

## *General Chemistry (Second Semester)*

This course covers material usually taught in the second semester of a two-semester sequence. By default, the topics listed below are all available, **new topics** have been highlighted. However, instructors can customize the course to align with their teaching goals using *any* topics from the complete ALEKS curriculum, which covers a full course sequence.

### Curriculum (685 topics)

- Math and Physics (126 topics)
  - ◆ Mathematics (25 topics)
    - ◇ Integer multiplication and division
    - ◇ Simplifying a fraction
    - ◇ Equivalent fractions
    - ◇ Signed fraction addition or subtraction: Basic
    - ◇ Signed fraction multiplication: Basic
    - ◇ Signed fraction division
    - ◇ Exponents and fractions
    - ◇ Introduction to inequalities
    - ◇ Writing expressions using exponents
    - ◇ Introduction to exponents
    - ◇ Introduction to order of operations
    - ◇ Ordering numbers with positive exponents
    - ◇ Evaluating expressions with exponents of zero
    - ◇ Evaluating an expression with a negative exponent: Whole number base
    - ◇ Evaluating an expression with a negative exponent: Positive fraction base
    - ◇ Complex fraction without variables: Problem type 1
    - ◇ Square root of a perfect square
    - ◇ Introduction to square root multiplication
    - ◇ Absolute value of a number
    - ◇ Multiplication of a decimal by a power of ten
    - ◇ Division of a decimal by a power of ten
    - ◇ Converting between decimal numbers and numbers written in scientific notation
    - ◇ Multiplying and dividing numbers written in scientific notation
    - ◇ Calculating positive powers of scientific notation
    - ◇ Finding negative powers of scientific notation
  - ◆ Algebra Expressions (21 topics)
    - ◇ Evaluating a quadratic expression: Integers
    - ◇ Combining like terms: Integer coefficients
    - ◇ Combining like terms in a quadratic expression
    - ◇ Distributive property: Integer coefficients
    - ◇ Using distribution and combining like terms to simplify: Univariate
    - ◇ Introduction to the product rule of exponents
    - ◇ Product rule with positive exponents: Univariate
    - ◇ Introduction to the product rule with negative exponents
    - ◇ Introduction to the quotient rule of exponents
    - ◇ Simplifying a ratio of univariate monomials
    - ◇ Quotient rule with negative exponents: Problem type 1

- ◇ Introduction to the power of a product rule of exponents
- ◇ Power and quotient rules with positive exponents
- ◇ 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
- ◆ Linear Equations (14 topics)
  - ◇ Identifying solutions to a linear equation in one variable: Two-step equations
  - ◇ Identifying solutions to a linear equation in two variables
  - ◇ Additive property of equality with integers
  - ◇ Additive property of equality with a negative coefficient
  - ◇ Multiplicative property of equality with signed fractions
  - ◇ 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 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
  - ◇ 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
- ◆ Quadratic and Radical Equations (6 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
  - ◇ 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 Equations (9 topics)
  - ◇ Classifying slopes given graphs of lines
  - ◇ Graphing a line given its equation in slope-intercept form: Fractional slope
  - ◇ Writing an equation of a line given the y-intercept and another point
  - ◇ Graphing a line through a given point with a given slope
  - ◇ Finding slope given the graph of a line on a grid
  - ◇ Finding slope given two points on the line
  - ◇ 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
- ◆ Graphing Data (13 topics)
  - ◇ 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
- ◆ Logarithms and Exponentials (13 topics)
  - ◇ Evaluating a logarithmic expression
  - ◇ Solving an equation of the form  $\log_b a = c$
  - ◇ 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:  $f(x) = a(e)^{x-b} + c$
- ◆ Trigonometry (9 topics)
  - ◇ 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 trigonometric ratio
  - ◇ 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
- ◆ Vectors (3 topics)
  - ◇ 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
- ◆ Force and Energy (3 topics)
  - ◇ Calculating gravitational potential energy
  - ◇ Using conservation of energy with gravitational potential energy
  - ◇ Using conservation of energy with electrostatic potential energy
- ◆ Electrostatics (10 topics)
  - ◇ Understanding that opposite charges attract and like charges repel
  - ◇ Understanding net electrical charge
  - ◇ Understanding how electrostatic force scales with charge and separation
  - ◇ Understanding how electrostatic potential energy 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
  - ◇ Understanding how electrostatic energy scales with charge and separation
  - ◇ Calculating electrostatic energy using Coulomb's Law
  - ◇ Sketching polarization induced by a nearby charge
- Measurement and Matter (94 topics)
  - ◆ Measurement (21 topics)
    - ◇ Knowing the dimension of common simple SI units
    - ◇ Understanding the purpose of SI prefixes
    - ◇ 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 compound SI units
- ◇ Interconverting derived SI units
- ◇ Interconverting whole degree temperatures in Celsius and kelvins
- ◇ Interconverting temperatures in Celsius and Kelvins
- ◇ Interconverting temperatures in Celsius and Fahrenheit
- ◇ Addition and subtraction of measurements
- ◇ Simplifying unit expressions
- ◇ Multiplication and division of measurements
- ◇ 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
- ◇ Reading a measurement from an analog instrument
- ◇ Distinguishing accuracy and precision
- ◇ Calculating absolute and relative error
- ◆ Quantitative Problem Solving (11 topics)
  - ◇ Naming components of the scientific method
  - ◇ 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 (9 topics)
  - ◇ 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
  - ◇ Calculating mass density
  - ◇ Using mass density to find mass or volume
  - ◇ Solving applied density problems
- ◆ Elements, Compounds, and Mixtures (19 topics)
  - ◇ Distinguishing mixtures from pure substances through physical properties
  - ◇ Naming common laboratory separation techniques
  - ◇ Distinguishing physical and chemical properties by a macroscopic description
  - ◇ Distinguishing extensive and intensive properties
  - ◇ Distinguishing elements and compounds
  - ◇ Distinguishing compounds and mixtures
  - ◇ 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
  - ◇ Names and symbols of important elements
  - ◇ Reading a Periodic Table entry

