
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<tr>
<td>10</td>
<td>March 26 –</td>
<td>16: Continued</td>
<td>Last day to Withdraw via the web is Friday 3/30</td>
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<td>March 30</td>
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<tr>
<td>11</td>
<td>April 2 – 6</td>
<td>17: Thermodynamics: Entropy, Free Energy, and Equilibrium</td>
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<tr>
<td>12</td>
<td>April 9 – 13</td>
<td>18: Electrochemistry</td>
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<tr>
<td>13</td>
<td>April 16 –</td>
<td>18: Continued</td>
<td>Midterm Exam 3, Fri 4/20, Chapters 16, 17, 18 (partial), and review of Exams 1 and 2</td>
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<td>April 20</td>
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<tr>
<td>14</td>
<td>April 23 –</td>
<td>18: Continued</td>
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<tr>
<td></td>
<td>April 27</td>
<td>20: Transition Elements and Coordination Chemistry</td>
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<tr>
<td>Finals Week</td>
<td>April 30 –</td>
<td>The Final Exam is comprehensive (Chapters 11-18, 20)</td>
<td>***** Final Exam *****</td>
</tr>
<tr>
<td></td>
<td>May 4</td>
<td></td>
<td>Wednesday, 5/2, 12:30pm – 2:30pm</td>
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<td>You must take the final at this time!</td>
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</tbody>
</table>
STUDENT LEARNING OUTCOMES

Chapter 11 Liquids, Solids, and Phase Changes
11.1 Predict which substance has higher viscosity or surface tension based on its molecular structure.
11.2 Use the equation for Gibbs free energy to calculate the temperature or $\Delta S$ for a phase change.
11.3 Calculate the amount of heat associated with phase changes and draw heating curves.
11.4 Use the Clausius–Clapeyron equation to calculate vapor pressure at varying temperatures or $\Delta H_{\text{vap}}$.
11.5 Classify types of solids based on their chemical composition and properties.
11.6 Identify a unit cell from a pattern.
11.7 Identify the four kinds of spherical packing arrangements in crystalline solids and the three kinds of cubic unit cells.
11.8 Use a phase diagram to interpret the behavior of a substance at a given temperature and pressure.
11.9 Sketch a phase diagram given the appropriate data.

Chapter 12 Solutions and Their Properties
12.1 Describe the types of intermolecular forces when a solute dissolves in a solvent.
12.2 Predict solubility based on the chemical structure of the solute and solvent.
12.3 Calculate the concentration of a solution in units of mass percent.
12.4 Calculate the concentration of a solution in units of parts per million (ppm) or parts per billion (ppb).
12.5 Calculate the concentration of a solution in units of molality.
12.6 Convert from one unit of concentration to another.
12.7 Use Henry’s Law to calculate the solubility of gas.
12.8 Qualitatively predict changes to the vapor pressure of a solution when a solute is added.
12.9 Calculate the vapor pressure of a solution containing a non-volatile solute.
12.10 Calculate the vapor pressure of a solution containing a volatile solute.
12.11 Calculate the amount of boiling-point elevation and freezing-point depression for a solution.
12.12 Calculate osmotic pressure for a solution.
12.13 Use osmotic pressure or other colligative property to calculate the molecular weight of a solute.

Chapter 13 Chemical Kinetics
13.1 Determine the average reaction rate over a specified period of time and estimate instantaneous reaction rate from a graph of concentration versus time.
13.2 Relate the rate of consumption of any reactant to the rate of formation of any product using reaction stoichiometry.
13.3 Find the order with respect to each reactant, the overall order of a reaction, and the units of the rate constant given the rate law.
13.4 Predict the change in reaction rate when the concentration of a reactant changes by a specified amount.
13.5 Determine the rate law and rate constant using initial rate and concentration data.
13.6 Use the integrated rate law to determine the half-life and the concentrations remaining at various times for a zeroth-order reaction.
13.7 Use the integrated rate law to determine the half-life and the concentrations remaining at various times for a first-order reaction.
13.8 Use the integrated rate law to determine the half-life and the concentrations remaining at various times for a second-order reaction.
13.9 Determine the reaction order and rate constant graphically.
13.10 Interpret potential energy diagrams and suggest geometries for successful collisions and transition states using collision theory.
13.11 Calculate rate constants, temperatures, and activation energy using the Arrhenius equation.
13.12 Given a reaction mechanism, write the overall reaction, identify intermediates, and determine the molecularity for each elementary step.
13.13 For mechanisms with an initial slow step (a) predict the rate law for the overall reaction or (b) propose a mechanism that agrees with the experimental rate law.
13.14 For mechanisms with an initial fast equilibrium step, predict the rate law.
13.15 Use a molecular diagram for a catalyzed reaction to determine the rate law and propose a mechanism consistent with the rate law.
13.16 Identify catalysts and intermediates in the mechanism of a catalyzed reaction.
13.17 Interpret a potential energy diagram representing the mechanism in a catalyzed reaction.

