

## AP Chemistry

This course covers the topics shown below.  
Students navigate learning paths based on their level of readiness.  
Institutional users may customize the scope and sequence to meet curricular needs.

Curriculum (363 topics + 470 additional topics)

- Math Toolbox (32 topics)
  - Mathematics (10 topics)
    - Integer multiplication and division
    - Simplifying a fraction
    - Equivalent fractions
    - Signed fraction multiplication: Basic
    - Signed fraction division
    - Writing expressions using exponents
    - Introduction to exponents
    - Ordering numbers with positive exponents
    - Evaluating an expression with a negative exponent: Whole number base
    - Square root of a perfect square
  - Algebra Expressions (9 topics)
    - Evaluating a quadratic expression: Integers
    - Combining like terms: Integer coefficients
    - Combining like terms in a quadratic expression
    - Introduction to the product rule of exponents
    - Introduction to the product rule with negative exponents
    - Introduction to the quotient rule of exponents
    - Simplifying a ratio of univariate monomials
    - Introduction to the power of a product rule of exponents
    - Power and quotient rules with positive exponents
  - Linear Equations (5 topics)
    - Additive property of equality with integers
    - Additive property of equality with a negative coefficient
    - Multiplicative property of equality with signed fractions
    - Solving for a variable in terms of other variables using addition or subtraction with division
    - Solving for a variable in terms of other variables in a linear equation with fractions
  - Quadratic and Radical Equations (3 topics)
    - Solving a quadratic equation using the square root property: Decimal answers, basic
    - Solving a quadratic equation using the square root property: Decimal answers, advanced
    - Applying the quadratic formula: Decimal answers
  - Graphing Equations (3 topics)
    - Classifying slopes given graphs of lines
    - Graphing a line through a given point with a given slope
    - Finding slope given two points on a line
  - Logarithms and Exponentials (2 topics)
    - Evaluating a logarithmic expression
    - Solving an equation of the form  $\log_b a = c$
- Science Toolbox (37 topics)
  - Scientific Notation (1 topics)
    - Converting between decimal numbers and numbers written in scientific notation
  - SI Units (4 topics)
    - Knowing the value of an SI prefix as a power of 10
    - Interconversion of prefixed and base SI units
    - Interconversion of prefixed SI units
    - Interconverting temperatures in Celsius and Kelvins
  - Measurement Math (3 topics)
    - Addition and subtraction of measurements
    - Simplifying unit expressions
    - Multiplication and division of measurements

- Measurement Uncertainty (5 topics)
  - Counting significant digits
  - Rounding to a given significant digit
  - Counting significant digits when measurements are added or subtracted
  - Counting significant digits when measurements are multiplied or divided
  - Adding or subtracting and multiplying or dividing measurements
- Quantitative Problem Solving (10 topics)
  - Setting up a one-step unit conversion
  - Setting up a unit reprefix conversion
  - Setting up a unit conversion
  - Predicting the units of the solution to a basic quantitative problem
  - Deducing the unit missing from the solution to a basic quantitative problem
  - Setting up the solution to a basic quantitative problem
  - Identifying errors in the solution to a basic quantitative problem
  - Setting up the math for a one-step quantitative problem
  - Setting up the math for a one-step problem with unit conversion
  - Setting up the math for a two-step quantitative problem
- Mass, Volume and Density (2 topics)
  - Calculating mass density
  - Using mass density to find mass or volume
- Electrostatics (8 topics)
  - Understanding that opposite charges attract and like charges repel
  - Understanding net electrical charge
  - Understanding how electrostatic force scales with charge and separation
  - Calculating the magnitude of an electrostatic force using Coulomb's Law
  - Understanding how electrostatic forces cancel
  - Understanding that electrostatic forces add as vectors
  - Calculating electrostatic energy using Coulomb's Law
  - Sketching polarization induced by a nearby charge
- The Periodic Table of Elements (4 topics)
  - Names and symbols of important elements
  - Reading a Periodic Table entry
  - Organization of the Periodic Table
  - Using the Periodic Table to identify similar elements
- Atomic Structure and Properties (43 topics)
  - Atomic Structure (8 topics)
    - Identifying the parts of an atom
    - Counting protons and electrons in atoms and atomic ions
    - Finding isoelectronic atoms
    - Predicting the ions formed by common main-group elements
    - Isotopes
    - Finding atomic mass from isotope mass and natural abundance
    - Finding isotope mass or natural abundance from atomic mass
    - Counting valence electrons in a neutral atom
  - Elements, Compounds, and Mixtures (10 topics)
    - Distinguishing elements and compounds
    - Distinguishing compounds and mixtures
    - Counting the number of atoms in a formula unit
    - Classifying substances from a sketch
    - Distinguishing chemical and physical change
    - Distinguishing solid, liquid and gas phases of a pure substance
    - Using the Law of Constant Composition
    - Using the Law of Multiple Proportions
    - Naming common laboratory separation techniques
    - Distinguishing extensive and intensive properties
  - Elemental Analysis (4 topics)
    - Finding mass percent from chemical formulae
    - Solving applied mass percent problems
    - Elemental analysis
    - Combustion analysis
  - Moles and Molar Mass (6 topics)
    - Using the Avogadro Number
    - Calculating and using the molar mass of elements
    - Finding mole ratios from chemical formulae
    - Finding chemical formulae from a mole ratio

