CHEM 1151H: General Chemistry for Engineers (Honors Section) Fall 2009

Co-requisite

CHEM 1153: Recitation for CHEM 1151

Credit Hours

4 semester hours

Lecture (Mon, Wed, Thurs)

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Office hours: TBA and by appointment

Key	Time	Room
10971	10:30-11:35 AM	130 HT

Recitation

Key	Day & Time	Room	TA
12079	M 2:50-4:30 PM	TBA	TBA TBA Office hours: TBA and by appointment
10967	Tu 11:45-1:25 PM	TBA	
11051	W 2:50-4:30 PM	TBA	

Required Textbook

Petrucci, RH, WS Harwood, FG Herring, & J Madura. General Chemistry: Principles and Modern Applications, 9th ed. Upper Saddle River, NJ: Prentice Hall, 2007. Also on reserve in Snell Library (along with full solutions manual).

Course Website

Accessible as "CHEM 1151H Honors Section Fall 2009" via http://blackboard.neu.edu. A short and helpful tutorial can be found at http://www.discoveringblackboard.neu.edu. Please check the course's Blackboard site periodically for announcements, missed handouts, review guides and practice problems for exams, and other useful resources and information.

Course Goals and Objectives

Why are you taking CHEM 1151? Consider the following. Engineering can be defined as the application of science to practical problem solving through the design and implementation of technological processes that improve our lives. As all designs and processes involve materials at some level, engineers should have an understanding of materials and their underlying chemistry. CHEM 1151 will provide you with the background to understand the design and properties of materials at the atomic level.

CHEM 1151 is designed to develop, deepen, and broaden your understanding of connections between the underlying structure of matter, the energetics of chemical transformations, and observable physical properties and responses. You will get to practice skills in describing and predicting the properties of chemical systems and modern materials—such as alternative fuels, polymers, and batteries and fuel cells—using words, pictures, graphs, numbers, and equations. An important intention is to inspire an appreciation of the importance and relevance of chemistry in engineering and our everyday lives.

Specific learning objectives for CHEM 1151 include:

1) Describe the composition of matter on atomic and molecular scales in terms of chemical formulas and structures.
2) Identify the products of chemical reactions and relate the quantities of reactants consumed and products created using balanced chemical equations.
3) Develop an understanding of the nature and types of chemical bonding and its consequences for molecular shape.
4) Predict key physical properties of gases, liquids and solids and relate these properties to molecular shape and interactions between constituent atoms, ions, and molecules.
5) Determine the energy changes that occur in chemical reactions in terms of the thermodynamic properties of reactants and products and apply these energy changes to determine whether a given reaction is spontaneous.
6) Apply, compare, and contrast kinetic and equilibrium descriptions for chemical reactions.
7) Identify the chemical reactions occurring in batteries and fuel cells and apply quantitative descriptions in terms of thermodynamics and stoichiometry to these systems.

The Honors section of CHEM 1151 also will introduce the quantum mechanical model for the atom as a basis for understanding chemical phenomena.

Resources

1) Many study aids may be found at the course's Blackboard site. You are encouraged to explore the tutorials, electronic media resources, and links to other useful sites on the web found at this site.
2) As part of your college experience, get to know your instructor (*e.g.*, for help & advice).
3) Office hours for the TA will be announced in class and posted on the course's Blackboard site.
4) Help is available daily from 10:00 AM-4:30 PM Mon-Fri in "Chem Central," 115 HT.

Special Accommodations

If you have specific physical, psychiatric, or learning disabilities that you believe may require accommodations for this course, please meet with your instructor after class, during his/her office hours, or at a mutually agreeable time to discuss appropriate adaptations or modifications that might help you. The Disability Resource Center (DRC), located in 20 Dodge Hall (x2675, http://www.access-disability-deaf.neu.edu/), can provide you with information and other assistance to help manage any challenges that may affect your performance in your coursework. The University requires that you provide documentation of your disability to the DRC.