Chapter 14 Chemical Equilibrium
14.1 Describe characteristics of a reaction in chemical equilibrium.
14.2 Write an equilibrium constant expression $K_c$ for gas and solution phase reactions.
14.3 Determine a new equilibrium constant expression when reactions are manipulated or added.
14.4 Calculate the value of the equilibrium constant $K_c$ given concentrations of reactant and products.
14.5 Identify a reaction in equilibrium from a molecular representation and evaluate the equilibrium constant.
14.6 Write the equilibrium expression $K_p$ in terms of partial pressures of reactants and products. Relate the equilibrium constants $K_p$ and $K_c$.
14.7 Write equilibrium constant expressions for reactions involving heterogeneous equilibria.
14.8 Determine the extent of a reaction given the equilibrium constant.
14.9 Predict the direction a reaction will shift to reach equilibrium given initial concentrations.
14.10 Calculate concentrations or partial pressures or products and reactants in equilibrium.
14.11 Calculate concentrations of reactants and products in equilibrium when initial concentrations are unequal.
14.12 Predict the direction a reaction in equilibrium will shift as a result of changes in concentration.
14.13 Predict the direction a reaction in equilibrium will shift as a result of changes volume or pressure.
14.14 Predict the direction a reaction in equilibrium will shift as a result of changes in temperature.
14.15 Relate the equilibrium constant to the rate of the forward and reverse reactions.
14.16 Describe the effect of a catalyst on the equilibrium position of a mixture.

Chapter 15 Aqueous Equilibria: Acids and Bases
15.1 Identify Arrhenius acids and bases and Brønsted–Lowry acids and bases and conjugate acid–base pairs.
15.2 Predict the direction of a reaction based upon relative strengths of the conjugate acid–base pairs.
15.3 Predict the relative strengths of binary acids (HA) and oxoacids ($H_nYO_m$) based on their chemical structure.
15.4 Calculate the concentration of $[H_3O^+]$ or $[OH^-]$ using the value of $K_w$.
15.5 Calculate the pH of a solution given $[H_3O^+]$ or $[OH^-]$.
15.6 Calculate $[H_3O^+]$ or $[OH^-]$ given the pH of a solution.
15.7 Calculate the pH of a strong acid or base solution.
15.8 Calculate the value for $K_w$ given the initial concentration of a weak acid and its equilibrium pH.
15.9 Given the $K_w$ value for a weak acid and its initial concentration, calculate the pH, percent dissociation, and the concentration of all species present in solution.
15.10 Calculate the pH and the concentration of all species present in a solution of a diprotic acid.
15.11 Visualize the species present when a diprotic acid dissociates.
15.12 Calculate the pH and equilibrium concentrations in a solution of a weak base.
15.13 Relate $K_a$, $K_b$, $pK_a$, and $pK_b$ for a conjugate acid–base pair.
15.14 Predict whether a salt is acidic, basic or neutral and calculate the pH of the salt solution.
15.15 Identify the Lewis acid and Lewis base and use curved arrow notation to indicate donation of a lone pair of elections in a Lewis acid–base reaction.

Chapter 16 Applications of Aqueous Equilibria
16.1 Write a balanced equation for a neutralization reaction, calculate the equilibrium constant, and determine whether the pH after neutralization is greater than, equal to, or less than 7.
16.2 Calculate the effect of a common-ion on concentrations, pH, and percent dissociation in a solution of a weak acid.
16.3 Visualize the common ion effect at the molecular level and predict the effect on pH and percent dissociation of a weak acid.
16.4 Calculate the pH of a buffer solution and the change in pH on addition of a strong acid or a strong base.
16.5 Use the Henderson–Hasselbalch equation to calculate the pH of a buffer solution and to prepare a buffer solution that has a given pH.
16.6 Calculate the pH at various points in a strong acid–strong base titration.
16.7 Calculate the pH at various points in a weak acid–strong base titration
16.8 Calculate the pH at various points in a weak base–strong acid titration.
16.9 Visualize the molecular species present during a titration and interpret titration curves.
16.10 Write the equilibrium-constant expression for dissolution of an ionic compound, and calculate the value of its $K_w$.
16.11 Calculate ion concentrations and the solubility of an ionic compound from its $K_w$.
16.12 Describe how the presence of molecular and ionic species will affect the solubility of an ionic compound.
16.13 Calculate solubility in a solution that contains a common ion.
16.14 Use the formation constant $K_i$ to calculate ion concentrations in a solution that contains a complex ion.
16.15 Use the formation constant $K_i$ to calculate the solubility of an ionic compound when the cation forms a complex ion.
16.16 Calculate the ion product IP for an ionic compound, and determine whether a precipitate will form when various solutions are mixed.