- Finding molar mass from chemical formulae
- Interconverting number of atoms and mass of compound
- Electron Configuration (8 topics)
  - Deciding the relative energy of electron subshells
  - Drawing a box diagram of the electron configuration of an atom
  - Interpreting the electron configuration of a neutral atom
  - Interpreting the electron configuration of a neutral atom in noble-gas notation
  - Writing the electron configuration of a neutral atom with s and p electrons only
  - Writing the electron configuration of a neutral atom with a filled d subshell
  - Writing the electron configuration of an atom using the Periodic Table
  - Identifying quantum mechanics errors in electron configurations
- Electronic Properties of the Elements (3 topics)
  - Identifying s, p, d and f block elements
  - Identifying elements with a similar valence electron configuration
  - Understanding the definitions of ionization energy and electron affinity
- Atomic Spectroscopy (4 topics)
  - Understanding the organization of the electromagnetic spectrum
  - Interconverting the wavelength and frequency of electromagnetic radiation
  - Interconverting wavelength, frequency and photon energy
  - Calculating the wavelength of a spectral line from an energy diagram
- Molecular and Ionic Compounds (41 topics)
  - Ionic Compounds (14 topics)
    - Predicting whether a compound is ionic or molecular
    - Predicting the formula of binary ionic compounds
    - Naming binary ionic compounds
    - Deducing the ions in a binary ionic compound from its empirical formula
    - Deducing the empirical formula of a binary ionic compound from its name
    - Predicting ionic compounds formed by two elements
    - Predicting and naming ionic compounds formed by two elements
    - Identifying common polyatomic ions
    - Predicting the formula of ionic compounds with common polyatomic ions
    - Naming ionic compounds with common polyatomic ions
    - Deducing the ions in a polyatomic ionic compound from its empirical formula
    - Identifying oxoanions
    - Naming ionic compounds with common oxoanions
    - Naming hydrates
  - Molecular Compounds (5 topics)
    - Writing a chemical formula given a molecular model
    - Writing a chemical formula given a chemical structure
    - Understanding the difference between a molecular and empirical formula
    - Understanding the prefixes used in naming binary compounds
    - Naming binary covalent compounds
  - Crystal Structures (2 topics)
    - Drawing the unit cell of a 2D lattice
    - Counting the atoms in a unit cell
  - Chemical Bonding (10 topics)
    - Counting bonding and nonbonding electron pairs in a Lewis structure
    - Counting valence electrons in a molecule or polyatomic ion
    - Deciding whether a Lewis structure satisfies the octet rule
    - Writing Lewis structures for diatomic molecules
    - Predicting the single-bonded molecular compounds formed by two elements
    - Predicting the compound formed by two main group elements
    - Calculating formal charge
    - Writing Lewis structures for a molecule with one central atom and no octet-rule exceptions
    - Writing the Lewis structures for a molecule with resonance
    - Drawing Lewis structures for simple organic compounds
  - Chemical Bonds (3 topics)
    - Predicting the relative electronegativities of atoms
    - Predicting relative bond polarity
    - Predicting the relative length and energy of chemical bonds
  - Molecules (5 topics)
    - Predicting the arrangement of electron groups around the central atom of a molecule
    - Identifying a molecule with one central atom from its 3D shape
    - Predicting whether molecules are polar or nonpolar

- Naming common chemical groups
  - Identifying common chemical groups in a Lewis structure
- VB and MO Theory (2 topics)
  - Counting sigma and pi bonds in a small molecule
  - Identifying carbon hybridization in simple organic molecules
- Intermolecular Forces and Properties (36 topics)
  - Gases (14 topics)
    - Interconverting pressure and force
    - Interconverting atmospheres and kilopascals
    - Interconverting atmospheres and torr
    - Understanding pressure equilibrium and atmospheric pressure
    - Understanding Boyle's Law
    - Solving applications of Boyle's Law
    - Using Charles's Law
    - Using the combined gas law
    - Using Avogadro's Law
    - Using the ideal equation of state
    - Interconverting molar mass and density of ideal gases
    - Calculating partial pressure of a gas from a sketch
    - Calculating partial pressure in a gas mixture
    - Calculating the mass of a gas collected over water
  - Kinetic Theory (6 topics)
    - Understanding how average molecular kinetic energy scales with temperature
    - Understanding how average molecular speed scales with temperature and molar mass
    - Interpreting a graph of molecular speed distribution
    - Predicting how molecular speed distribution changes with temperature and molar mass
    - Understanding how molecular collision rate scales with temperature and volume
    - Using relative effusion rates to find an unknown molar mass
  - Real Gases (2 topics)
    - Using thermodynamic state to order the ideality of gases
    - Identifying the origin of nonideality in a gas
  - Intermolecular Forces (6 topics)
    - Identifying a molecule from its electrostatic potential map
    - Predicting the strength of intermolecular forces from an electrostatic potential map
    - Identifying hydrogen-bonding interactions between molecules
    - Identifying the intermolecular forces between atoms, ions and molecules
    - Predicting the relative strength of the dispersion force between molecules
    - Predicting the relative boiling points of pure substances
  - Liquids (3 topics)
    - Identifying important physical properties of liquids
    - Understanding consequences of important physical properties of liquids
    - Relating vapor pressure to vaporization
  - Solids (3 topics)
    - Predicting the type of solid formed by a compound
    - Predicting the relative stability of ionic crystals from a sketch
    - Predicting the relative lattice energy of binary ionic compounds
  - Solubility (2 topics)
    - Applying like dissolves like
    - Understanding how solubility varies with temperature and pressure
- Chemical Reactions (42 topics)
  - Chemical Equations (6 topics)
    - Stoichiometric coefficients
    - Balancing chemical equations with noninterfering coefficients
    - Balancing chemical equations with interfering coefficients
    - Writing a chemical equation from a description of the reaction
    - Writing a chemical equation from a molecular movie
    - Writing the net equation for a sequence of reactions
  - Reaction Stoichiometry (9 topics)
    - Using a chemical equation to find moles of product from moles of reactant
    - Solving for a reactant using a chemical equation
    - Identifying the limiting reactant in a drawing of a mixture
    - Solving moles-to-moles limiting reactant problems

