Proposed Content for the Project
(Scope and Sequence)

The scope and sequence of the proposed project is not unusual. It follows the path of many available general chemistry texts. What we feel is innovative about the proposed curriculum is the tools that we will develop and how they offer a fully integrated teaching and learning package. As such the following proposed topics is not rigid. The authors are open to additions and subtractions to suit the needs of potential users.

a. Topics

Chemistry I
Unit 1 - Basic Concepts, Atoms, Molecules, & Ions -
Unit 2 - Stoichiometry -
Unit 3 - Thermochemistry -
Unit 4 - Atomic Structure & Periodicity -
Unit 5 - Molecular Structure & Bonding -
Unit 6 - Properties of Gases, Liquids and solids

Chemistry II
Unit I - Kinetics -
Unit II - Equilibrium -
Unit III - Acid/Base -
Unit IV - Aqueous Equilibrium -
Unit V - Chemical Thermodynamics -
Unit VI - Electrochemistry -

b. Sub Topics

Chemistry I
Unit 1 - Basic Concepts, Atoms, Molecules, & Ions -
- Metric Measurement and Conversions
- Significant Figures
- Basic Periodicity
- Basic Atomic Theory
- Formulas and Nomenclature of Simple Compounds

Unit 2 - Stoichiometry -
- Molar Masses
- Chemical Equations
- Mass and Molar and Molecular Reaction Relationships
- Molar Concentration

Unit 3 - Thermochemistry -
- Calorimetry
- Enthalpy in Physical and Chemical Change
- Hess' Law
- Enthalpies of Formation

- Bond Energies

Unit 4 - Atomic Structure & Periodicity -
- Light
- Line Spectra
- Energy Levels
- Quantum Numbers
- Electron Configuration
- Orbitals
- Periodicity

Unit 5 - Molecular Structure & Bonding -
- Polarity
- Simple Bonding Types
- Lewis Structures
- Molecular Geometry

Unit 6 - Properties of Gases -
- Pressure
- Ideal Gas Law (Boyle's Law, Charles' Law, Gay Lussac, Avogadro)
    - Gas Density
    - Molar Mass
    - Gas Stoichiometry
- Dalton's Law
- KMT
- Graham's Law
- Real Gases
- Phase Change
- Intermolecular Bonding
- Solutions

Chemistry II

Unit I - Kinetics -
- Collision Theory
- Rates, Rate Laws, and Rate Constants
- Half Life
- Reaction Profiles
- Catalysts
- Activation Energy
- Temperature Effects
- Mechanisms

Unit II - Equilibrium -
- Law of Mass Action
- Equilibrium Stoichiometry
- Le Chatelier's Principle

Unit III - Acid/Base -
- pH
- Acid/Base Theories
- Strong Acids

Weak Acids
A/B Salts
Polyprotic Acids

Unit IV - Aqueous Equilibrium -
Buffers
A/B Neutralization/Titration
Solubility Product

Unit V - Chemical Thermodynamics -
Enthalpy
Entropy
Gibbs Equation
Free Energy and Equilibrium and Temperature

Unit VI - Electrochemistry -
Balance Redox Equations
Voltaic Cells
Standard Potentials
Electrical Potential, Equilibrium, and Free Energy
Non Standard Conditions
Electrolytic Cells

c. Learning Objectives:

Chemistry I

Unit 1 - Basic Concepts, Atoms, Molecules, & Ions -

1.1. Convert units (e.g., length, mass, volume, temperature) within a unit system
1.2. Convert units (e.g. length, mass, volume, temperature) between unit systems.
1.3. Combine measurements to calculate properties (e.g. density).
1.4. Express measured and calculated quantities in exponential form.
1.5. Express measured quantities in the proper number of significant figures.
1.6. Express calculated quantities in the proper number of significant figures.
1.7. Trace the historical development of theories of matter.
1.8. State the name and symbol for the elements and their ions.
1.9. Characterize the important subatomic particles.
1.10. Determine the subatomic structure of atoms, ions, and isotopes. Use ${}^{A}_{Z}X$ charge notation.
1.11. Characterize the various parts of the periodic table.
1.12. Name and write formulas for simple compounds.

Unit 2 - Stoichiometry -

2.1. Determine atomic weights from isotope abundance.
2.2. Relate formula weights and moles to weights and numbers of particles in a chemical formula.
2.3. Determine the % composition of compounds.
2.4. Determine molecular formulas from experimental analysis data.
2.5. Write and balance simple chemical equations.
2.6. Relate numbers of moles, grams, and particles in a chemical equation. (including limiting reagents)

2.7. Determine and use molar concentration units.
2.8. Use the $M_AV_A = M_BV_B$ relationship to do dilution determinations.