- ◇ Understanding periods and groups of the Periodic Table
- ◇ Recognizing element families
- ◇ Organization of the Periodic Table
- ◇ Standard chemical and physical states of the elements
- ◇ Using the Periodic Table to identify similar elements
- ◇ Distinguishing a metal from a nonmetal by physical properties
- ◆ Atoms, Ions and Molecules (34 topics)
  - ◇ Identifying the parts of an atom
  - ◇ Counting the number of protons and electrons in a neutral atom
  - ◇ Counting protons and electrons in atoms and atomic ions
  - ◇ Finding isotopic atoms
  - ◇ 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
  - ◇ 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
  - ◇ Counting the number of atoms in a formula unit
  - ◇ 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
  - ◇ Predicting whether a compound is ionic or molecular
  - ◇ Distinguishing an ionic from a molecular compound by physical properties
  - ◇ 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
- Chemical Reactions (83 topics)
  - ◆ Stoichiometry (38 topics)
    - ◇ Using the Avogadro Number
    - ◇ Calculating and using the molar mass of elements
    - ◇ Calculating and using the molar mass of diatomic elements
    - ◇ Calculating and using the molar mass of heterodiatomic compounds
    - ◇ 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
    - ◇ Finding mass percent from chemical formulae
    - ◇ Solving applied mass percent problems