- Limiting reactants
- Understanding theoretical, actual, and percent yield
- Theoretical yield of chemical reactions
- Percent yield of chemical reactions
- Reaction sequence stoichiometry
- Solution Stoichiometry (6 topics)
  - Calculating molarity using solute moles
  - Calculating molarity using solute mass
  - Using molarity to find solute mass and solution volume
  - Calculating ion molarity using solute mass
  - Solving for a reactant in solution
  - Solving limiting reactant problems in solution
- Precipitation (3 topics)
  - Identifying the correct sketch of a compound in aqueous solution
  - Writing net ionic equations
  - Predicting precipitation
- Acid-Base Reactions (5 topics)
  - Identifying acids and bases by their chemical formula
  - Predicting the products of a neutralization reaction
  - Determining the volume of base needed to titrate a given mass of acid
  - Determining the molar mass of an acid by titration
  - Standardizing a base solution by titration
- Oxidation-Reduction Reactions (7 topics)
  - Assigning oxidation numbers
  - Recognizing reduction and oxidation
  - Identifying oxidizing and reducing agents
  - Identifying oxidized and reduced reactants in a metal-nonmetal reaction
  - Identifying oxidized and reduced reactants in a single-displacement reaction
  - Predicting whether simple electrochemical reactions happen
  - Solving a redox titration problem
- Predicting Products (6 topics)
  - Identifying combination, decomposition, single and double displacement reactions
  - Identifying precipitation, combustion and acid-base reactions
  - Predicting the products of a combustion reaction
  - Predicting the products of a single displacement reaction involving hydrogen
  - Predicting the products of a gas-evolving double displacement reaction
  - Predicting products from a general statement about reactivity
- Kinetics (19 topics)
  - Rates of Reaction (3 topics)
    - Predicting how reaction rate varies with pressure, concentration and temperature
    - Calculating the reaction rate of one reactant from that of another
    - Calculating average and instantaneous reaction rate from a graph of concentration versus time
  - Rate Laws (7 topics)
    - Using a rate law
    - Using reactant reaction order to predict changes in initial rate
    - Calculating the change in concentration after a whole number of half-lives of a first-order reaction
    - Using a zero order integrated rate law to find concentration change
    - Using an integrated rate law for a first-order reaction
    - Finding half life and rate constant from a graph of concentration versus time
    - Solving applied problems with first-order kinetics
  - Activation Energy (4 topics)
    - Interpreting a reaction energy diagram
    - Relating activation energy to reaction rate
    - Drawing the reaction energy diagram of a catalyzed reaction
    - Understanding the qualitative predictions of the Arrhenius equation
  - Reaction Mechanisms (5 topics)
    - Identifying the molecularity of an elementary reaction
    - Identifying intermediates in a reaction mechanism
    - Writing a plausible missing step for a simple reaction mechanism
    - Writing the rate law of an elementary reaction
    - Deducing information about reaction mechanisms from a reaction energy diagram
- Thermodynamics (21 topics)

- Energy (4 topics)
  - Understanding how kinetic energy scales with mass and speed
  - Calculating kinetic energy
  - Using conservation of energy to predict the qualitative exchange of kinetic and potential energy
  - Understanding the definition of enthalpy
- Calorimetry (5 topics)
  - Calculating specific heat capacity
  - Using specific heat capacity to find heat
  - Using specific heat capacity to find temperature change
  - Solving a basic calorimetry problem
  - Finding the equilibrium temperature when substances at different temperatures mix
- Reaction Enthalpy (8 topics)
  - Using the general properties of reaction enthalpy
  - Calculating the heat of reaction from molar reaction enthalpy and the mass of a reactant
  - Calculating heat of reaction from constant-pressure calorimetry data
  - Using Hess's Law to calculate net reaction enthalpy
  - Writing a standard formation reaction
  - Calculating a molar heat of reaction from formation enthalpies
  - Solving combustion thermochemistry problems
  - Calculating the heat of reaction from bond energies and Lewis structures
- Phase Change (4 topics)
  - Using heat of fusion or vaporization to find the heat needed to melt or boil a substance
  - Using a phase diagram to predict phase at a given temperature and pressure
  - Labeling a typical simple phase diagram
  - Identifying phase transitions on a heating curve
- Equilibrium (21 topics)
  - Dynamic Equilibrium (4 topics)
    - Understanding that no reaction goes to 100% completion
    - Predicting relative forward and reverse rates of reaction in a dynamic equilibrium
    - Using Le Chatelier's Principle to predict the result of changing concentration
    - Using Le Chatelier's Principle to predict the result of changing temperature
  - Equilibrium Constants and Expressions (8 topics)
    - Writing a concentration equilibrium constant expression
    - Writing a pressure equilibrium constant expression
    - Writing the concentration equilibrium expression for a heterogeneous equilibrium
    - Writing the pressure equilibrium expression for a heterogeneous equilibrium
    - Calculating an equilibrium constant from an equilibrium composition
    - Using an equilibrium constant to predict the direction of spontaneous reaction
    - Using the general properties of equilibrium constants
    - Interconverting  $K_p$  and  $K_c$
  - Equilibrium Composition (4 topics)
    - Recognizing equilibrium from a sketch
    - Predicting equilibrium composition from a sketch
    - Setting up a reaction table
    - Calculating equilibrium composition from an equilibrium constant
  - Ionic Equilibria (5 topics)
    - Writing a solubility product ( $K_{sp}$ ) expression
    - Using  $K_{sp}$  to calculate the solubility of a compound
    - Using the solubility of a compound to calculate  $K_{sp}$
    - Calculating the solubility of an ionic compound when a common ion is present
    - Understanding the effect of pH on the solubility of ionic compounds
- Acids and Bases (31 topics)
  - Concepts of Acidity (7 topics)
    - Identifying acids and bases by their reaction with water
    - Identifying Bronsted-Lowry acids and bases
    - Identifying strong or weak acids and bases from a sketch
    - Finding the conjugate of an acid or base
    - Predicting acid or base strength from the conjugate
    - Predicting the reactants of a neutralization reaction
    - Predicting the qualitative acid-base properties of salts
  - Acid-Base Nomenclature (4 topics)
    - Naming inorganic acids
    - Deducing the formulae of inorganic acids from their names