Unit 3 - Thermochemistry -
3.1. Utilize and convert different forms of energy.
3.2. Determine the heat produced by a chemical or physical process from experimental data (calorimetry).
3.3. Determine the heat produced during changes in state from experimental data.
3.4. Given a thermochemical equation, calculate ΔH for a given amount of reactant or product.
3.5. Apply Hess' Laws to determine ΔH for reactions.
3.6. Apply standard ΔH_f to determine ΔH_{rxn} of reactions.
3.7. Use bond energies to predict ΔH_{rxn}.

Unit 4 - Atomic Structure & Periodicity -
4.1. Relate color, λ, speed, and energy of light being released or absorbed by atoms.
4.2. Interpret the line spectrum of an atom in terms of quantum mechanics.
4.3. Describe the location and nature of electrons in an atom or ion in terms of: (a) quantum numbers, (b) energy level diagrams, (c) electron configuration, and (d) orbital shape.
4.4. Relate the periodic table to electron configurations.
4.5. Predict trends; similarities, and differences of physical and chemical properties of elements using the periodic table and electron configuration. (e.g. ionization energy, radius, formulas, reactivity)

Unit 5 - Molecular Structure & Bonding -
5.1. Predict the relative polarity and ionic/covalent character of bonds and molecules.
5.2. Identify simple bonding types.
5.3. Draw Lewis structures of ions and molecules.
5.4. Identify resonance structures for molecules.
5.5. Determine the geometric arrangement of atoms in a molecule.
5.6. Predict the types of orbitals (including hybrids) involved in bonding and resulting bond types (sigma, pi).

Unit 6 - Properties of Gases -
6.1. Describe measuring gas pressures using barometers and manometers. Relate pressure units.
6.2. Apply the ideal gas law to relate and calculate values for pressure, volume, temperature, and amount of a gas.
6.3. Apply Dalton's Law of partial pressure to calculate the pressure of combined gases and to calculate the partial pressures of gases in mixtures.
6.4. Describe gases in terms of KMT.
6.5. Relate MW and speeds of molecules using Graham's law.
6.6. Distinguish between ideal and real gases.
6.7. Use KMT to explain the general properties of liquids and solids and to explain phase changes.
6.8. Classify intermolecular bonds and predict relative properties of chemical substances.
6.9. Describe the structure and properties of liquids.
6.10. Describe the structure and properties of solids.

6.11. Interpret phase diagrams.
6.12. Characterize the dissolving process. Characterize hydrolysis.
6.13. Characterize solutions as strong electrolytes, weak electrolytes, and nonelectrolytes.

Chemistry II
Unit I - Kinetics -
1.1. Express and compare rates of chemical reactions in terms of the concentration changes of the reactants and products (or factors proportional to concentration) per unit time.
1.2. Use collision theory to explain how chemical reactions occur and how rates are affected.
1.3. From experimental kinetics data, derive the rate law, order, and rate constant for a chemical reaction.
1.4. For a zero, first or second order reaction, determine the exact rate constant and half-life for a chemical reaction from time/concentration data.
1.5. From a reaction profile, determine ΔH & E_a for a chemical reaction. [Readings 16.6 Problem 62]
1.6. Explain the role of catalysts, what they are, how they work, and how they affect a reaction profile.
1.7. From kinetic data, determine the relationship between E_a, k, and the temperature of both catalyzed and uncatalyzed chemical reactions.
1.8. Determine the relationship between the rate law and the mechanism of a simple chemical reaction.

Unit II - Equilibrium -
2.1. Characterize chemical reactions in terms of reversibility and relative concentrations of reactants and products.
2.2. Determine equilibrium expressions for homogeneous and heterogeneous chemical reactions from stoichiometry.
2.3. Determine the stoichiometric relationship between initial and equilibrium concentrations of reactants and products.
2.4. Determine the relationship between Kold and Knew when a chemical reaction is reversed or multiplied by a constant factor of n.
2.5. Determine the relationship between KC and KP for a chemical reaction involving gaseous components.
2.6. Determine value for K from equilibrium concentrations of reactants and products in a chemical reaction.
2.7. Determine the equilibrium concentrations of reactants and products of a chemical reaction from initial concentrations and value of K.
2.8. Determine if equilibrium has been reached in a chemical reaction; determine the direction the reaction will shift if equilibrium has not been reached.
2.9. Use Le Châtelier's Principle to predict the direction a reaction at equilibrium will shift as a result of changes in concentration, pressure/volume, and temperature as it approaches a new equilibrium.

