Chemistry
Semester 1 Outline 2011-2012

I. **Chapter 1: Introduction to Chemistry**
- a. Evolution of Chemistry (Philosophers, alchemists, chemists)
  - Aristotle, Boyle, Lavoisier
- b. Science defined
- c. Scientific Method (Observation, question, hypothesis, experiment, appraise results for support of hypothesis)
- d. Theory vs. Law
- e. Branches of chemistry and applications
- f. Science vs. Technology

II. **Chapter 2: Scientific Measurements**
- a. Accuracy vs. precision
- b. Scientific Notation
  - i. Expressing a number in scientific notation.
  - ii. Addition and subtraction
  - iii. Multiplication and division
- c. The Factor-Label Method of Solving Problems
- d. Significant Figures
  - i. Determining the number of significant figures
  - ii. Addition and subtraction
  - iii. Multiplication and division

III. **Chapter 3: The Metric System**
- a. Units and prefixes of the metric system
- b. Base vs. derived units
- c. Calculating volumes
- d. Volume by displacement
- e. Density
- f. Temperature conversions (°C, °F, K)
- g. Heat and Specific Heat

IV. **Chapter 4: Matter and Energy**
- a. Matter defined
- b. Phases of matter
  - i. Solid, liquid, gas
- c. Heating and cooling curves
- d. Classification of matter
  - i. Pure substance vs. mixture
  - ii. Element vs. compound
  - iii. Heterogeneous mixture vs. homogeneous mixture (solution)
- e. Regions of the periodic table
- f. Properties of metals, nonmetals and semimetals (metalloids)
- g. Interpretation and writing of chemical formulas (composition and fixed ratios)
- h. Chemical vs. physical properties

i. Similarities among elements within the same group (family)
j. Conservation of matter
k. Different forms of energy (Heat, Light, Chemical, Electrical, Mechanical, Nuclear)
l. Mass-energy equivalence; $E=mc^2$ (Einstein)
m. Development of the periodic table (Dobereiner, Newlands, Mendeleev, Moseley)
n. The layout of the modern periodic table
    i. Groups (families) (including alkali metals, alkaline earth metals, halogens and noble gases
    ii. Periods
    iii. Regions (including metals, nonmetal, semimetals, transition and post-transition metals, inner transition elements [lanthanides and actinides; aka rare-earth elements], transuranium elements)
o. Diatomic elements (H_2, N_2, F_2, O_2, I_2, Cl_2, Br_2)

V. **Chapter 5: Models of the Atom / Chapter 6: The Periodic Table**
a. John Dalton (Dalton's Atomic Theory; Law of constant composition)
b. Law of multiple proportions
c. J. J. Thomson; Cathode ray tube experiment (cathode rays = electron beam)
    i. Plum pudding model of the atom
    ii. Charge to mass ratio of electron
d. Eugen Goldstein; Canal rays (positively charged particles)
e. Robert Millikan; Millikan's Oil Drop Experiment (discovered charge on electron)
f. Ernest Rutherford; Rutherford's Gold Foil Experiment (discovery of the nucleus)
    i. Nuclear model of the atom
g. James Chadwick; Discovery of the neutron
h. Atomic mass unit (amu) defined; 1/12 mass of a carbon-12 isotope
i. Atomic notation (atomic number, mass number, symbol)
    i. Element defined by number of protons in the nucleus
j. Isotope defined (Same element with different number of neutrons)
k. Electromagnetic waves defined.
    i. Electrical and magnetic wave components.
    ii. Energy carried on the frequency of the EM wave
    iii. Photoelectric effect (Einstein); revealed particle (photon) nature of light
l. Explanation of spectral lines (electron transitions)
    i. Bohr model of the atom
    ii. Electrons in specific quantized orbits
    iii. Electron representation in the Bohr model (max e = $2n^2$)
m. Erwin Schrodinger and the Wave Mechanical Model of the atom
    i. Electrons exist in atoms as waves of probability
    ii. Different energy states correspond to different probability regions (shapes)
    iii. Shapes represent 90% probability region
    iv. Quantum numbers (n, l, m_l, m_s) determine energy state of the electron
    v. Follows Aufbau Principle, Hund's Rule and the Pauli Exclusion Principle
    vi. Electron configurations can be represented with spectroscopic and condensed spectroscopic notation
n. Periodic properties based on electron configuration
    i. Core vs. valence electrons
    ii. Atomic radius; Ionization energy; electron affinity; predicting charges
    iii. Lewis dot diagram for representing valence electrons
    iv. Charged atoms that are isoelectronic with noble gases