- Naming acid salts
  - Recognizing common acids and bases
- Acidity and Chemical Structure (1 topics)
  - Understanding the effect of induction on acidity
- pH (8 topics)
  - Interconverting pH and hydronium ion concentration
  - Interconverting pH and pOH at 25°C
  - Interconverting hydronium and hydroxide concentration at 25°C
  - Making qualitative estimates of pH change
  - Calculating the pH of a strong acid solution
  - Calculating the pH of a strong base solution
  - Diluting a strong acid solution to a given pH
  - Preparing a strong base solution with a given pH
- Weak Acids and Bases (6 topics)
  - Writing an acid dissociation constant expression
  - Determining the strength of acids from a sketch
  - Calculating the  $K_a$  of a weak acid from pH
  - Calculating the pH of a weak acid solution
  - Interconverting  $K_a$  and  $pK_a$
  - Writing the dissociation reactions of a polyprotic acid
- Acid-Base Titrations (1 topics)
  - Calculating the pH of a weak acid titrated with a strong base
- Buffers (4 topics)
  - Identifying the major species in weak acid or weak base equilibria
  - Setting up a reaction table for a pH calculation with a common ion
  - Calculating the pH of a buffer
  - Calculating the composition of a buffer of a given pH
- Applications of Thermodynamics (25 topics)
  - Entropy (7 topics)
    - Calculating entropy change from reversible heat flow
    - Calculating absolute entropy using the Boltzmann hypothesis
    - Calculating entropy change using the Boltzmann hypothesis
    - Predicting qualitatively how entropy changes with temperature and volume
    - Predicting qualitatively how entropy changes with mixing and separation
    - Qualitatively predicting reaction entropy
    - Using the Second Law to predict spontaneous change
  - Gibbs Free Energy (6 topics)
    - Using the general properties of Gibbs free energy
    - Calculating  $dG$  from  $dH$  and  $dS$
    - Using the conditions of spontaneity to deduce the signs of  $\Delta H$  and  $\Delta S$
    - Interconverting standard Gibbs free energy and  $K$
    - Recognizing consistency between statements about standard Gibbs free energy
    - Using the maximum work theorem with chemical work
  - Half Reactions (7 topics)
    - Writing a simple half-reaction from its description
    - Writing the half-reactions of a metal-nonmetal reaction
    - Writing the half-reactions of a single-displacement reaction
    - Writing and balancing complex half-reactions in acidic solution
    - Writing and balancing complex half-reactions in basic solution
    - Balancing a complex redox equation in acidic or basic solution
    - Writing the half-reactions of a complex redox reaction in acidic or basic solution
  - Galvanic Cells (4 topics)
    - Designing a galvanic cell from a single-displacement redox reaction
    - Designing a galvanic cell from two half-reactions
    - Analyzing a galvanic cell
    - Picking a reduction or oxidation that will make a galvanic cell work
  - Electrolysis (1 topics)
    - Analyzing the electrolysis of molten salt
- Chemistry of the Elements (15 topics)
  - The Main-Group Elements (9 topics)
    - Understanding main-group periodic trends in ionization energy

- Understanding main-group periodic trends in atomic radius
  - Understanding main-group periodic trends in metallicity
  - Predicting the most positive and negative oxidation states of main-group elements
  - Predicting the oxide formed by a main-group element
  - Identifying a main-block group from an element oxide
  - Identifying a main-block group from an element halide
  - Predicting the type of bonding in a main-group element
  - Assessing the consistency of statements relating to main-group valence electron configuration
- Properties of Groups (4 topics)
    - Predicting the products of the reaction of a Group 1A or 2A metal with water
    - Predicting the products of the reaction of a Group 1A or 2A metal with oxygen
    - Predicting the products of the reaction of elements at either end of the Periodic Table
    - Ordering the melting points of elements at either end of the Periodic Table
  - Properties of Transition Metals (2 topics)
    - Understanding words that describe where transition metals lie in the Periodic Table
    - Predicting the highest common oxidation state of a metal in the first transition series
- Other Topics Available(\*) (470 additional topics)
    - Math Toolbox (75 topics)
      - Signed fraction addition or subtraction: Basic
      - Exponents and fractions
      - Introduction to inequalities
      - Introduction to order of operations
      - Evaluating expressions with exponents of zero
      - Evaluating an expression with a negative exponent: Positive fraction base
      - Complex fraction without variables: Problem type 1
      - Introduction to square root multiplication
      - Absolute value of a number
      - Distributive property: Integer coefficients
      - Using distribution and combining like terms to simplify: Univariate
      - Product rule with positive exponents: Univariate
      - Quotient rule with negative exponents: Problem type 1
      - Rewriting an algebraic expression without a negative exponent
      - Squaring a binomial: Univariate
      - Multiplying binomials with leading coefficients greater than 1
      - Multiplying rational expressions involving multivariate monomials
      - Complex fraction involving univariate monomials
      - Square root of a perfect square monomial
      - Writing a one-step expression for a real-world situation
      - Writing a multi-step equation for a real-world situation
      - Identifying solutions to a linear equation in one variable: Two-step equations
      - Identifying solutions to a linear equation in two variables
      - Solving a multi-step equation given in fractional form
      - Solving a linear equation with several occurrences of the variable: Fractional forms with monomial numerators
      - Solving a rational equation that simplifies to linear: Denominator  $x+a$
      - Solving a proportion of the form  $a/(x+b) = c/x$
      - Solving a word problem with two unknowns using a linear equation
      - Additive property of inequality with integers
      - Solving a two-step linear inequality: Problem type 2
      - Discriminant of a quadratic equation
      - Introduction to solving a radical equation
      - Solving a radical equation that simplifies to a linear equation: One radical, basic
      - Graphing a line given its equation in slope-intercept form: Fractional slope
      - Writing the equation of a line given the y-intercept and another point
      - Finding slope given the graph of a line on a grid
      - Finding the slope and y-intercept of a line given its equation in the form  $Ax + By = C$
      - Finding x- and y-intercepts given the graph of a line on a grid
      - Finding x- and y-intercepts of a line given the equation: Advanced
      - Constructing a scatter plot
      - Sketching the line of best fit
      - Scatter plots and correlation
      - Approximating the equation of a line of best fit and making predictions
      - Classifying linear and nonlinear relationships from scatter plots
      - Linear relationship and the correlation coefficient
      - Choosing a graph to fit a narrative: Basic
      - Choosing a graph to fit a narrative: Advanced
      - Constructing a histogram for numerical data
      - Mean of a data set
      - Finding the mean of a symmetric distribution
      - Population standard deviation