Unit III - Acid/Base -

3.1. Relate $[H^+]$, $[OH^-]$, and K_W in an aqueous solution.
3.2. Determine the pH and/or pOH of an aqueous solution from the $[H^+]$ (or $[OH^-]$) and v.
3.3 Define acids and bases in terms of Arrhenius, and Brönsted-Lowry theories.
3.4. Recognize and construct conjugates of acids or bases.
3.5. Determine the $[H^+]$, $[OH^-]$, pH and/or pOH of a strong acid or strong base solution.
3.6. Determine and relate equilibrium concentrations, $[H^+]$, $[OH^-]$, pH and/or pOH with K_a values for weak acids (also, same for K_b values for weak bases).
3.7. Determine the $[H^+]$, $[OH^-]$, pH and/or pOH for weak acids or weak bases from initial concentrations.
3.8. Construct an ordered list of strongest to weakest (or v.v.) for acids or bases.
3.9. Determine the K_b for a weak base, given the K_a value of its conjugate acid (v.v.).
3.10. Determine the $[H^+]$, $[OH^-]$, pH and/or pOH of a salt solution.
3.11. Qualitatively determine the acidic, basic, or neutral properties of a salt.
3.12. Identify acids and bases using Lewis theory.
3.13. Determine the $[H^+]$, $[OH^-]$, pH and/or pOH of weak and strong polyprotic acids.

Unit IV - Aqueous Equilibrium -
4.1. Define and make buffer solutions from (1) a weak acid and its conjugate base, (2) a weak base and its conjugate acid, (3) a weak acid and a strong base, and (4) a weak base and a strong acid.
4.2. Determine the pH of a buffer solution from concentrations and v.v.
4.3. Make a buffer with a specific pH. [Readings 19.1 Problems 23,25]
4.4. Determine the conjugate pair best suited to make a buffer of desired pH.
4.5. Analyze a strong acid/strong base titration (including polyprotic) (determine end point location and entire pH curve, including pH at beginning, pH at end point, and pH at all other points).
4.6. Analyze a titration of a weak acid or base with a strong base or acid (determine end point location and entire pH curve, including pH at beginning, pH at end point, and pH at all other points).
4.7. Determine the K_{SP} equilibrium expression for a partially soluble salt.
4.8. Determine the K_{SP} value, given the solubility of a salt (v.v.).
4.9. Determine the effect of a common ion on the solubility of a partially soluble salt.

Unit V - Chemical Thermodynamics -
5.1. Apply Hess' Laws to thermodynamic quantities.
5.2. Determine $\Delta H°$ for a chemical reaction from $\Delta H_f°$ values of reactants and products.
5.3. Predict the qualitative change in enthalpy for various chemical reactions.
5.4. Predict and compare the qualitative change in entropy for various chemical reactions and physical processes.
5.5. Determine $\Delta S°$ for a chemical reaction from $S°$ values of reactants and products.
5.6. Determine $\Delta G°$ for a chemical reaction from the Gibbs equation.
5.7. Determine $\Delta G°$ for a chemical reaction from $\Delta G_f°$ values of reactants and products.
5.8. Determine ΔG for a chemical reaction from $\Delta G°$ and the reaction quotient, Q.
5.9. Predict whether a chemical reaction, as written, is spontaneous, non-spontaneous, or at equilibrium.
5.10. Calculate the standard free energy for a chemical reaction from the equilibrium constant

(v.v.).
5.11. Determine the equilibrium temperature, T_e, for a chemical reaction from $\Delta H°$ and $\Delta S°$ (v.v.).

Unit VI - Electrochemistry -
6.1. Assign oxidation numbers (oxidation states) to individual elements in a chemical compound or complex ion.
6.2. Recognize redox reactions; distinguish from reactions not involving oxidation/reduction.
6.3. Stoichiometrically balance both half-reactions and cell reactions involving redox.
6.4. Draw a diagram of a voltaic (galvanic, spontaneous) cell and explain how it works, predicting changes that will occur during discharge.
6.5. Define and identify anode, cathode, oxidation process, reduction process, oxidizing agent, and reducing agent for a redox reaction.
6.6. Calculate $E°$ for a chemical reaction using a standard reduction potential table.
6.7. Predict the products of a redox reaction.
6.8. Calculate and relate values of $E°$, $\Delta G°$, and K for an oxidation-reduction reaction.
6.9. Calculate E for a redox reaction under non-standard conditions of constituent concentrations and/or pressures.
6.10. Draw a diagram of an electrolytic (non-spontaneous) cell and explain how it works, predicting changes that will occur during operation.
6.11. Construct a line notation for an electrochemical cell from information concerning the anode, cathode, oxidation process, reduction process, oxidizing agent, and/or reducing agent (v.v.).
6.12. Relate the amount of product(s) produced and/or reactant consumed in an electrolytic cell to the current used, time involved, and moles of electrons associated with the corresponding half-reaction.