- ◇ Elemental analysis of binary compounds
- ◇ Elemental analysis
- ◇ Finding a molecular formula from molar mass and elemental analysis of binary compounds
- ◇ Finding a molecular formula from molar mass and elemental analysis
- ◇ Combustion analysis
- ◇ 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
- ◇ 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
- ◇ Calculating molarity using solute moles
- ◇ Using molarity to find solute moles and solution volume
- ◇ Calculating molarity using solute mass
- ◇ Using molarity to find solute mass and solution volume
- ◇ Calculating ion molarity using solute mass
- ◇ Dilution
- ◇ Solving for a reactant in solution
- ◇ Solving limiting reactant problems in solution
- ◆ Simple Reactions (22 topics)
  - ◇ Predicting the products of dissolution
  - ◇ Identifying the correct sketch of a compound in aqueous solution
  - ◇ Writing net ionic equations
  - ◇ Predicting precipitation
  - ◇ 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
  - ◇ 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
  - ◇ 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
- ◆ Thermochemistry (23 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
- ◇ Calculating pressure–volume work
- ◇ Understanding the definitions of heat and work
- ◇ Understanding the definition of enthalpy
- ◇ Interconverting calories and joules
- ◇ Calculating specific heat capacity
- ◇ Using specific heat capacity to find heat
- ◇ Using specific heat capacity to find temperature change
- ◇ Calculating molar heat capacity
- ◇ Solving a basic calorimetry problem
- ◇ Finding the equilibrium temperature when substances at different temperatures mix
- ◇ 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
- ◇ Calculating heat of reaction from bomb 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
- ◇ Calculating the heat of reaction from bond energies
- Structure and Bonding (73 topics)
  - ◆ Electronic Structure of Atoms (38 topics)
    - ◇ 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
    - ◇ Deciding the relative energy of electron subshells
    - ◇ Drawing a box diagram of the electron configuration of an atom
    - ◇ 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 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
    - ◇ 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
    - ◇ Writing the electron configuration of an atom using the Periodic Table
    - ◇ Identifying quantum mechanics errors in electron configurations
    - ◇ 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
    - ◇ 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
    - ◇ 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
- ◇ 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
- ◇ Predicting the qualitative features of a line spectrum
- ◇ Calculating the wavelength of a line in the spectrum of hydrogen
- ◆ Chemical Bonding (35 topics)
  - ◇ Counting bonding and nonbonding electron pairs in a Lewis structure
  - ◇ Counting electron pairs in a Lewis structure with double or triple bonds
  - ◇ 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
  - ◇ Recognizing exceptions to the octet rule
  - ◇ Writing Lewis structures for an expanded valence shell central atom
  - ◇ Writing the Lewis structures for a molecule with resonance
  - ◇ Drawing Lewis structures for simple organic compounds
  - ◇ Predicting the relative electronegativities of atoms
  - ◇ Predicting bond polarity
  - ◇ Predicting relative bond polarity
  - ◇ Predicting the relative ionic character of chemical bonds
  - ◇ Predicting the relative length and energy of chemical bonds
  - ◇ Predicting the arrangement of electron groups around the central atom of a molecule
  - ◇ Identifying a molecule with one central atom from its 3D shape
  - ◇ 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
  - ◇ Predicting whether molecules are polar or nonpolar
  - ◇ Naming common chemical groups
  - ◇ Identifying common chemical groups in a Lewis structure
  - ◇ Identifying hybridization in a small molecule
  - ◇ Counting sigma and pi bonds in a small molecule
  - ◇ Identifying carbon hybridization in simple organic molecules
  - ◇ 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
- Gases, Liquids, and Solids (83 topics)
  - ◆ Gas Laws (16 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 mole fraction in a gas mixture
- ◇ Calculating partial pressure in a gas mixture
- ◇ Calculating the mass of a gas collected over water
- ◇ Solving for a gaseous reactant
- ◆ Kinetic Theory (7 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
  - ◇ Calculating average molecular speed
  - ◇ Understanding how molecular collision rate scales with temperature and volume
  - ◇ Using relative effusion rates to find an unknown molar mass
- ◆ Real Gases (4 topics)
  - ◇ Using thermodynamic state to order the ideality of gases
  - ◇ Identifying the origin of nonideality in a gas
  - ◇ Understanding the origin of the van der Waals equation of state
  - ◇ Using the van der Waals equation of state
- ◆ Intermolecular Forces (7 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
  - ◇ Identifying the important intermolecular forces in pure compounds
  - ◇ Predicting the relative strength of the dispersion force between molecules
  - ◇ Predicting the relative boiling points of pure substances
- ◆ Liquids (6 topics)
  - ◇ Identifying important physical properties of liquids
  - ◇ Understanding consequences of important physical properties of liquids
  - ◇ Relating vapor pressure to vaporization
  - ◇ 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
- ◆ Solids (12 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
  - ◇ Interpreting a Born-Haber cycle
  - ◇ Drawing the unit cell of a 2D lattice
  - ◇ Counting the atoms in a unit cell
  - ◇ 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
- ◆ Phase Change (8 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
- ◇ Using a phase diagram to find a phase transition temperature or pressure
- ◇ Sketching a described thermodynamic change on a phase diagram
- ◇ Identifying phase transitions on a heating curve
- ◇ Interpreting a heating curve
- ◇ Drawing a heating curve
- ◆ Solution Composition (8 topics)
  - ◇ Calculating mass percent composition
  - ◇ Using mass percent composition to find solution volume
  - ◇ 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
- ◆ Solubility (7 topics)
  - ◇ Applying like dissolves like
  - ◇ Calculating solubility
  - ◇ Using solubility to calculate solute mass or solution volume
  - ◇ Understanding how solubility varies with temperature and pressure
  - ◇ 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
- ◆ Ideal Solutions (8 topics)
  - ◇ 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
- Kinetics and Equilibrium (59 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 (11 topics)
    - ◇ Using a rate law
    - ◇ Using reactant reaction order to predict changes in initial rate
    - ◇ Deducing a rate law from initial reaction rate data
    - ◇ 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
    - ◇ 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
    - ◇ Finding half life and rate constant from a graph of concentration versus time
    - ◇ Solving applied problems with first-order kinetics
  - ◆ Activation Energy (6 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
- ◇ 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
- ◆ Reaction Mechanisms (8 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
  - ◇ 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
  - ◇ Deducing information about reaction mechanisms from a reaction energy diagram
- ◆ 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 (10 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
  - ◇ Calculating an equilibrium constant from a heterogeneous equilibrium composition
  - ◇ Using an equilibrium constant to predict the direction of spontaneous reaction
  - ◇ Using the general properties of equilibrium constants
  - ◇ Interconverting  $K_p$  and  $K_c$
  - ◇ Writing an equilibrium constant for a reaction sequence
- ◆ Equilibrium Composition (9 topics)
  - ◇ Recognizing equilibrium from a sketch
  - ◇ Predicting equilibrium composition from a sketch
  - ◇ Setting up a reaction table
  - ◇ Calculating equilibrium composition from an equilibrium constant
  - ◇ 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
- ◆ Ionic Equilibria (8 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
  - ◇ 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 (47 topics)
  - ◆ Concepts of Acidity (12 topics)
    - ◇ Identifying acids and bases by their reaction with water
    - ◇ Understanding the difference between strong and weak acids
    - ◇ 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 products of the reaction of a strong acid with water
- ◇ Predicting the reactants of a neutralization reaction
- ◇ Predicting the qualitative acid–base properties of salts
- ◇ 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
- ◆ 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 (2 topics)
  - ◇ Predicting the relative acidity of binary acids
  - ◇ 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 (14 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
  - ◇ Writing a base protonation constant expression
  - ◇ Calculating the pH of a weak base solution
  - ◇ Deriving  $K_b$  from  $K_a$
  - ◇ Interconverting  $K_a$  and  $pK_a$
  - ◇ 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
  - ◇ Writing the dissociation reactions of a polyprotic acid
  - ◇ Solving a polyprotic acid equilibrium composition problem
- ◆ Acid–Base Titrations (3 topics)
  - ◇ Calculating the pH of a weak acid titrated with a strong base
  - ◇ Calculating the pH of a weak base titrated with a strong acid
  - ◇ Calculating the pH at equivalence of a titration
- ◆ 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
- Entropy and Free Energy (19 topics)
  - ◆ Entropy (8 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
- ◇ Calculating reaction entropy using the standard molar entropies of reactants
- ◆ Gibbs Free Energy (11 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  $H$  and  $S$
  - ◇ Calculating standard reaction free energy from standard free energies of formation
  - ◇ Estimating a phase transition temperature from standard thermodynamic data
  - ◇ Interconverting standard Gibbs free energy and  $K$
  - ◇ Using thermodynamic data to calculate  $K$
  - ◇ Recognizing consistency between statements about standard Gibbs free energy
  - ◇ Using the maximum work theorem with chemical work
  - ◇ Calculating reaction free energy under nonstandard conditions
  - ◇ Using reaction free energy to predict equilibrium composition
- Electrochemistry (20 topics)
  - ◆ 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 (9 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
    - ◇ 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
  - ◆ Electrolysis (4 topics)
    - ◇ Using the relationship between charge, current and time
    - ◇ Using the Faraday constant
    - ◇ Analyzing the electrolysis of molten salt
    - ◇ Calculating the mass of an electrolysis product from the applied current
- The Main–Group Elements (23 topics)
  - ◆ Periodic Trends (12 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 common oxidation states of main–group elements
    - ◇ Predicting the hydride formed by a main–group element
    - ◇ Predicting the oxide formed by a main–group element
    - ◇ Identifying a main–block group from its general properties