- Word problem involving calculations from a normal distribution
- Basic properties of logarithms
- Expanding a logarithmic expression: Problem type 1
- Expanding a logarithmic expression: Problem type 2
- Writing an expression as a single logarithm
- Evaluating an exponential function with base e that models a real-world situation
- Converting between common logarithmic and exponential equations
- Converting between natural logarithmic and exponential equations
- Solving a multi-step equation involving natural logarithms
- Solving an exponential equation by using logarithms: Decimal answers, basic
- Solving an exponential equation by using natural logarithms: Decimal answers
- Graphing an exponential function and its asymptote:  $f(x) = a(e)^{x-b} + c$
- Finding an angle measure of a triangle given two angles
- Finding an angle measure for a triangle with an extended side
- Finding an angle measure for a triangle sharing a side with another triangle
- Pythagorean Theorem
- Sine, cosine, and tangent ratios: Numbers for side lengths
- Using the Pythagorean Theorem to find a sine, cosine, or tangent ratio in a right triangle
- Using a trigonometric ratio to find a side length in a right triangle
- Using a trigonometric ratio to find an angle measure in a right triangle
- Solving a right triangle
- Finding the magnitude and direction of a vector given its graph
- Finding the components of a vector given its graph
- Finding the component of a vector along another vector
  
- Science Toolbox (34 topics)
  - Multiplication of a decimal by a power of ten
  - Division of a decimal by a power of ten
  - Multiplying and dividing numbers written in scientific notation
  - Calculating positive powers of scientific notation
  - Finding negative powers of scientific notation
  - Knowing the dimension of common simple SI units
  - Understanding the purpose of SI prefixes
  - Interconverting compound SI units
  - Interconverting derived SI units
  - Interconverting whole degree temperatures in Celsius and kelvins
  - Interconverting temperatures in Celsius and Fahrenheit
  - One step dosage calculations
  - Dosage calculations using patient weight
  - Dosage rate calculations
  - Reading a measurement from an analog instrument
  - Distinguishing accuracy and precision
  - Calculating absolute and relative error
  - Naming components of the scientific method
  - Estimating the volume in liters of a square prism object
  - Finding the side length of a cube from its volume in liters
  - Estimating the volume in liters of a spherical object
  - Estimating the volume in liters of a cylindrical object
  - Calculating volume by combining the volume of simple shapes
  - Understanding the relationship between mass, volume, and density
  - Solving applied density problems
  - Calculating gravitational potential energy
  - Using conservation of energy with gravitational potential energy
  - Using conservation of energy with electrostatic potential energy
  - Understanding how electrostatic potential energy scales with charge and separation
  - Understanding how electrostatic energy scales with charge and separation
  - Understanding periods and groups of the Periodic Table
  - Recognizing element families
  - Standard chemical and physical states of the elements
  - Distinguishing a metal from a nonmetal by physical properties
  
- Atomic Structure and Properties (35 topics)
  - Counting the number of protons and electrons in a neutral atom
  - Finding isotopic atoms
  - Counting valence electrons in an atomic ion
  - Drawing the Lewis dot diagram of a main group atom or common atomic ion
  - Counting the electron shells in a neutral atom
  - Distinguishing mixtures from pure substances through physical properties
  - Distinguishing physical and chemical properties by a macroscopic description
  - Elemental analysis of binary compounds
  - Finding a molecular formula from molar mass and elemental analysis of binary compounds
  - Finding a molecular formula from molar mass and elemental analysis
  - Calculating and using the molar mass of diatomic elements
  - Calculating and using the molar mass of heterodiatomic compounds

- Understanding the meaning of a de Broglie wavelength
- Finding the minimum uncertainty in a position or velocity measurement
- Interpreting the radial probability distribution of an orbital
- Interpreting the angular probability distribution of an orbital
- Recognizing s and p orbitals
- Deducing n and l from a subshell label
- Deducing the allowed quantum numbers of an atomic electron
- Calculating the capacity of electron subshells
- Knowing the subshells of an electron shell
- Interpreting the electron configuration of an atom or atomic ion
- Interpreting the electron configuration of an atom or atomic ion in noble-gas notation
- Writing the electron configuration of an atom or atomic ion with s and p electrons only
- Identifying the electron added or removed to form an ion from an s or p block atom
- Identifying the electron added or removed to form an ion
- Predicting the relative ionization energy of elements
- Deducing valence electron configuration from trends in successive ionization energies
- Ranking the screening efficacy of atomic orbitals
- Understanding periodic trends in effective nuclear charge
- Deducing the block of an element from an electron configuration
- Understanding periodic trends in atomic size
- Understanding periodic trends in atomic ionizability
- Predicting the qualitative features of a line spectrum
- Calculating the wavelength of a line in the spectrum of hydrogen
  
