

Scope and Sequence for *Discovering Design with Chemistry*

This college-preparatory, laboratory-based chemistry course offers the student who has completed algebra 1 a firm foundation in the basic laws and theories of modern chemistry. It begins with a thorough discussion of measurement and units, significant figures, accuracy, precision, and density. It then discusses the classification of matter, emphasizing mixtures, pure substances, compounds, and elements. This leads to a discussion of the Periodic Table of the Elements.

The student then learns atomic theory, which begins with Dalton's Atomic Theory and ends with the modern quantum-mechanical model. Along the way, the student explores the nature of light, including particle/wave duality. The student also learns the relationships between wavelength, frequency, and energy. The quantum-mechanical model of the atom allows the student to learn electron configurations and the logic behind the Periodic Table's arrangement of the elements.

Once the student understands electron configurations, Lewis structures are taught so the student can understand compounds. Ionic compounds are discussed first, followed by covalent compounds. In each case, the student is taught how to name and determine the chemical formulas of these compounds as well as the difference between ionic and covalent compounds. Finally, the student learns the geometry of covalent compounds and the distinction between polar and nonpolar molecules.

An understanding of molecular structure allows the student to distinguish between chemical and physical changes. Physical changes such as temperature changes and phase changes are discussed in depth, and then chemical change is discussed. The student learns to balance chemical equations and classify chemical reactions.

The course then moves into a rigorous discussion of stoichiometry, including the mole concept, hydrated compounds, mole relationships in chemical equations, and mass relationships in chemical equations. These concepts are applied in discussing combustion analysis, decomposition analysis, and percent yield. The student also learns the distinction between empirical and molecular formulas.

At this point, the student learns about the chemistry that occurs in solution, including why solutes dissolve in solvents, the importance of concentration, molarity, molality, freezing-point depression, and boiling-point elevation. The gas phase is then discussed, covering Boyle's Law, Charles's Law, the Ideal Gas Law, Avogadro's Law, Dalton's Law of Partial Pressures, and the real definition of boiling point.

The course then moves on to a discussion of acid/base reactions, pH, neutralization, indicators, and titration. Reduction/oxidation reactions are then discussed, teaching the student how to determine oxidation state, analyze reduction/oxidation reactions, and balance simple reduction/oxidation equations. The student also learns how to analyze Galvanic cells and batteries.

With this understanding of the basic types of chemical reactions that occur in nature, the student is then introduced to thermochemistry, including discussions of heat capacity, calorimetry, and latent heat. With this information, the student is ready to learn thermodynamics, including the meanings behind ΔH , ΔS , and ΔG . The student learns how to calculate each of these quantities and how to use them to determine whether or not a reaction is spontaneous. Special attention is given to the proper means by which one interprets entropy changes.

The book continues with a discussion of kinetics that allows the student to analyze the Rate Equation and use experiments to determine the order of a reaction with respect to its reactants. The student also learns the factors that affect the rate of a chemical reaction and how the rate constant varies with temperature and activation energy. The concepts of kinetics are then used in the final chapter of the book, which covers chemical equilibrium. The student learns the equilibrium constant, how to use it to predict the progress of an equilibrium reaction, and Le Chatelier's Principle.

There are a total of total of 46 experiments that require roughly 40 hours of laboratory work. Of those experiments, 13 are quantitative in nature. For example, one experiment has the student measure the wavelength of the microwaves used in a microwave oven. In another experiment, the student determines the number of molecules of water incorporated into the crystal of a hydrated compound. The student also measures the amount of sodium bicarbonate in an Alka-Seltzer tablet, the concentration of hydrogen peroxide in a drug store solution, the percent of acetic acid in vinegar, and the energy released in a chemical reaction. In addition, there is a classic percent yield experiment.

The rest of the experiments are qualitative in nature. For example, the student uses a feather and a lamp to see interference among light waves. A battery and steel wool demonstrate that metals can be burned. Ice and hot water are used to illustrate the importance of latent heat, and the student uses hydrogen peroxide and yeast to see that a catalyst is not used up during a chemical reaction. This combination of quantitative and qualitative experiments allows the student to learn good laboratory technique and helps the student visualize many of the concepts that are being discussed.