Chem 103, Spring 2006
Prof. Sevian
Suggested Problems to Study from ACS Study Guide in Preparation for the Final Exam

The final exam will be on Monday, May 15, 8:00-11:00 am, in Snowden Auditorium. The exam is entirely multiple choice. You must use a #2 pencil to fill out the answer sheet. You will not be permitted to bring your own scratch paper to the exam, but scratch paper will be provided at the exam. A periodic table will be supplied with the exam, as well as a table of common symbols (similar to page 113 in the ACS study guide).

Bring with you to the exam:

- a #2 pencil
- an eraser
- a calculator

Sometimes the auditorium is cold in the morning. You may also wish to bring a sweater or jacket with you.

ACS Study Guide questions that may help you to prepare:

Chapter	Study Questions	Practice Questions
Atomic Structure	1-10	1-13, 17-30
Molecular Structure & Bonding	1-10	1-19, 21-27, 29, 30
Stoichiometry	1-6, 8-10	1-30
States of Matter/Solutions	3, 8-10	3, 4, 15-19, 27, 28
Energetics	1, 3-6	1, 3-6, 8-22
Electrochemistry & Redox	1, 3, 5	1-3, 5-8
Descriptive Chem/Periodicity	3, 6-10	7, 11, 13-30
Laboratory Chemistry	1-6, 8-10	1-9, 12, 16-20

Also, see the list of topics on the following pages, taken from the study guide from last year's chem 103 final exam.

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Final Exam Study Guide
Chem 103 in a Nutshell

Material that was covered on Exam 1

Concepts
- Periodic table basic structure (metals vs. nonmetals vs. semimetals, groups, periods)
- using information in the Periodic table (atomic number, atomic mass)
- properties/classification of matter
- mass-moles-molecules measures of quantity of matter, and determining wt%
- atoms: protons-neutrons-electrons-ions
- ionic vs. molecular
- charges of common ions
- nomenclature
- balancing chemical equations
- empirical formula from combustion analysis
- molecular formula
- basic stoichiometry
- limiting reagents

Skills (with applicability beyond chemistry)
- thinking of processes in terms of mass in = mass out (conservation of matter), with two ways of quantifying matter (mass or moles)
- significant digits and why they are significant (precision of measurement)
- solving problems by dimensional analysis

Material that was covered on Exam 2

Concepts
- using the Periodic table to make predictions of ion charge and solubility (similarities within groups)
- predicting products given certain reactants
- writing net ionic equations with states of matter
- solubility
- molarity and titration; calculating pH, the pH scale and how to read it
- electrolytes
- types of rxns (e.g., precipitation, redox, acid-base)
- calorimetry, enthalpy of combustion
- endothermic/exothermic processes (from the perspective of the "system")
- using Hess's law (conservation of energy) to predict energy changes in chemical reactions

Skills (with applicability beyond chemistry)
- thinking about processes in terms of total starting energy = total ending energy (conservation of energy)
- seeing processes from the vantage point of the "system" (where everything else is the "surroundings")
- keeping track of exponents in calculations

Material that was covered on Exam 3

Concepts
- why the Periodic table has the structure it does (i.e., s-block, p-block, d-block)
- electronic transitions, and particle-level explanation of how emission spectroscopy works
- wavelength, frequency, energy representations of electromagnetic radiation

- wave vs. particle representations of electromagnetic radiation (light energy) and electrons (matter)
- electronic configuration, orbitals, valence, and *spdf*-shorthand notation
- solutions to the Schrodinger equation (wave functions or orbitals) and how they are uniquely specified by 3 quantum numbers
- periodicity: ionization energy, electronegativity, electron affinity, lattice energy, atomic radius
- paramagnetism and particle-level explanation for why it arises
- Lewis dots: resonance, single/multiple bonds, bond order, length and strength
- polarity of bonds, polarity of molecules
- electron-pair geometry (based on central atom in a molecule or ion) vs. molecular geometry
- VSEPR and how bond angles are affected

<u>Skills (with applicability beyond chemistry)</u>
- multiple-step reasoning, explaining it in writing
- predicting properties of materials based on the structures of the particles that comprise them

<u>Material that has been covered since Exam 3</u>
- valence bond theory: hybridization of atomic orbitals that give rise to specific electron pair geometries
- molecular orbital theory: combinations of all atomic orbitals in a molecule
- comparison of valence bond theory and molecular orbital theory
- how molecular orbital theory begins to explain semiconductors (not tested on exam)

<u>Skills (with applicability beyond chemistry)</u>
- applicability of a particle-level theory, as measured by its predictive power at the macroscopic level

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<u>The Most Important Organizing Principles of Chemistry 103</u>
(adapted from Atkins, P. "Skeletal chemistry." *Education in Chemistry* (January, 2005), available at http://www.rsc.org/lap/educatio/eic/2005/jan05/EC0050100020.htm)

Overall principle: Chemists try to understand nature on three levels in order to be able to explain it.

- <u>Macroscopic level</u>: observations (often in the laboratory) of how matter behaves.
- <u>Particle level</u>: explanations (models) of what particles in matter do, how they interact, and why. Note: no model is perfect; all models break down under certain conditions, and it is important to know what those conditions are in order to apply a specific model to a situation.
- <u>Symbolic level</u>: representations of the particle-level models used to explain macroscopic behavior of matter.

With Chem 103, we have covered approximately half of introductory chemistry:

1. ***Matter is made of atoms***. Atoms are identified by the quantity of protons they have. All the different kinds of atoms in nature are cataloged neatly in the Periodic table.
2. ***Elements display periodicity***. The organization of the Periodic table is a model of how chemists understand the particle-level structure of atoms. It is based on mathematical solutions (called orbitals or wave functions) of the Schrodinger equation for the hydrogen atom. The Periodic table is a powerful predictive model of electronic structure of atoms, how the trends in atomic properties arise (periodicity), and why different elements tend to react as they do.
3. ***Chemical bonds form when electrons pair***. The Schrodinger equation is based on a model of electrons as waves with specific energies, therefore, due to the Heisenberg uncertainty principle, it is impossible to determine the locations of electrons at specific times, so we instead know only the probabilities that electrons will spend time at certain 3-dimensional locations. Orbitals (wave function solutions to the Schrodinger equation) that exist on individual atoms combine with orbitals on other atoms to make bonds between atoms, in such a way that bonds are formed of pairs of electrons existing in bonding orbitals (wave function solutions to the Schrodinger equation).
4. ***The shapes and sizes of particles determine the properties of materials***. The structure of molecules (and ions) at the particle level determines the properties that materials made of them will have at the macroscopic level. These particle-level 3-D structures can be predicted by valence bond theory, which is a Schrodinger equation extension to Lewis structure modeling. Sometimes, the very same atoms and electrons can be configured in ways that are different enough to give rise to molecules or ions with different properties (e.g., molecular isomers). Sometimes, different elements can be used to build structures with the same numbers of electrons (e.g., isoelectronic species), and then these structures have similar properties. What matters in all cases is how the electrons are configured.
5. ***All behavior of particles can be explained by the attractions between unlike charges (+ and –) and the repulsions between like charges (+ and +, or – and –)***. These forces of attraction and repulsion are modeled by Coulomb's law, which says that the force increases in direct proportion with the magnitudes of the charges, and the force increases in indirect proportion with the square of the distance between the charges. These forces lead to residual forces between particles (atoms, molecules, ions) that govern how these particles interact with each other. That is, the residual forces are the causes of change in matter.