- Molecular and Ionic Compounds (22 topics)
  - Distinguishing an ionic from a molecular compound by physical properties
  - Recognizing and naming close-packed crystal lattices
  - Recognizing and naming lattices with cubic unit cells
  - Calculating key distances in the fcc unit cell
  - Calculating key distances in the bcc unit cell
  - Finding an atomic radius from an fcc or bcc lattice constant
  - Finding density from an fcc or bcc lattice constant
  - Counting electron pairs in a Lewis structure with double or triple bonds
  - Recognizing exceptions to the octet rule
  - Writing Lewis structures for an expanded valence shell central atom
  - Predicting bond polarity
  - Predicting the relative ionic character of chemical bonds
  - Using the AXE notation to describe a molecule with a central atom
  - Naming the shape of molecules with one central atom and no octet-rule exceptions
  - Predicting bond angles in molecules with one central atom and no octet-rule exceptions
  - Predicting bond angles in a small organic molecule
  - Predicting and naming the shape of molecules with a central atom
  - Predicting deviations from ideal bond angles
  - Identifying hybridization in a small molecule
  - Recognizing typical LCAO molecular orbitals
  - Drawing the MO energy diagram for a Period 2 homodiatom
  - Using the MO model to predict bond order and paramagnetism
  
- Intermolecular Forces and Properties (34 topics)
  - Calculating mole fraction in a gas mixture
  - Calculating average molecular speed
  - Understanding the origin of the van der Waals equation of state
  - Using the van der Waals equation of state
  - Identifying the important intermolecular forces in pure compounds
  - Understanding the connection between vapor pressure, boiling point, and enthalpy of vaporization
  - Calculating vapor pressure from boiling point and enthalpy of vaporization
  - Calculating enthalpy of vaporization from vapor pressure
  - Interpreting a Born-Haber cycle
  - Calculating mass percent composition
  - Using mass percent composition to find solution volume
  - Calculating volume percent composition
  - Finding mass or volume from percent concentration
  - Calculating ionic solution composition in equivalents
  - Solving applied equivalents composition problems
  - Calculating molality
  - Calculating mole fraction
  - Calculating mass concentration
  - Using mass concentration to find solute mass and solution volume
  - Solving applied mass concentration problems
  - Solving applied dilution problems
  - Calculating solubility
  - Using solubility to calculate solute mass or solution volume
  - Understanding conceptual components of the enthalpy of solution
  - Using Henry's Law to calculate the solubility of a gas

- Predicting the relative heat of hydration of ions
- Predicting relative boiling point elevations and freezing point depressions
- Using the  $K_f$  and  $K_b$  equations
- Using the  $K_f$  and  $K_b$  equations with electrolytes
- Calculating and using the van't Hoff factor for electrolytes
- Using osmotic pressure to find molar mass
- Using a solution freezing point to calculate a molar mass
- Using Raoult's Law to calculate the vapor pressure of a component
- Calculating ideal solution composition after a distillation
- Chemical Reactions (4 topics)
  - Solving for a gaseous reactant
  - Using molarity to find solute moles and solution volume
  - Dilution
  - Predicting the products of dissolution
- Kinetics (9 topics)
  - Deducing a rate law from initial reaction rate data
  - Using a second-order integrated rate law to find concentration change
  - Using first- and second-order integrated rate laws
  - Deducing a rate law from the change in concentration over time
  - Using the Arrhenius equation to calculate  $k$  at one temperature from  $k$  at another
  - Using the Arrhenius equation to calculate  $E_a$  from  $k$  versus  $T$  data
  - Writing the rate law implied by a simple mechanism with an initial slow step
  - Expressing the concentration of an intermediate in terms of the concentration of reactants
  - Writing the rate law implied by a simple mechanism
- Thermodynamics (10 topics)
  - Calculating pressure-volume work
  - Understanding the definitions of heat and work
  - Interconverting calories and joules
  - Calculating molar heat capacity
  - Calculating heat of reaction from bomb calorimetry data
  - Calculating the heat of reaction from bond energies
  - Using a phase diagram to find a phase transition temperature or pressure
  - Sketching a described thermodynamic change on a phase diagram
  - Interpreting a heating curve
  - Drawing a heating curve
- Equilibrium (10 topics)
  - Calculating an equilibrium constant from a heterogeneous equilibrium composition
  - Writing an equilibrium constant for a reaction sequence
  - Using the small  $x$  approximation to solve equilibrium problems
  - Calculating an equilibrium constant from a partial equilibrium composition
  - Calculating an equilibrium composition after a prior equilibrium determines  $K$
  - Solving problems that mix equilibrium ideas with gas laws
  - Using the van't Hoff equation to predict  $K$  at a different temperature
  - Writing a complex ion formation constant expression
  - Using  $K_f$  to calculate the equilibrium molarity of a complex
  - Calculating the solubility of an ionic compound when a complex may form
- Acids and Bases (16 topics)
  - Understanding the difference between strong and weak acids
  - Predicting the products of the reaction of a strong acid with water
  - Predicting the qualitative acid-base properties of metal cations
  - Identifying Lewis acids and bases in reactions
  - Predicting the acid-base properties of a binary oxide in water
  - Predicting the relative acidity of binary acids
  - Writing a base protonation constant expression
  - Calculating the pH of a weak base solution
  - Deriving  $K_b$  from  $K_a$
  - Calculating the pH of a salt solution
  - Calculating percent dissociation of a weak acid
  - Understanding connections between descriptions of weak acid dissociation
  - Calculating the pH of a dilute acid solution
  - Solving a polyprotic acid equilibrium composition problem
  - Calculating the pH of a weak base titrated with a strong acid
  - Calculating the pH at equivalence of a titration
- Applications of Thermodynamics (14 topics)
  - Calculating reaction entropy using the standard molar entropies of reactants
  - Calculating standard reaction free energy from standard free energies of formation
  - Estimating a phase transition temperature from standard thermodynamic data
  - Using thermodynamic data to calculate  $K$