- ◇ 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 (11 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
  - ◇ 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
  - ◇ Ordering the melting points of elements at either end of the Periodic Table
  - ◇ Ranking the oxidizing power of halogens
- The Transition Metals (28 topics)
  - ◆ Electronic Structure of Transition Metals (6 topics)
    - ◇ 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
  - ◆ Properties of Transition Metals (6 topics)
    - ◇ Understanding words that describe where transition metals lie in the Periodic Table
    - ◇ 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 highest common oxidation state of a metal in the first transition series
    - ◇ Predicting the reaction of a transition metal with a strong acid
  - ◆ Metal Complexes and Coordination Compounds (13 topics)
    - ◇ 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
  - ◆ Crystal Field Theory (3 topics)
    - ◇ 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
- Nuclear and Organic Chemistry (30 topics)
  - ◆ Nuclear Reactions (5 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
- ◆ Radioactive Decay (5 topics)
  - ◇ 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
- ◆ Nuclear Technology (2 topics)
  - ◇ Using isotope ratios to radiodate
  - ◇ Using activity to radiodate
- ◆ Organic Structure (6 topics)
  - ◇ Identifying organic compounds
  - ◇ Interpreting condensed chemical structures
  - ◇ Identifying organic functional groups
  - ◇ Identifying the main chain of branched alkanes
  - ◇ Numbering the main chain of branched alkanes
  - ◇ Interpreting condensed chemical structures with benzene rings
- ◆ Organic Nomenclature (12 topics)
  - ◇ Naming normal alkanes
  - ◇ Using family suffixes to name organic compounds
  - ◇ Naming the parent hydrocarbon of branched alkanes
  - ◇ Naming alkyl side chains
  - ◇ Naming branched alkanes
  - ◇ Using multiplying affixes in the names of branched alkanes
  - ◇ Naming unbranched alkenes and alkynes
  - ◇ Naming alkenes and alkynes
  - ◇ Naming alkyl halides
  - ◇ Naming alcohols
  - ◇ Naming aldehydes and acids
  - ◇ Naming benzene derivatives