CHM 150/151 Topic Coverage and Sequence (Burdge/Overby Atoms First, 1 Ed.)
Academic Year 2012-2013

This list represents the minimum coverage of material for this course. Individual instructors may add additional information to provide a more complete educational experience for their students. Inclusion of real-world examples that illustrate important chemical principles is encouraged.

Chapter 1: Chemistry: The Science of Change, Sections 1 – 6

Emphasize significant figures, dimensional analysis

Section 1 The Scientific Method

Section 2 Classification of matter

Section 3 Physical and Chemical Properties

Section 4 SI units; students must know G, M, k, c, m, μ, n, 1 cm^3 = 1 mL; 1 dm^3 = 1 L, derived units

Section 5 Define accuracy and precision, determining sig. figs., rounding numbers in calculations, exact vs. inexact numbers

Section 6 How to calculate metric-metric conversions; students will be given conversions between English-metric units and English-English units (students need to know 1 in. = exactly 2.54 cm, 453.59g = 1 lb, 3.785 L = 1 gal and temperature conversions), dimensional analysis, scientific notation

Chapter 2: Atoms and the Periodic Table, Sections 1 – 6

Section 1: Dalton's theory; Law of Multiple Proportions

Section 2: Discovery of electrons/CRT (no calculations); Protons, neutrons: Rutherford's experiment Millikan's experiment, α, β and γ emissions and radioactivity

Section 3: Atomic and mass numbers; symbols

Section 4: Atomic mass; weighted averages (isotopic composition)

Section 5: Names of groups in Periodic Table; Students must know names and symbols of at least the following elements: Elements 1-36, Groups IA and B, IIA and B, the halogens and the noble gases, W, Pd, Pt, Sn, Pb and U (Group IA, Group IIA, Ag^+, Zn^{2+}, Cd^{2+} and Al^{3+} should be covered as only having one charge for cation in their compounds)

Section 6: Moles and molar mass, Avogadro's number

Chapter 3: Quantum Theory and the Electronic Structure of Atoms, Sections 1-9

Section 1: Forms of energy: kinetic, electrical, and units. No calculations

Section 2: Types of electromagnetic radiation; define the parts of a wave; $c = \lambda\nu$ (double slit experiment optional)

Section 3: Planck equation: $E = h\nu$ or $E = hc / \lambda$; direct/inverse relationship between variables; photoelectric effect; define quanta

Section 4: Emission spectra; Bohr Hydrogen atom qualitatively and quantitatively (electrons relax down to lower state and emit energy to give emission spectra – can refer to Figure 3.11 here) For calculating energy, frequency and wavelength of photons absorbed or emitted, Bohr treatment is simpler and more directly tied to fundamental principles than the Rydberg equation is. $E_n = (-2.18 \times 10^{-18}\ J)/n^2$, $\Delta E = E_f - E_i$

Section 5: Wave-particle duality; de Broglie equation: $m = h/\lambda v$ (emphasize units $J = kg\ m^2/s^2$)

Section 6: Uncertainty Principle qualitatively (no equation), Schrodinger equation (no equation)

Section 7: Cover quantum numbers (n, l, m_l and m_s); relative energies of orbitals (Figure 3.23); n = shells; l = subshells, m_l = orbital orientation, s = spin.

Section 8: Shapes of orbitals: *s* – spherical, *p* – dumbbell, *d* – show pictures only; *f* orbitals optional, Radial distribution graphs optional

Section 9: Define Pauli Exclusion Principle, Aufbau, and Hund's Rule.