- Calculating reaction free energy under nonstandard conditions
- Using reaction free energy to predict equilibrium composition
- Ranking the strength of oxidizing and reducing agents using standard reduction potentials
- Calculating standard reaction free energy from standard reduction potentials
- Recognizing consistency among equilibrium constant, free energy, and cell potential
- Using the Nernst equation to calculate nonstandard cell voltage
- Understanding concentration cells
- Using the relationship between charge, current and time
- Using the Faraday constant
- Calculating the mass of an electrolysis product from the applied current
- Nuclear Chemistry (14 topics)
  - Interpreting the symbol for a nuclide
  - Writing the symbols in a nuclear chemical equation
  - Balancing a nuclear chemical equation
  - Writing the equation for a typical radioactive decay
  - Calculating the energy change in a nuclear reaction from the mass change
  - Knowing the properties of the common types of nuclear radiation
  - Understanding the common modes of radioactive decay
  - Understanding radioactive half life
  - Interconverting amount of radioactive decay and half life
  - Calculating radioactive activity from half life
  - Using isotope ratios to radiodate
  - Using activity to radiodate
  - Knowing units of radiation dosage and exposure
  - Identifying important types of nuclear medicine procedure
- Chemistry of the Elements (36 topics)
  - Predicting the common oxidation states of main-group elements
  - Predicting the hydride formed by a main-group element
  - Identifying a main-block group from its general properties
  - Identifying Group 3A elements
  - Identifying Group 4A elements
  - Identifying Group 5A elements
  - Identifying Group 6A elements
  - Understanding the chemical formulae of interhalogens
  - Understanding how halide bond length varies down a main-block group
  - Ranking the oxidizing power of halogens
  - Writing the electron configuration of a first transition series atom
  - Interpreting an outer electron box diagram
  - Drawing the outer electron box diagram of a transition metal cation
  - Identifying transition metal cations with a given number of d electrons
  - Deducing the number of d electrons and unpaired spins in a transition metal cation
  - Understanding the exceptional electron configurations in the first transition series
  - Predicting the relative atomic radius of a transition metal atom
  - Predicting the relative density of a transition metal
  - Predicting the relative melting point of a transition metal
  - Predicting the reaction of a transition metal with a strong acid
  - Writing the formula of a metal complex from its description
  - Recognizing typical metal ligands
  - Determining the oxidation state of the metal in a complex ion
  - Naming complex cations with one type of ligand
  - Naming complex anions with one type of ligand
  - Naming complex ions
  - Determining the oxidation state of the metal in a coordination compound
  - Naming coordination compounds
  - Determining the coordination number of a metal in a complex
  - Understanding the connection between geometry and coordination number of a metal complex
  - Distinguishing isomers and alternate views of a metal complex
  - Drawing an isomer of a metal complex
  - Drawing cis and trans isomers of a metal complex
  - Adding electrons to a crystal field theory energy level diagram
  - Predicting color and magnetic properties from a crystal field theory energy level diagram
  - Drawing a crystal field theory energy level diagram
- Organic Chemistry (87 topics)
  - Identifying organic compounds
  - Identifying rigid parts of an acyclic organic molecule
  - Identifying hydrophobic and hydrophilic parts of an organic molecule
  - Interpreting condensed chemical structures
  - Interpreting condensed chemical structures with benzene rings
  - Interpreting the skeletal structure of a neutral organic molecule
  - Drawing a skeletal structure from a simple condensed structure
  - Drawing a skeletal structure from a condensed structure