Lectures and Reading

The Lecture and Exam Schedule on page 6 outlines the topics and assigned reading corresponding to each lecture. Readings may help clarify topics introduced and discussed in class. You also may find it helpful to stop and test your comprehension as you read by making sure you can work the example problems.

Homework Assignments

Homework problems have been selected to reinforce key concepts and skills for specific topics. In addition to helping you prepare for exams and quizzes in recitation, solving problems is by far the best way to learn chemistry. Page 8 lists assigned problems for each chapter. In addition, the Study Guide on pages 9-14 matches specific concepts for each lecture and chapter with specific assigned homework problems. Use this study guide as tool to check and review your chemistry skills as you progress through the semester.

Assigned homework will be collected **in lecture** on the dates listed on page 7; note that most assignments are due on a Thursday, with only two exceptions. **Satisfactory completion of homework means attempting all assigned problems at a minimum. Late and/or electronic submissions without instructor approval are unacceptable for credit.** Detailed solutions for all homework problems will be posted on the course's Blackboard site prior to due dates, exams, or discussion in recitation.

Recitation

You are expected to attend your registered recitation session weekly (see Recitation and Homework Schedule on page 7 for topics for each week). Activities during recitations will include addressing more difficult concepts and skills introduced in lectures and the reading, introducing new concepts and skills through discovery-focused group activities, returning homework collected in lecture, and examining homework problems due that week. In addition, short quizzes will be given, typically consisting of questions similar to problems assigned for homework and given weekly. Attendance will be taken during recitations. Your grade for recitation is based on scores on recitation quizzes (40%), satisfactory completion of assigned homework (30%), and attendance (30%), with lowest scores for quizzes and homework dropped and one unexcused absence from recitation allowed without penalty.

Prior to coming to recitation we highly recommend that you attempt as much of the homework for the chapter to be discussed so that you can ask productive questions and get the optimal guidance in mastering the assigned material.

Calculators

Please bring a basic scientific calculator to every lecture, recitation, and exam.

Assessment and Grading

Final course grades will be determined as follows:

- **20%** Recitation
- **10%** Lecture quizzes
- **40%** Midterm examinations (lowest score of 3 tests will be dropped)
- **30%** Final examination

Grade scale: $A > 87 \geq A^- > 84 \geq B^+ > 81 \geq B > 78 \geq B^- > 76 \geq C^+ > 70 \geq C > 64 \geq C^- > 59 \geq D^+ > 54 \geq D > 49 \geq D^- > 45 \geq F$.

Lecture Quizzes

Quizzes will be given in lectures in the form of "attendance-based" in-lecture practice problems. These assignments do not require additional study prior to class and are intended to promote lecture attendance and enhance comprehension of key concepts and skills. Lecture quizzes will be graded on the scale of 10 for "present and active," 5 for "present but inactive," and 0 for "absent." You will not be penalized for a first unexcused absence from a lecture quiz.

Midterm Exams

There will be three midterm exams given during the course of the semester. Midterm exams will not be given during regular class hours but instead given in the evening on the dates indicated on the accompanying Lecture and Exam Schedule (see page 6) in a location to be announced. **If you are unable to take a midterm exam at the assigned date and time, you must notify the instructor no later than one week prior to the exam for rescheduling. Only unavoidable excuses will be acceptable for rescheduling.**

The two best scores from your set of exams will be counted towards your final grade. If it is unavoidable for you to miss or you choose to skip an exam, that exam is the one that will be dropped. The averaged exam grade for a student missing more than one exam is at the discretion of the instructor.

Prior to each exam review guides outlining key concepts to be evaluated will be posted on the course's Blackboard site. Review sessions also will be scheduled outside of regular lectures for the evening on the day prior to the exam. Recommended strategies for preparing for exams include reviewing your notes and handouts from lecture, recitation, and lab and studying example problems in the assigned reading.

Final Exam

A comprehensive final exam will be scheduled during the Final Exam Period in December.

