Incoming Graduate Student Expectations

It is expected that incoming graduate students will possess a solid foundation in the four main areas of Chemistry (analytical, inorganic, organic and physical). Some specific foundation topics that are expected to have been mastered include: compositional analysis, stoichiometry, chemical reactions, thermochemistry, gases, solutions, chemical kinetics, chemical equilibria, pH, thermodynamics & electrochemistry. The students' background in each of the four areas will be assessed by a comprehensive exam given upon entering our masters program and the performance on this exam will determine whether the student will need to take undergraduate level classes to correct deficiencies before continuing on to take graduate level classes in these areas.

The expected Chemistry background for incoming graduate students is outlined below (arranged by each of the sub-disciplines in Chemistry).

Analytical Chemistry

Entering graduate students will be expected to have taken at least one semester of analytical chemistry including advanced chemical equilibria, statistical analysis of data, and spectrophotometry. A second semester covering instrumental methods is recommended but not required. Relevant topics include (but are not limited to): Gaussian distributions, t-tests, F-test, Q-test, strong acids & bases, weak acid/base equilibria, buffer solutions, polyprotic acids/bases and buffers, systematic treatment of equilibria, solubility equilibria, complexation equilibria, spectrophotometry, volumetric analyses, gravimetry, Beer's law applications, calibrations and linear least squares, electrochemistry fundamentals, Nernst equation, and potentiometry.

Students displaying deficiencies in the above areas on the entrance exam will be required to take and pass CHM2730 (Quantitative Analysis) before graduate level classes in this field may be taken.

Inorganic Chemistry

Entering graduate students will be expected to have taken at least one semester of inorganic chemistry beyond general chemistry including periodicity, structure and bonding, solid state, and coordination chemistry. Relevant topics include (but are not limited to): Lewis structures, VSEPR theory, symmetry elements, point groups, bonding theories (crystal field, valence bond, and molecular orbital theories), coordination complexes (nomenclature, structure, bonding, electronic and magnetic properties, and reactivity), rates and mechanisms of reactions of coordination complexes, periodic law, effective nuclear charge, periodic variation of properties (atomic radii, ionization energy, and electron affinity), crystal lattices, radius ratios, solid-state energetics, acid-base theories and oxidation-reduction.

Students displaying substantial deficiencies in the above areas on the entrance exam may be required to take and pass CHM 2310 (Inorganic Chemistry I) before graduate level classes in this field (CHM 4900; Inorganic Chemistry II or courses numbered 5000 and above) may be taken.

Organic Chemistry

Entering graduate students will be expected to have taken at least two semesters of sophomore level organic chemistry along with at least one semester of organic lab. Relevant topics include (but are not limited to):

- Atoms, molecules, bonding, polar and nonpolar molecules, intermolecular forces, solubilities, Lewis structures, resonance structures, curved arrow formalism, acids and bases.
- Molecular orbital description of bonding and hybridization, Hückel MO theory for conjugated alkenes and aromatics.
- Conformation analysis: alkanes (Newman projections), cycloalkanes
- Stereochemistry - chirality, enantiomerism, diastereomerism, R/S nomenclature, E/Z nomenclature, optical resolution
- Nomenclature of organic compounds
- Principles of reactivity - induction, resonance, hyperconjugation, sterics; application to predicting/explaining products in a reaction, free-radical reactions
- Reactions of alkenes, alkynes, alkyl halides (S_N1, S_N2, E1, E2), alcohols (substitution, elimination, oxidation), aromatics (electrophilic and nucleophilic substitutions, benzyne), carbonyls (additions, substitutions, condensations, reductions), amines, dienes (1,2 vs 1,4 additions, Diels-Alder reactions)
- Spectroscopy: NMR, IR, UV-vis, and mass spectrometry.

Students displaying deficiencies in the above areas on the entrance exam will be required to take and pass CHM2440 and 2840 (Organic Chemistry I and II) before graduate level classes in this field may be taken. Students without the prerequisite lab experience will be required to take and pass CHM2445 (Organic I lab).

Physical Chemistry

Entering graduate students will be expected to have taken at least one semester of physical chemistry, including thermodynamics and kinetics. A second semester, covering quantum mechanics and spectroscopy, is recommended but not required. Relevant topics include (but are not limited to): conceptual understanding and calculation of changes in heat, work, internal energy, enthalpy, entropy, Gibbs energy, and Helmholtz energy using calculus-based methods; Maxwell relations between thermodynamic quantities; gas laws and the kinetic-molecular theory of gases; 0^{th}, 1^{st}, 2^{nd}, and 3^{rd} Laws of Thermodynamics; equilibrium and Le Châtelier's Principle; interpretation of one and two component phase diagrams (including one, two or three phases); colligative properties; models governing behavior and thermodynamics of electrolyte solutions (such as the Debye-Hückel Limiting Law); electrochemical cells, cell potentials, and redox reactions; thermodynamics of electrochemical cells; conceptual and quantitative understanding of rate laws, integrated rate laws, Arrhenius equation, elementary reactions, and the steady-state approximation.

Students displaying deficiencies in the above areas on the entrance exam will be required to take and pass CHM3910 (Thermodynamics and Kinetics) before graduate level classes in this field may be taken.