Section 10: Electron configurations (atoms and ions H through Sr); periodic table as a map of outer electrons, cover transition metal exceptions (Cr, Mo, Cu, Ag, Au); show orbital diagrams based on electron configurations; define s, p, and d blocks of elements

Chapter 4: Periodic Trends of the Elements, Sections 1 – 6

Section 1: Development of the periodic table
Section 2: The Modern Periodic Table (new IUPAC definition of transition elements)
Section 3: Effective nuclear charge
Section 4: Periodic trends: Atomic size, Ionization energy, systematic exceptions to the IE trends, Electron affinity – cover briefly
Section 5: Electronic configuration of ions, Main group and D-block (explanation of d block ions is wrong, do not 'take s electrons first', the orbital order changes so d subshell is lower E than s)
Section 6: Ionic radius

Chapter 5: Ionic and Covalent Compounds, Sections 1-10

Section 1: Compounds definition
Section 2: Lewis dot symbols
Section 3: Lattice Energy qualitatively (no calculations), energy and charge directly related/energy, number of ions directly related, and radius inversely related. See table 5.1.
Section 4: Formulas and nomenclature of ionic compounds
Section 5: Molecular and empirical formulas
Section 6: Nomenclature of molecular compounds, naming acids and bases, organic nomenclature optional
Section 7: Polyatomic ions, oxoacids and hydrates
Students need to know Table 5.10 (polyatomics-we may distribute our own list)
Section 8: Molecular and formula masses
Section 9: Percent composition
Section 10: Molar mass and Avogadro's number

Chapter 6: Representing Molecules, Sections 1-6

Section 1: The octet rule, Lewis structures and multiple bonds (intuitive method), relative lengths and strengths of bonds. Energy is required to break bonds.
Section 2: General electronegativity trends as range between ionic and covalent bonds (no numbers); C-H, B-H, P-H bonds are "nonpolar" (similar electronegativity of B, C, P and H)
Section 3: Six step procedure for drawing Lewis Structures. Cover this method. Supplement text with sufficient examples; cover examples of double and triple bonds. Show larger molecules like ethane and acetic acid, but give skeleton. Show oxyacids.
Section 4: Formal charge
Section 5: Resonance
Section 6: Exceptions to the octet rule. Exceptions with B, Be, S, P, Xe, Cl, and I as central atoms.

Chapter 7: Molecular Geometry and Bonding Theories, Sections 1-4

Section 1: Students should know the 5 **electron-pair geometries** (the electron cloud arrangements, electron group geometries, electron domain geometries, etc.). VSEPR. Students must know **molecular** geometry including linear, trigonal planar, bent, tetrahedral, trigonal pyramidal, trigonal bipyramidal, octahedral, see-saw, T-shaped, square pyramidal, and square planar. They should know ideal bond angles and qualitatively how real angles differ from ideal ones. Students need to know molecular shapes and bond angles around atoms in larger molecules if they are given the atomic skeleton.

Section 2: Molecular geometry and polarity, qualitatively
Section 3: Define Valence Bond Theory
Section 4: Hybridization of orbitals based on number of electron domains (sp, sp^2, sp^3, sp^3d, sp^3d^2);
Sections 6-7: Skip

Chapter 12: Intermolecular Forces and the Physical Properties of Liquids and Solids, Sections 1 – 7

Section 1: Intermolecular forces: Dipole-dipole, Hydrogen bonds (bridges), Dispersion forces, ion-dipole forces
Section 2: Viscosity and surface tension
Section 3: Solid structure and packing models optional
Section 4: Types of crystals qualitatively, difference between "molecular" and "extended lattice", "crystalline" and "amorphous", and "ionic", "covalent" and "metallic".
Section 5: Define amorphous solids
Section 6: Define phase changes, cover heating curve qualitatively (can define heat of fusion, heat of vaporization); Describe how vapor pressure relates to intermolecular forces; define boiling point and normal boiling point
Sections 7: Define key points of phase diagrams; explain water's negative slope and CO_2 sublimation

Chapter 8: Chemical Reactions, Sections 1 – 5

Section 1: What a chemical equation means. Balancing chemical equations
Section 2: Combustion analysis
Section 3: Calculations with balanced chemical equations; mole to mole, mole to gram, and gram to mole.
Section 4: Determination of limiting reactants. Reaction yields, percent yield.
Section 5: Some reaction patterns in main group elements. Metals react with oxygen, acids or water.