Format for Examinations

Midterm and final exams will be closed book and consist of both multiple-choice and open-response questions. Because you will not be expected to memorize key equations, you will be provided a Useful Information Package with key equations, physical constants, and tables relevant for the exam prior to and at the start of each exam.

Excused Absences and Make-Ups

1) Absences will be excused only under appropriate circumstances (*e.g.*, illness or death of an immediate family member) and by the discretion of the instructor/TA.
2) Quizzes must be taken in your scheduled section unless you have prior permission of the instructor/TA.
3) No make-ups will be given for missed quizzes or exams.

Expectations

You are encouraged and expected to:

1) Arrive on time for every class, take comprehensive notes, and participate in activities and discussions.
2) Should it be necessary to miss a class, obtain notes from a classmate and review them before the next class.
3) Notify ASAP the instructor or TA in the event of an excused absence from lecture or recitation, respectively.
4) Read the assigned readings.
5) Work through assigned homework problems and come to recitation prepared to discuss and ask questions regarding these problems, their solutions, and your attempted work.
6) Organize into study groups as a great way to overcome hurdles when doing homework or preparing for a quiz or exam.
7) Seek help from the instructor, TA, and/or members of your study group so as to take active responsibility for learning the material, not just surviving homework assignments, quizzes, and exams.
8) Safeguard all of your original course documents, including handouts, returned homework, quizzes, and exams, for future reference, study, and problems or disputes related to grading and/or record keeping.
9) Treat your instructor, TA, and other members of the class with respect and consideration and avoid disrupting class with cell phones or other distracting activities.
10) Observe and abide by the rules of ethical behavior outlined in the Student Handbook and the Honor Code of the College of Engineering.

Lecture and Exam Schedule

Week	Lectures – Topics & Reading (Page numbers refer to relevant reading in textbook)	Exams
9/9-9/11	W Introduction (pp. 67-75) Th Oxidation states; inorganic nomenclature (pp. 75-91)	
9/14-9/18	M Organic nomenclature (pp. 91-98) W Balancing chemical reactions; solutions (pp. 109-119) Th Electrolytes; precipitation reactions (pp. 142-149)	
9/21-9/25	M Stoichiometric calculations & yields (pp. 125-131) W Pressure, temperature, & ideal gases (pp. 178-197) Th Effusion; gas mixtures (pp. 198-211)	
9/28-10/2	M Work & heat (pp. 225-231 & 235-238) W The 1st Law (pp. 238-242) Th Thermochemistry of phase changes & reactions (pp. 231-235 & 242-247)	**Wednesday, 9/30** **Midterm Exam 1**
10/5-10/9	M Hess's Law & standard molar enthalpy changes (pp. 248-263) W Foundations of quantum chemistry (pp. 277-299) Th Orbitals & electron configurations (pp. 299-326)	
10/12-10/16	W Bond characteristics; Lewis structures (pp. 372-394) Th Properties of covalent bonds; molecular geometry (pp. 395-409)	
10/19-10/23	M Hybridized orbitals & polarity (pp. 423-438) W Complex organic molecules & polymers (pp. 1089-1101 & 1117-1121) Th Intermolecular forces, liquid, & phase diagrams (pp. 472-497) Properties of solids (pp. 497-501, 512-513, & 516-517)	
10/26-10/30	M Colligative properties; crystalline solids (pp. 548-557, 497-501, & 512-517) W Interpreting unit cells (pp. 501-512) Th Introduction to rates (pp. 572-578)	**Wednesday, 10/28** **Midterm Exam 2**
11/2-11/6	M Integrated rate laws (pp. 578-590) W Reaction energies & mechanisms (pp. 590-609) Th Reversible reactions & equilibrium constants (pp. 622-638 & & 748-751)	
11/9-11/13	M Equilibrium calculations (pp. 644-650 & 755-757) Th LeChâtelier's Principle & common-ion effect (pp. 638-643 & 751-755)	
11/16-11/20	M Acid/base reactions (pp. 149-151 & 663-680) W Entropy (pp. 780-791) Th Gibbs free energy (pp. 791-796)	
11/23-11/27	M Gibbs free energy & equilibrium (pp. 796-811)	
11/30-12/4	M Redox reactions (pp. 153-163) W Electrochemical cells & ½ reactions (pp. 822-831) Th Equilibrium electrochemistry; Faraday's Laws (pp. 832-856)	**Wednesday, 12/2** **Midterm Exam 3**
12/7-12/9	M Consolidation Day 1 W Consolidation Day 2	
12/11-12/19		**Comprehensive Final Exam**