VI. **Chapter 7: Language of Chemistry**

a. Define IUPAC (International Union of Pure and Applied Chemistry) naming rules
b. Define organic vs. inorganic chemistry
c. Predicting formulas and names of different types of compounds
d. Nomenclature of compounds containing ionic bonding (ionic compounds)
    i. Binary ionic compounds with fixed cation charge
    ii. Binary ionic compounds with variable cation charge
    iii. Ionic compounds containing polyatomic ions
    iv. Empirical formula
e. Nomenclature of compounds containing covalent bonding (covalent compounds – molecules)
    i. Nonmetal-nonmetal bonding rules
    ii. Molecular vs. empirical formula
f. Acid nomenclature
    i. Identifying an acid (Leading hydrogens)
    ii. Binary acid nomenclature
    iii. Oxyacid (ternary) acid nomenclature

VII. **Chapter 8: Chemical Reactions**

a. Recognizing physical vs. chemical changes
b. Evidence and driving forces of chemical reactions
    i. Gas produced; insoluble compound produced; permanent color change; energy change; water produced.
c. Writing and balancing chemical reaction equations
    i. Writing correct compound formulas
    ii. Balancing with coefficients
d. Interpreting and translating reaction descriptions into symbolic form
e. Symbology related to chemical reactions (e.g. (s), (l), (g), (aq), etc.)
f. Definition of a catalyst
g. Reaction Types
    i. Combination (synthesis reactions): $A + Z \rightarrow AZ$
    ii. Decomposition: $AZ \rightarrow A + Z$
    iii. Behavior of specific decomposition reactions (containing carbonates, bicarbonates and metallic oxides)
    iv. Single replacement reactions: $A + BZ \rightarrow AZ + B$
    v. Double displacement (precipitation): $AX + BZ \rightarrow AZ + BX$
    vi. Activity series and solubility rules will be provided on the exam as needed
    vii. Acid-Base: $HX + BOH \rightarrow BX + HOH$ (acid + base yields a salt and water)
    viii. Combustion: $C_xH_y + O_2 \rightarrow CO_2 + H_2O$

VIII. **Chapter 12: Chemical Bonding**

a. Core vs. valence electrons revisited
b. Lewis dot structure and the octet rule
c. Transferring vs. sharing of electrons
d. Ionic bonding (formula unit) and ionic radius
e. Covalent bonding (molecule) and internuclear distance
f. Representing ionic and molecular compounds using Lewis dot diagrams
g. Identifying and drawing resonance structures
h. Bond polarity and electronegativity trend on the periodic table
i. Coordinate covalent bonds defined

j. Hydrogen bonding (hydrogen bonded to N, O or F)
k. Intramolecular and intermolecular attractions
l. VSEPR (valence shell electron pair repulsion) theory
    i. Accounts for geometry of molecules
    ii. Electron pairs spatially as far apart as possible.
m. Electron geometry vs. molecular geometry
n. geometric classes
    i. Linear
    ii. Trigonal planar (subclass bent)
    iii. Tetrahedral (subclasses trigonal pyramidal and bent)
o. Molecular polarity dependent upon ΔElectronegativity of bonding atoms and geometry of molecule.

Please remember that this outline is only a guide. It is not meant to be a substitute for a comprehensive review of the material.

Information and equations that will be included on the final.

$^oC = 5(^oF-32)/9$ $K = {}^oC + 273.15$ $^oF = 9^oC/5 + 32$ $1mL = 1cm^3$

Density (d) = mass/Volume 1 micro = $1\mu = 10^{-6}$ 1 nano = $1n = 10^{-9}$

$E = mc^2$ Mass of electron = $9.11x10^{-31}kg$ Charge of electron = $-1.602x10^{-19}C$

Weighted average = (Isotopic $mass_1$)(isotopic decimal percent $abundance_1$) + (Isotopic $mass_2$)(isotopic decimal percent $abundance_2$) + (Isotopic $mass_3$)(isotopic decimal percent $abundance_3$) + …

$c = \lambda\nu$ $E = h\nu$ or $E = hc/\lambda$ c = speed of light = $3.0x10^8 m/s$

h = Planck's constant ($6.626x10^{-34}Js$) $\Delta x \Delta mv \geq h/4\pi$

Max $e = 2n^2$ q = m x c x ΔT (specific heat equation)