Chemistry

The chemistry graduate admission test (MS and PhD programs) will consist of about 80 multiplechoice questions. A periodic table and essential information regarding physical constants and conversion factors will be provided at appropriate places. Use of calculators and mobile phones is not allowed.

The content of the test emphasizes physical chemistry, inorganic chemistry, analytical chemistry and organic chemistry as described below.

I. Physical Chemistry (~30%)

Thermodynamics: First, second and third laws, thermochemistry, ideal and real gases and solutions, Gibbs and Helmholtz energy, chemical potential, chemical equilibria, phase equilibria, colligative properties, statistical thermodynamics.
Quantum Chemistry and Applications to Spectroscopy: Classical experiments, principles of quantum mechanics, atomic and molecular structure, molecular spectroscopy.
Dynamics: Experimental and theoretical chemical kinetics, solution and liquid dynamics, photochemistry.

II. Inorganic Chemistry (~25%)

General Chemistry: Periodic trends, stoichiometry, oxidation states, nuclear chemistry.
Ionic Substances: Lattice geometries, lattice energies, ionic radii, and radius/ratio effects. Covalent Molecular Substances: Lewis diagrams, molecular point groups, VSEPR concept, valence bond description and hybridization, molecular orbital description, bond energies, covalent and van der Waals radii of the elements, intermolecular forces.
Metals and Semiconductors: Structure, band theory, physical and chemical consequences of band theory.
Acids and Bases: Bronsted-Lowry approaches, Lewis theory, solvent system approaches. Chemistry of the Main Group Elements: Electronic structures, occurrences and recovery, physical and chemical properties of the elements and their compounds.
Chemistry of the Transition Elements: Electronic structures, occurrences and recovery, physical and chemical properties of the elements and their compounds, coordination chemistry. Special Topics: Organometallics, catalysis, bioinorganic chemistry, solid state chemistry and environmental chemistry.

III. Analytical Chemistry (~15%)

Data Acquisition and Use of Statistics: Errors, statistical considerations
Solutions and Standardization: Concentration terms, primary standards
Homogeneous Equilibria: Acid-base, oxidation-reduction, complexometry

Heterogeneous Equilibria: Gravimetric analysis, solubility, precipitation titrations, chemical separations.

Instrumental Methods: Electrochemical methods, spectroscopic methods, chromatographic methods, thermal methods, calibration of instruments.

IV. Organic Chemistry (~30%)

Structure, Bonding and Nomenclature: Lewis structures, orbital hybridization, configuration and stereochemical notation, conformational analysis, systematic IUPAC nomenclature, spectroscopy (IR, ^{1}H and ^{13}C NMR).

Functional Groups: Preparation, reactions, and interconversions of alkanes, alkenes, alkynes, dienes, alkyl halides, alcohols, ethers, epoxides, sulfides, thiols, aromatic compounds, aldehydes, ketones, carboxylic acids and their derivatives, amines.

Reaction Mechanisms: Nucleophilic displacements and additions, nucleophilic aromatic substitutions, electrophilic additions, electrophilic aromatic substitutions, eliminations, DielsAlder and other cycloadditions.

Reactive Intermediates: Chemistry and nature of carbocations, carbanions, free radicals, carbenes, benzynes, enols.

Organometallics: Preparation and reactions of Grignard and organolithium reagents, and other modern main group and transition metal reagents and catalysts.

Special Topics: Resonance, molecular orbital theory, catalysis, acid-base theory, carbon acidity, aromaticity, antiaromaticity, macromolecules, lipids, amino acids, peptides, carbohydrates, nucleic acids, terpenes, asymmetric synthesis, orbital symmetry, polymers.