Recitation and Homework (HW) Schedule

Week	Recitation Topic & Activity	HW Due*
9/9-9/11	No recitation	
9/14-9/18	Review of Chapters 1 & 2 Chapter 3 Activity: Identifying & Naming Compounds	Th 9/17: Ch 3 HW
9/21-9/25	Chapter 4 Activity: Solutions & Reactions	Th 9/26: Ch 4 HW
9/28-10/2	Chapter 6	M 9/28: Ch 6 HW
10/5-10/9	Chapter 7 Activity: Calorimetry	Th 10/8: Ch 7 HW
10/12-10/16	Chapter 8 Activity: Introduction to Spectroscopy	Th 10/15: Ch 8 HW
10/19-10/23	Chapter 10 Activity: Computational Chemistry	Th 10/22: Ch 10 HW
10/26-10/30	Review for Midterm Exam 2	
11/2-11/6	Chapter 12 Activity: Crystal Modeling	Th 11/5: Ch 12 HW
11/9-11/13	Chapter 14 Activity: Using MS Excel for Kinetics	Th 11/12: Ch 14 HW
11/16-11/20	Chapter 15 Activity: Using Graphing Calculators in Chemistry	Th 11/19: Ch 15 HW
11/23-11/27	No recitation	
11/30-12/4	Chapter 19	
12/7-12/9	Chapter 20 Activity: Building and Testing Al-Air Batteries	M 12/7: Ch 19 HW

*** Homework will be collected in lecture and returned during the following recitation.**

Assigned End-of-Chapter Homework Problems

Chapter 1: Matter: Its Properties and Measurement (not collected)
Problems 1.7, 1.12, 1.23, 1.39, 1.43, 1.72, 1.81, & 1.100

Chapter 2: Atoms and the Atomic Theory (not collected)
Problems 2.6, 2.10, 2.15, 2.19, 2.24, 2.25, 2.39, 2.50, 2.53, 2.76, 2.86, & 2.94

Chapter 3: Chemical Compounds
Collected: Problems 3.12, 3.51, 3.53, 3.55(a, b, d, f, j, k, l, m), 3.59(a, c, d, e, f, g, h), 3.76, & 3.77, & 3.101
Not Collected: Problems 3.25, 3.33, 3.37, 3.43, 3.45, & 3.80

Chapter 4 (Including Sections 5.1-5.2): Chemical Reactions
Problems 4.3, 4.21, 4.29, 4.37, 4.61, 4.66, 4.67, 4.77(a-c)), 4.84, 5.1, 5.2, 5.21, & 5.23

Chapter 6: Gases
Problems 6.2, 6.28, 6.37, 6.45, 6.59, 6.75(typo: determine ratio of *effusion*, not *diffusion*, rates), 6.76, 6.81, 6.88, & 6.89

Chapter 7: Thermochemistry
Problems 7.2, 7.8, 7.9, 7.15, 7.19, 7.25, 7.26, 7.30(a), 7.36, 7.39, 7.41, 7.45, 7.57, 7.77, 7.91, & 7.97(hint: 1 W = 1 J/s)

Chapter 8: Electrons in Atoms
Problems 8.37, 8.57, 8.84, 8.85(b, d, f), 8.87(b, c, d), 8.101, 8.113, & 8.117