Chapter 17 Thermodynamics: Entropy, Free Energy, and Equilibrium
17.1 Define a spontaneous process and classify various physical processes and chemical reactions as spontaneous or nonspontaneous.
17.2 Predict the sign of $\Delta S$ for various physical processes and chemical reactions.
17.3 Predict which state of substance has higher entropy.
17.4 Calculate $\Delta S$ for the expansion or compression of an ideal gas at constant temperature.
17.5 Predict the relative entropies of two substances.
17.6 Use standard molar entropies ($S^\circ$) to calculate the standard entropy change of a reaction ($\Delta S^\circ$).
17.7 Describe how the change in entropy and enthalpy of a system affect spontaneity.
17.8 Calculate values of $\Delta S_{sys}$, $\Delta S_{surr}$, and $\Delta S_{total}$ for a reaction, and use these values to determine whether the reaction is spontaneous.
17.9 Estimate the temperature at which a reaction changes between spontaneous and nonspontaneous.
17.10 Describe how the sign and magnitude of $\Delta S$, $\Delta H$, and temperature affect the value of $\Delta G$ and the spontaneity of the reaction.
17.11 Calculate values of $\Delta S$, $\Delta H$, and $\Delta G$ for a reaction, and use these values to determine whether the reaction is spontaneous.
17.12 Estimate the temperature at which a reaction changes between spontaneous and nonspontaneous.
17.13 Define the standard free-energy change ($\Delta G^\circ$) for a reaction, and calculate $\Delta G$ from $\Delta H^\circ$ and $\Delta S^\circ$.
17.14 Use values of $\Delta G^\circ$ to determine if a compound is thermodynamically stable.
17.15 Calculate $\Delta G^\circ$ for a reaction from values of $\Delta G^\circ$, and determine if the reaction is spontaneous under standard conditions and how temperature will affect spontaneity.
17.16 Calculate $\Delta G$ for a reaction under nonstandard-state conditions.
17.17 Use the relationship between $\Delta G^\circ$ and the equilibrium constant for a reaction, and calculate one quantity given the other.

Chapter 18 Electrochemistry
18.1 Assign oxidation numbers and classify half reactions as oxidation or reduction reactions.
18.2 Use the half-reaction method to balance a redox reaction.
18.3 Draw and interpret the sketch a galvanic cell. Label the anode and cathode, indicate the direction of electron and ion flow, and write balanced equations for the electrode and overall cell reactions.
18.4 Use shorthand notations to represent a galvanic cell.
18.5 Interconvert between cell potentials and standard free–energy changes for an electrochemical reaction.
18.6 Use tabulated values of standard reduction potentials for half reactions to order substances by increasing strength as an oxidizing or reducing agent.
18.7 Use standard reduction potentials for half reactions to calculate a standard cell potential and determine spontaneity.
18.8 Calculate the cell potential under nonstandard-state conditions using the Nernst equation.
18.9 Use the cell potential to calculate solution concentration.
18.10 Use standard reduction potentials to calculate the equilibrium constant.
18.11 Describe batteries and fuel cells, and calculate values of $E^\circ$, $\Delta G^\circ$, and $K$ for the cell reaction.
18.12 Describe how corrosion occurs and methods used to prevent it.
18.13 Draw and interpret the sketch of an electrolytic cell. Label the anode and cathode, indicate the direction of electron and ion flow, and write balanced equations for the electrode and overall cell reactions.
18.14 Predict the products formed and the electrode and overall cell reactions when an aqueous solution of an ionic compound is electrolyzed.
18.15 Relate the current, time, and amount of product produced in an electrolytic or galvanic cell.

**Chapter 20 Transition Elements and Coordination Chemistry, selected objectives from this list:**
20.1 Identify Lewis acids, Lewis bases, ligands, and donor atoms in a coordination complex.
20.2 Determine the formula of a coordination complex, identify the oxidation state and coordination number of the metal atom, and draw the structure of the complex.
20.3 Classify a ligand as mono, bi, tri, tetra, or hexadentate based on its chemical structure.
20.4 Classify isomers of coordination complexes.
20.5 Draw diastereomers for octahedral and square planar complexes.
20.6 Classify a coordination complex as chiral or achiral and draw enantiomers for chiral compounds.
20.7 Relate the color of a metal complex, the wavelength of light it absorbs, and the energy difference between its ground and excited state.