Chapter 9: Chemical Reactions in Aqueous Solutions, Sections 1-6

Section 1: Define and describe the difference between strong, weak, and non-electrolytes. Students should know Table 9.1, The Strong Acids.
Section 2: Solubility guidelines and the definition of solubility. Write molecular, ionic, and net ionic equations. Using solubility rules to predict precipitation reactions.
Section 3: Acid/Base reactions. Know the Bronsted definition of acids and bases. Know the strong acids and bases (Table 9.4). Predict the products of acid/base reactions (water is often a product, but not always!).
Section 4: Redox reactions; oxidation numbers. Assign oxidation numbers to elements. Identifying and products of redox reactions; define oxidation, reduction, reducing agent, oxidizing agent; **do not** cover balancing equations with half reactions, writing half reaction optional. Identify single replacement/displacement, combination, decomposition, and combustion as examples of redox reactions as applicable. Use the activity series to predict products of single replacement reactions.
Section 5: Concentration of solutions. Students should be able to do calculations involving molarity and dilutions. Determine the number of ions in solution.
Section 6: Acid base titrations and other applications of solution stoichiometry. Define terms like endpoint, equivalence point, indicator, and calculate quantities or concentrations of reactants or products.

Chapter 10: Energy Changes in Chemical Reactions, Sections 1 – 6

ΔG or ΔS definitions – are covered in CHM 152!

Section 1: Define system, surroundings. Cover energy unit conversions.
Section 2: Define state functions and give examples. Cover definitions and conservation of energy. Define heat and signs associated with direction of heat flow
Section 3: Define enthalpy, thermochemical equations, standard state, and that $q = \Delta H$ at constant P (don't cover the derivation). Define terms associated with physical changes, endothermic and exothermic reactions, with graphs of enthalpy of reactants and products; cover thermochemical calculations.
Sections 4-7: Calculation of the enthalpy of a reaction by various methods.
Section 4: Calorimetry. Emphasize $q = m \bullet s \bullet \Delta T$; calculations involving specific heat. Define heat capacity and the difference between specific heat (capacity) and heat capacity. Cover Calorimetry and calorimetric calculations.
Sections 5: Hess's Law. Cover with calculations.
Section 6: Standard Enthalpy of Formation. Cover with calculations.
Section 7: Average Bond Energies. Cover breaking bonds costs energy and forming bonds releases energy. Cover the average bond enthalpy calculations to give an approximate enthalpy of reaction.
Section 8: Lattice energy qualitatively.

Chapter 11: Gases, Sections 1-8
Section 1: Properties of gases. Cover all qualitative properties of gases.
Section 2: Cover KMT postulates and implications qualitatively. Do not cover kinetic energy (E_K) or speed calculations. Cover effusion and diffusion qualitatively. Cover relative speeds qualitatively (speed increases as molar mass decreases)
Section 3: Define pressure qualitatively (force per area); cover units of pressure and conversions (atm, torr, mm Hg) and the measurement of pressure.
Section 4: The Gas Laws. Cover inverse vs. direct relationships, equations that give straight lines, and proportional relationships between variable (Boyle's Law, Charles' Law and Avogadro's Law). Cover the combined gas law.
Section 5: The Ideal Gas Law. Cover the value and units of R and ideal gas calculations.
Section 6: Real gases. Qualitative treatment of real gas behavior. .
Section 7: Gas Mixtures. Cover Dalton's Law of Partial Pressures and mole fractions.
Section 8: Gas Stoichiometry.

Chapter 13: Physical Properties of Solutions, Sections 1 – 8
Sections 1: Define solutions
Section 2: Molecular view of the solution process. Describe energies of solvent-solvent, solute-solute and solvent-solute interactions and overall enthalpy of solutions; Cover enthalpy for hot and cold packs.
Section 3: Concentration calculations: molarity, molality, mole fraction, mass percent (ppm, ppb optional)
Section 4: Factors that affect solubility. Define saturated, supersaturated; Henry's law qualitatively
Section 5: Define colligative and cover vapor pressure lowering, freezing point depression and boiling point elevation. Cover osmosis qualitatively. Cover Raoult's law qualitatively for covalent molecules only;
Section 6: Cover calculations for freezing point depression and boiling point elevation.
Section 7: Colloids optional.