Chapter 10 (Including Sections 11.3-11.4, 26.4-26.8, & 26.13): Chemical Bonding I: Basic Concepts
Part I: Molecular Structures
Problems 10.3, 10.25(a-c), 10.27(b-d), & 10.35
Part II: Molecular Shape and Polarity
Problems 10.56(a-c), 10.59(b-c), 10.70(a-d), 10.72, 10.76, 10.92, 11.12, & 11.59
Part III: Organic and Polymer Chemistry
Problems 26.18, 26.21, & 26.92

Chapter 12 (Including Sections 13.7-13.9): Liquids, Solids, and Intermolecular Forces
Problems 12.2, 12.36, 12.38, 12.47, 12.50, 12.54, 12.63, 12.97, 12.110, 12.122, 12.126, 13.62, & 13.105(a)

Chapter 14: Chemical Kinetics
Problems 14.1, 14.27, 14.28, 14.29, 14.32, 14.47, 14.50, 14.53, 14.59, 14.61, 14.62, 14.65, 14.77, & 14.95

Chapter 15 (Including Sections 5.3, 16.1-16.5, & 18.1-18.5): Principles of Chemical Equilibrium
Part I: Foundations of Chemical Equilibrium
Problems 15.3, 15.4, 15.15, 15.26, 15.29, 15.51, 15.57, 15.64, 18.1, 18.15, & 18.28
Part II: Acid/Base Reactions
Problems 16.3, 16.9(a, b), 16.10(b, d), 16.27, & 16.30

Chapter 19: Spontaneous Change: Entropy and Free Energy
Problems 19.6, 19.7, 19.18, 19.19, 19.23, 19.25, 19.38, 19.42, 19.52, 19.61, 19.63, & 19.90(a, b, d)

Chapter 20 (Including Sections 5.4-5.6): Electrochemistry (not collected)
Problems 5.33, 5.47(a-b), 5.80, 20.11, 20.21(a-c), 20.45, 20.51, 20.57, 20.58, & 20.65

Study Guide with Key Concepts

(Assigned homework problems in parentheses after each concept)

Chapter 1: Matter—Its Properties and Measurement (For Review/Not Covered in Regular Lectures)*

A) Distinguish between physical and chemical properties of matter, chemical compounds, and homogeneous or heterogeneous mixtures (Problems 1.7 & 1.12)
B) Convert between different fundamental units of length, mass, time, and temperature and "derived" units, such as volume and energy, using the metric/international system (SI), scientific notation, and unit prefixes (Problems 1.39 & 1.43)
C) Use density to convert between mass and volume in expressing the amount of a material (Problems 1.72 & 1.81)
D) Distinguish between the accuracy and the precision of a set of measurements, identify the number of significant figures in a number, and express the result of calculations with the correct number of significant figures (Problems 1.23 & 1.100)

Chapter 2: Atoms and the Atomic Theory (For Review/Not Covered in Regular Lectures)*

A) Outline Dalton's atomic theory of matter, describe its experimental foundation based on observations of chemical reactions (Law of Conservation of Mass & Law of Constant Composition), and describe the reasoning that permits chemical formulas to be determined purely by chemical means (Law of Multiple Proportions) (Problems 2.6, 2.10, & 2.15)
B) Outline the experiments revealing the basic structure of the atom and know the definitions of atomic number, mass number, and net charge (Problem 2.19 & 2.94)
C) Find the numbers of neutrons, protons, and electrons in an isotope from its standard atomic symbol (Problem 2.24)
D) Given the atomic masses and natural abundances of the isotopes of an element, calculate its chemical atomic mass (Problems 2.39 & 2.76)
E) Understand the basic features of the periodic table of the elements and find the numbers of protons, neutrons, and electrons in an isotope from its standard atomic symbol (Problems 2.25 & 2.50)
F) Understand the mole concept and convert between number of particles, number of moles, and the mass of a chemical substance (Problems 2.53 & 2.86)

