Course Prerequisite Information for Incoming CHEM Graduate Students

Incoming CHEM graduate students will be required to enroll in two OR three graduate courses in the first semester. For a complete summary of PhD course requirements, see the Chemistry and Biochemistry Graduate Handbook: http://www.chemistry.gatech.edu/sites/www.chemistry.gatech.edu/files/chemgradhandbook.pdf .

Below are topics that students should know prior to starting graduate courses in the first semester. Students will be asked to take a self-assessment exam (15-20 questions) during orientation. Incoming students are strongly advised to review their likely major area of study and an additional area of study prior to arrival.

Analytical chemistry course prerequisites:

1) Strongly Encouraged Topics

1. Basic Thermodynamics and Chemical Kinetics:
   1. Stoichiometry. Chemical Equilibria.
   2. Acids & Bases. Buffers.
   3. Activity vs. Concentration.
   4. Ionic strength.
   5. Thermodynamics : Enthalpy, Entropy and Free Energy.
   6. Electrochemistry: Galvanic Cells, Electrolytic Cells, Batteries etc.
   7. General concepts of bonding, electronic structure and Quantum Chemistry.
   8. Chemical Kinetics: reaction rates and rate laws.
2. Basic knowledge of Quantitative Analysis techniques and theory:
   1. Experimental Error and Basic Statistics. Probability distributions. Measurement of accuracy and precision. Hypothesis testing. Experimental design. ANOVA.
   2. Calibration curves and standard addition techniques. Least-Squares Regression and Correlation.
   3. Detection and Quantitation limits. Sensitivity and Selectivity.
   4. Mass and Charge Balances applied to Aqueous Chemical Equilibria (Acid Base, Solubility, Complexation)
   5. Fundamentals of Spectrophotometry. Beer's Law, mixtures.
   6. Basic Analytical Separations. Liquid-Liquid Extraction, Solid Liquid Extraction. Chromatography, Electrophoresis. Ion Exchange.
3. Basic knowledge of Instrumental Analysis techniques and associated concepts
   1. Molecular Spectroscopy: UV-VIS, Luminescence, IR, Raman, NMR, Mass Spectrometry.
   2. Potentiometry, Coulometry, Voltametry.
   3. HPLC, CE, GC,

2) Suggested topics

1. Electrical components and Electronics
2. Digital Electronics and Computer Interfacing
3. Analog and Digital Signal Processing Methods: Fourier Transform, Filter Designs, Sampling of Digital Signals, A/D conversion, Smoothing and Peak Detection Algorithms.
4. Modern optical detectors (CCDs, Avalanche Photodiodes, EMCCDs)
5. Particle size analyses

3) Suggestions and other useful skills that could make your life easier depending on planned research

- Knowledge of data processing software such as Matlab, Igor, Mathematica.
- Knowledge of graphing software such as Origin, Sigmaplot
- Knowledge of Microsoft Office suite or equivalent. Use of revision tools (track changes, compare versions etc.)
- Knowledge of LabView
- Hard work
- Patience, patience, patience
- Resilience
- Knowledge of a CAD program for figures, presentations, etc. (e.g. Solidworks or Google Sketchup)
- Take pictures/sketches of set-ups and instrument configurations throughout all phases of experiments to aid in troubleshooting later on-

- Recording ideas and updates in lab notebook regularly

Biochemistry course prerequisites:

General chemistry: Acid-base equilibria, Redox reactions

Basic Organic Chemistry: recognition of the common functional groups encountered in biochemistry (amine, alcohol, , ketone, aldehyde, carboxylic acid, amide, thiol) reactivities of alcohols, amines, thiols, carbonyls, carboxylic acids, familiarity with the S_N2, S_N1, E1, and E2 reaction mechanisms

Basic Physical Chemistry: basic thermodynamics (chemical potential, equilibrium constant), basic kinetics (zero order reactions, first order reactions)

Introductory Biology: structure of prokaryotic and eukaryotic cells, evolution of life, basic concepts of replication, transcription, and translation

Undergraduate Biochemistry:

- ► Acid-base equilibria and pH buffers
- ► Basic mechanisms of Replication, Transcription, Translation
- ► Structure and properties of the 20 biogenic amino acids
- ► Structure and properties of the common nucleotides in DNA and RNA, Basic structure and properties of DNA
- ► General principles of protein structure and folding
- ► Enzyme kinetics (including the Michaelis-Menten Equation and Lineweaver Burke analysis), Enzyme inhibition, Utilization of a Lineweaver Burke analysis to determine the type of enzyme inhibitor, general mechanisms of enzyme catalysis, allosteric regulation
- ► Carbohydrates (basic chemistry, glucose and biological glucose polymers) and fundamentals of glycoproteins (N- and O-glycosylation)
- ► Structure and properties of lipids and biomembranes (fluid-mosaic model)
- ► Fundamentals of metabolism (glycolysis, TCA cycle, fatty acid degradation, fatty acid biosynthesis, gluconeogenesis, ethanol and lactic acid fermentation, oxidative phosphorylation, common coenzymes and their general uses)

Inorganic chemistry course prerequisites:

1] Atomic structure and periodic trends.
Atomic orbitals and quantum numbers; orbital ordering and orbital shapes; trends in ionization energy, electron affinity and electronegativity.
2] Structures and bonding models for covalent compounds of p-block elements.
VSEPR; hybrid orbitals; molecular orbitals for simple diatomic and triatomic molecules and network covalent solids.
3] Structures and bonding in metals and ionic compounds.
Structures and bonding in metals, alloys, and ionic compounds; crystal lattices and unit cells; lattice energies and energetics of ionic bonds; solubilities of ionic compounds and intermolecular forces.
4] Descriptive chemistry of s- and p-block elements.
Common reactivity patterns of compounds of hydrogen, oxygen and halogens; Bronsted and Lewis acids and bases.
5] Redox chemistry.
Oxidation numbers; thermodynamics of oxidation and reduction; Latimer, Frost and Pourbaix Diagrams.
6] Introductory coordination chemistry.
Structures of coordination complexes, including stereochemistry, isomerism and nomenclature; bonding and energetics of coordination complexes; ligand substitution reactions and equilibria, including kinetic vs. thermodynamic stability; oxidation states in transition metal complexes.

Organic chemistry course prerequisites:

Topics for Graduate Organic Course Preparation:

Students should be familiar with topics covered in sophomore organic chemistry. "Organic Chemistry", 10th edition, by T.W. Graham Solomons or a similar text should be reviewed.

Topics include: bonding and molecular structure, functional groups, intermolecular forces, resonance structures, fundamentals of acids and bases, nomenclature, conformational analysis of cycloalkanes, stereochemistry, a mechanistic understanding of the following types of reactions: nucleophilic substitution, elimination, addition reactions, radical reactions, aromatic electrophilic substitution, oxidation-reduction and organometallic compounds (Grignard, Wittig, Organolithium reagents), condensation reactions, addition-elimination reactions at acyl carbons, reactions of diazonium salts, reactions of amino compounds. In addition, one should know chemistry of conjugated unsaturated systems, aromaticity, protecting groups, NMR, IR, mass spectrometry fundamentals, 1H and 13C NMR, MS, and FTIR analysis.

Practice exams:
http://ww2.chemistry.gatech.edu/~collard/CHEM2311/(exams).htm
http://ww2.chemistry.gatech.edu/~collard/CHEM2312/(exams).htm

Physical chemistry course prerequisites:

Quantum Chemistry-McQuarrie, 2nd Edition.
A thorough understanding of quantum mechanics at the level of this textbook will prepare you for graduate-level quantum mechanics. The math review chapters (only in the 2nd edition) will serve you well in all of your graduate classes.

Molecular Thermodynamics-McQuarrie and Simon This textbook will give you a good understanding of thermodynamics and help to prepare you for statistical mechanics.

* Knowledge of basic linear algebra: how to take the dot product of two vectors, how to multiply a matrix by a vector or another matrix, how to take the determinant of a matrix, how to get the eigenvectors and eigenvalues of a matrix.

* Knowledge of basic calculus and simple differential equations: how to differentiate and integrate polynomials, trigonometric functions, and exponentials; how to obtain exponential decays from first order differential equations; how to Taylor expand a function near a minimum.