- o Interpreting a skeletal structure with aromatic rings
- o Recognizing different skeletal structures
- o Understanding H atoms in a skeletal structure
- o Comparing skeletal structures related by one fewer bond
- o Using wedges and dashes in skeletal structures
- o Naming normal alkanes
- o Identifying the main chain of branched alkanes
- o Naming the parent hydrocarbon of branched alkanes
- o Naming alkyl side chains
- o Identifying organic functional groups
- o Using family suffixes to name organic compounds
- o Understanding the basic descriptive vocabulary of hydrocarbons
- o Understanding the basic descriptive vocabulary of molecules with functional groups
- o Numbering the main chain of branched alkanes
- o Naming and drawing small alkyl substituents
- o Naming and drawing alkyl and alkoxy substituents
- o Identifying constitutional isomers
- o Drawing the condensed structure of a constitutional isomer
- o Drawing the skeletal structure of a constitutional isomer
- o Identifying a chiral molecule from its condensed structure
- o Identifying chiral centers in a cyclic molecule
- o Drawing the mirror image of a simple organic molecule
- o Identifying the enantiomer of a simple organic molecule
- o Classifying organic reactions
- o Recognizing organic acids and bases
- o Deducing oxidation state from a Lewis structure
- o Identifying oxidation and reduction in organic reactions
- o Naming branched alkanes
- o Using multiplying affixes in the names of branched alkanes
- o Naming and drawing normal alkanes.
- o Naming and drawing simple cyclic alkanes
- o Naming and drawing branched alkanes
- o Naming and drawing simple substituted cycloalkanes
- o Naming unbranched alkenes and alkynes
- o Naming alkenes and alkynes
- o Naming and drawing linear alkenes with one double bond
- o Naming benzene derivatives
- o Identifying cis/trans isomerism in a small condensed structure
- o Identifying cis/trans isomerism in a skeletal structure
- o Drawing the cis or trans isomer of a small alkene
- o Predicting the reactants or products of alkene hydrogenation
- o Predicting the reactants or products of alkene hydration
- o Naming alkyl halides
- o Naming and drawing alkyl halides
- o Naming alcohols
- o Naming and drawing alcohols without alkyl side groups
- o Naming and drawing thiols without alkyl side groups
- o Naming and drawing alcohols
- o Identifying primary, secondary, and tertiary alcohols
- o Identifying common alcohols from a description
- o Predicting the products of symmetric alcohol dehydration
- o Predicting the reactants or products of alcohol oxidation
- o Understanding the common names of simple ethers
- o Understanding the common names of simple ketones
- o Naming and drawing ketones
- o Naming and drawing aldehydes
- o Predicting the reactants or products of alcohol and aldehyde oxidation
- o Predicting the reactants or products of carbonyl reduction
- o Identifying and drawing hemiacetals and acetals
- o Predicting the reactants or products of hemiacetal and acetal formation
- o Predicting the reactants or products of acetal hydrolysis
- o Understanding the common names of simple amines
- o Identifying primary, secondary, and tertiary amines
- o Naming and drawing primary amines without alkyl side groups
- o Naming and drawing secondary and tertiary amines
- o Naming aldehydes and acids
- o Naming and drawing carboxylic acids
- o Understanding the names of carboxylate salts
- o Naming and drawing unsubstituted esters
- o Identifying primary, secondary, and tertiary amides
- o Naming and drawing unsubstituted amides
- o Understanding common names of carboxylic acids and derivatives
- o Identifying positions labeled with Greek letters in acids and derivatives
- o Knowing the common names of small diacids

- Predicting the reactants or products of esterification
- Predicting the reactants or products of ester hydrolysis
- Predicting the products of ester saponification
- Predicting the reactants or products of amidation
- Predicting the products of amide hydrolysis
- Biochemistry (70 topics)
  - Understanding the descriptive vocabulary of monosaccharides
  - Drawing the Fischer projection of the enantiomer of a monosaccharide
  - Drawing the Haworth projection of an aldose from its Fischer projection
  - Drawing the Haworth projection of a ketose from its Fischer projection
  - Naming and drawing cyclic monosaccharides
  - Identifying a given carbon in a cyclic monosaccharide
  - Naming and drawing the products of aldose oxidation and reduction
  - Identifying the parts of a disaccharide
  - Knowing the names and properties of common sugars
  - Identifying common polysaccharides
  - Understanding the glycosidic links in common polysaccharides
  - Understanding the basic descriptive vocabulary of fatty acids
  - Understanding lipid number notation
  - Understanding melting points trends of fatty acids
  - Identifying the components of wax esters
  - Identifying the parts of a triacylglycerol
  - Identifying the parts of a glycerophospholipid
  - Identifying the parts of a sphingomyelin
  - Identifying molecules that could be in a cell membrane
  - Recognizing the steroid nucleus
  - Classifying lipids derived from fatty acids
  - Matching structure and function of common lipids
  - Predicting the products or reactants of triacylglycerol hydrogenation
  - Predicting the products or reactants of triacylglycerol hydrolysis or saponification
  - Recognizing alpha amino acids
  - Classifying amino acids
  - Identifying the stereochemistry of natural amino acids
  - Understanding the general acid-base properties of amino acids
  - Identifying and drawing peptide bonds
  - Describing peptides with 3-letter codes
  - Identifying specific interactions between residues in a protein
  - Predicting the location in a protein of a residue sequence
  - Naming an element of protein secondary structure from a description
  - Identifying changes at different levels of protein structure
  - Recognizing nucleotides
  - Numbering the carbons in nucleotides
  - Naming and drawing nucleosides
  - Naming and drawing nucleotides
  - Understanding the arrangement of hydrogen bonds in DNA base pairs
  - Understanding the structure of nucleic acid strands
  - Writing complementary DNA sequences
  - Understanding that DNA replication is semiconservative
  - Identifying the major types of RNA from a description
  - Understanding the relationship between DNA and mRNA base sequences
  - Using the genetic code
  - Classifying mutations
  - Predicting reactants or products of phosphorylation
  - Predicting the products of phosphoester or phosphoanhydride hydrolysis
  - Understanding major biochemical energy storage and release reactions
  - Identifying common redox coenzymes by their roles in a reaction
  - Understanding the formation and hydrolysis of acyl-CoA
  - Knowing basic facts about enzymes
  - Classifying enzymes
  - Identifying reactants and products from an enzyme name
  - Understanding basic models of competitive and noncompetitive inhibition
  - Predicting the effect of temperature or pH on enzyme activity
  - Understanding the biochemistry of digestion
  - Knowing inputs and outputs of the citric acid cycle
  - Understanding the general mechanism of oxidative phosphorylation
  - Solving citric acid cycle ATP stoichiometry problems
  - Knowing inputs and outputs of glycolysis
  - Completing a simplified diagram of glycolysis
  - Completing a simplified diagram of glucose catabolism
  - Solving carbohydrate catabolic stoichiometry problems
  - Knowing the steps of beta oxidation
  - Predicting the product of beta oxidation activation
  - Knowing inputs and outputs of beta oxidation

- Solving fatty acid catabolic stoichiometry problems
- Predicting the products of catabolic amino acid transamination
- Completing a diagram of protein catabolism

**\*Other Topics Available** By default, these topics are NOT included in the course, but can be added using the content editor in the Teacher Module.