*** Students are responsible for the material in Chapters 1 and 2 even though it will not be covered formally in lectures or as collected homework.** The first meeting of each recitation section for the semester will include a review of the homework problems for these two chapters. In addition, the document entitled "Review of Basic Skills" provides a review of the core material in Chapters 1 and 2. **Please seek additional help if you have trouble with this material, including attending supplementary review sessions offered outside of regular lecture and recitation hours.**

Chapter 3: Chemical Compounds

Part I: Moles and Chemical Formulas

A) Calculate the molar mass of a substance from its formula (Problems 3.12 & 3.101)
B) Calculate mass percent composition of a substance from its chemical formula (Problems 3.25 & 3.80)†
C) Relate the empirical or molecular formula of a substance to its percent composition (Problems 3.33 & 3.37)†
D) Find the empirical or molecular formula of a substance from analysis of its combustion products (Problems 3.43 & 3.45)†

Part II: Chemical Nomenclature

E) Assign oxidation states to the atoms in a substance given its chemical formula (Problems 3.51 & 3.53)
F) Name simple inorganic compounds from the formulas and write formulas for inorganic compounds from the name (Problems 3.55(a, b, d, f, j, k, l, m) & 3.59(a, c, d, e, f, g, h))
G) Name simple organic compounds from their chemical formulas and write chemical formulas for organic compounds from their names (Problems 3.76 & 3.77)

† **Students are responsible for this material (see note for Chapters 1 and 2) even though it will not be covered formally in lectures or as collected homework.**

Chapter 4 (Including Sections 5.1-5.2): Chemical Reactions

A) Balance a chemical equation given the identities of reactants and products (Problems 4.3 & 4.77(a-c))
B) Interconvert between amount of a compound or ion (in units of moles or mass) and the volume of a solution of that compound or ion with a given molarity (Problems 4.29, 4.37, & 4.84)
C) Distinguish between strong electrolytes, weak electrolytes, and nonelectrolytes in solution (Problem 5.1 & 5.2)
D) Predict the outcome of simple precipitation reactions (Problems 5.21 & 5.23)
E) Given the mass of a reactant or product in a chemical reaction, use a balanced chemical equation to calculate the masses of other reactants consumed and other products formed (Problem 4.21)
F) Given a set of initial masses of reactants and a balanced chemical equation, identify the limiting reactant and calculate the masses of reactants and products after the reaction has gone to completion (Problem 4.61)
G) Determine the percentage yield of a reaction from its calculated theoretical yield and its measured actual yield (Problems 4.66 & 4.67)

Chapter 6: Gases

A) Describe how pressure and temperature are defined and measured and interconvert among different units of pressure (torr, Pa, atm, and psi) and temperature (°C and K) (Problem 6.2)
B) Apply the ideal gas law to determine the pressure, volume, temperature, amount, density or molar mass for a gas and to stoichiometric calculations involving gases (Problems 6.37, 6.81, & 6.88)
C) Calculate the relative rates of effusion through a small aperture in a vessel wall for a gaseous mixture of light and heavy molecules (Problems 6.75(typo: determine ratio of *effusion*, not *diffusion*, rates) & 6.76)
D) Use Dalton's law to calculate partial pressures in gas mixtures (Problems 6.59 & 6.89)

Chapter 7: Thermochemistry

Part I: Work, Heat, and the 1st Law of Thermodynamics

A) Give a physical interpretation to the concept of P-V work and calculate the work done on/by a chemical system from volume changes (Problems 7.39 & 7.41)
B) Give a physical interpretation to the concept of heat and relate the change in temperature of a given quantity of a substance, the amount of heat transferred to or from it, and its heat capacity (Problems 7.2 & 7.97(hint: 1 W = 1 J/s))
C) Apply the 1st Law of Thermodynamics to relate the energy change of a system to the flow of heat and work between the system and its surroundings (Problem 7.45)
D) Find the final temperature reached when multiple substances at different initial temperatures are placed in thermal contact (Problems 7.8 & 7.9)

Part II: Thermochemistry of Phase Changes and Reactions

E) Perform thermochemical calculations for processes involving phase changes (Problems 7.25 & 7.26)
F) Determine the heat evolved or absorbed and temperature change for systems in which a reaction occurs based on reaction energy and enthalpy (Problems 7.15, 7.19, 7.30(a), & 7.36)
G) Use Hess's Law to relate enthalpy changes for sets of reactions (Problem 7.57)
H) Calculate standard-state changes in enthalpy for a reaction from standard molar enthalpies of formation for reactants and products (Problems 7.77 & 7.91)

Chapter 8: Electrons in Atoms

A) Compare the properties of light and electrons using the concepts of wave-particle duality, the Heisenberg uncertainty principle, and quantized energy (Problems 8.101 & 8.117)
B) Explain how atomic excitation and emission spectra result from the quantization of electron energies (Problems 8.37 & 8.113)
C) Describe solutions to the Schrödinger equation for the hydrogen atom in terms of electron orbitals and quantum numbers (Problem 8.57)
D) Assign electron configurations to atoms using the Pauli exclusion principle, the aufbau process, and Hund's rule (Problems 8.84, 8.85(b, d, f), & 8.87(b, c, d))

Chapter 10 (Including Sections 11.3-11.4, 26.4-26.8, & 26.13):
Chemical Bonding I: Basic Concepts

Part I: Molecular Structures

A) Evaluate the ionic character of a bond and identify the polarity of a covalent bond based on differences in electronegativity between its constituent atoms (Problem 10.35)
B) Draw the Lewis structure for a molecule or polyatomic ion given its molecular formula (Problems 10.3, 10.25(a-c), & 10.27(b-d))

Part II: Molecular Shape and Polarity

C) Identify relationships between bond order, bond length, and bond energy (Problem 10.76)
D) Predict the geometry of a molecule or polyatomic ion using the VSEPR model (Problems 10.56(a-c), 10.59(b-c), & 10.92)
E) Apply the valence-bond method to identify hybridized orbitals and geometry of molecules with multiple central atoms (Problems 11.12 & 11.59)
F) Determine whether a molecule is polar or nonpolar (Problems 10.70(a-d) & 10.72)

Part III: Organic and Polymer Chemistry

G) Describe the structural characteristics of complex organic molecules (Problems 26.18 & 26.21)
H) Compare the structural characteristics of different organic polymers (Problem 26.92)

Chapter 12 (Including Sections 13.7-13.9): Liquids, Solids, and Intermolecular Forces

A) Relate different types of intermolecular forces to the structure of molecules (Problem 12.47)
B) Relate the effects of different kinds of intermolecular forces to properties of liquids such as surface tension, viscosity, boiling point, and vapor pressure (Problems 12.2 & 12.50)
C) Interpret the pressure-temperature phase diagram for a typical substance and identify key features such as phases, phase transitions, and critical and triple points (Problems 12.36 & 12.38)
D) Evaluate the colligative properties, including freezing point depression, boiling point elevation, and osmotic pressure, of dilute solutions (Problems 13.62 & 13.105(a))
E) Compare and contrast the properties of different types of crystalline solids, including metals, ceramics, and network covalent solids, and of non-crystalline solids, including liquid crystals and amorphous polymers (Problems 12.54 & 12.122)
F) Relate composition, atomic radius, unit cell dimensions, and density for crystals with cubic units cells (Problems 12.63 & 12.126)
G) Determine empirical formula of crystalline solids from their unit cell structure (Problems 12.97 & 12.110)

Chapter 14: Chemical Kinetics

A) Identify an overall rate for a chemical reaction and relate it to the rate of disappearance of a reactant or appearance of a product (Problems 14.1 & 14.95(a-e))
B) Deduce reaction rate laws from experimental measurement of concentration vs. time (Problems 14.27, 14.28, & 14.29)
C) Use integrated rate laws for 0^{th}, 1^{st}, and 2^{nd} order reactions to predict the time dependence of a reactant concentration (Problems 14.32 & 14.95(f-j))
D) Use reaction profiles to relate the forward and reverse activation energies of a reaction and identify reaction intermediates (Problems 14.47 & 14.50)
E) Apply the Arrhenius Equation to relate activation energy and rate constants at different temperatures (Problems 14.53 & 14.77)
F) Explain reaction rate laws based on reaction mechanisms (Problems 14.62 & 14.65)
G) Describe different types of catalysts and characterize their effect on chemical reactions (Problems 14.59 & 14.61)

Chapter 15 (Including Sections 5.3, Sections 16.1-16.5, & 18.1-18.5): Principles of Chemical Equilibrium

Part I: Foundations of Chemical Equilibrium

A) Apply the Law of Mass Action to relate equilibrium constants and equilibrium conditions (Problems 15.3, 15.4, & 18.1)
B) Determine equilibrium constants from equilibrium concentrations or partial pressures (Problems 15.15 & 15.64)
C) Identify the direction in which a chemical reaction will proceed spontaneously for a given set of reactant and product concentrations or partial pressures (Problems 15.26 & 18.28)
D) Calculate the equilibrium concentrations or partial pressures of all species in a reaction given a set of starting conditions (Problem 15.29)
E) Use LeChâtelier's Principle to predict the effect of removing/adding reactant or product, changing the temperature, or changing the reaction volume on a reaction at equilibrium (Problems 15.51 & 15.57)
F) Assess the common-ion effect on the solubility of a slightly-soluble salt (Problem 18.15)

Part II: Acid/Base Reactions

G) Apply the Brønsted-Lowry definitions to identify the acid, base, conjugate acid, and conjugate base for an acid/base reaction (Problem 16.3)
H) Use the pH scale to express the acidity of a solution and determine the pH and pOH of solutions of strong and weak acids and bases (Problems 16.9(a, b), 16.10(b, d), 16.27, & 16.30)

Chapter 19: Spontaneous Change: Entropy and Free Energy

A) Predict the entropy change for systems undergoing different chemical or physical processes (Problems 19.6 & 19.7)
B) Calculate standard-state changes in entropy for chemical processes from standard molar entropies (Problem 19.38)
C) Apply the criterion for the spontaneity of a process based on changes in Gibbs free energy to identify temperature ranges in which a particular process is spontaneous (Problems 19.18, 19.19, & 19.90(a, b, d))
D) Calculate standard-state changes in Gibbs free energy for chemical processes from standard molar Gibbs free energies of formation (Problems 19.23 & 19.25)
E) Determine spontaneity and equilibrium properties by applying relationships between changes in Gibbs free energy at standard and non-standard states, reaction quotient, and equilibrium constants (Problems 19.42 & 19.52)
F) Evaluate the temperature dependence of an equilibrium constant using the van't Hoff Equation (Problems 19.61 & 19.63)

Chapter 20 (Including Sections 5.4-5.6): Electrochemistry

A) Determine the reductant and oxidant in a redox reaction and combine half reactions to obtain a balanced overall redox reaction (Problems 5.33, 5.47(a-b), & 5.80)
B) Identify the cathode, anode, reduction and oxidation half-reactions, and direction of electron flow in galvanic and electrolytic cells (Problems 20.21(a-c) & 20.57)
C) Calculate the standard voltage of an electrochemical cell based on standard reduction potentials for its half-cell reactions (Problem 20.51)
D) Apply standard reduction potentials to predict the spontaneity for a redox reaction (Problems 20.11 & 20.58)
E) Relate cell potentials and electrolyte concentrations for electrochemical cells under non-standard conditions using the Nernst Equation (Problem 20.45)
F) Use Faraday's laws to predict the quantities of substances produced or consumed at the electrodes of electrochemical cells from the total charge passing through the circuit (Problems 20.65)