AP® Chemistry Curriculum Guide

AP® Program

Our school offers one section of AP Chemistry, which meets two periods (back-to-back) each day, five days a week. Each period is 51 minutes in length; averaging 1.7 hours per day (8.5 hours/week).

Course Design

This course is designed to provide a solid, first-year college chemistry experience, both conceptually and in the laboratory. The labs serve to supplement the learning in the lecture section of the course. Problem solving skills, both on paper and in the lab, are emphasized. Exams are administered at the conclusion of each section of material. These exams are formatted to simulate an actual AP exam.

Laboratory

Students are required to submit a complete report for each lab experiment, including purpose, procedure, observations/data, calculations, and a results & discussion section. All reports are kept in a laboratory notebook which follows the format of a college laboratory notebook. All laboratory exercises are hands-on unless otherwise noted.

Goals of the course

- Students are prepared to be critical and independent thinkers who are able to function effectively in a scientific and technological society.
- Students will be able to analyze scientific and societal issues using scientific problem solving.
- Students will emerge from this program with an appreciation for the natural world.
- Students will be able to make an acceptable score on the AP Chemistry Examination.

Text

Zumdahl, S. S. & Zumdahl, S. A. (2000) *Chemistry* (5th ed.).Boston: Houston Mifflin Company.

Laboratory Manuals

We do not use a laboratory manual but rather a collection of labs from various sources. These include:

- Wards Natural Science
- Flinn Scientific Inc.
- Modular Laboratory Program in Chemistry

AP® Course Outline

I. Introduction to measurements, matter, and the atom *1 Week --Review*

A. Units and significant figures
B. Accuracy and precision
C. Classes, phases, and properties of matter
D. Atomic theory
    1. History
    MCO: Students discuss the impact of culture on the formation of atomic theory
    2. Atomic number, mass number, and atomic mass

Laboratory

- Separating the components of a ternary mixture of NaCl, SiO_2, & $NaHCO_3$
- Percent water in the hydrate, $CuSO_4 \cdot 5H_2O$
- Freezing point depression of a salt water solution

MCO: Laboratories are to be conducted in groups to develop socialization skills of students as well as demonstrate the nature of science

II. Formulas *1 Week -- Review*

A. Calculations of atomic mass, mass spectroscopy
B. Mole calculations, empirical formulas, and molecular formula
C. Nomenclature of ionic & covalent compounds, and acids

Laboratory

- Determination of the molecular mass of a liquid (Isopropyl Alcohol)
- Mole ratio of reactants
- Stoichiometry in the synthesis of an ionic compound

MCO: Laboratories are to be conducted in groups to develop socialization skills of students as well as demonstrate the nature of science

III. Reactions

A. Chemical Reaction Equations *2 Days -- Review*
    1. Balancing
    2. Stoichiometry
B. Introductory Aqueous chemistry *2 Days*
    1. Molarity
    2. Net ionic equations
    3. Solubility rules
C. Precipitation reactions *1 Week*
    1. Solubility
    2. Net ionic equations
    3. Stoichiometry
D. Oxidation-reduction reactions *2 Weeks*
    1. Oxidation numbers
    2. Balancing equations by half-reactions

MCO: Students work in pairs or in triads and present their work to the rest of the class

E. Electrochemistry *3 Weeks*

1. Standard electrode potentials, including reaction spontaneity
2. Voltaic/galvanic cells
3. Electrolytic cells
4. Faraday's Law
5. Nernst equation

F. Acid –base reactions *3 Weeks*

1. Theories
    a. Arrhenius
    b. Bronsted-Lowry
    c. Lewis

    MCO: Students investigate the historical and cultural underpinnings of development of acid-base theory
2. Ionization/dissociation equations for strong & weak acids/bases
3. K_w and pH
4. Introduction to equilibrium (K_a and K_b)
5. Salts

Laboratory

- Precipitation reactions and net ionic equations
- Oxidation-reduction reactions: "Blue Bottle"
- Electrochemical cells: Determination of cell potentials using galvanic cells
- Standardization of a NaOH solution.
- Determination of acid concentration by titration with a standardized base solution (HCl and NaOH)
- Dissociation constant of a weak acid
- Determination of a suitable indicator for various acid-base titrations

  MCO: Students work in pairs or triads to complete these labs and work cooperatively to present the results in a creative format

IV. Thermodynamics—Part I: Thermochemistry *3 Weeks*

A. Introductory energy concepts

1. Types of energy
2. Units
3. System versus surroundings

B. First law of thermodynamics

1. State functions
2. Calculations of work and heat

C. Calorimetry

D. Hess's law

E. Standard enthalpy of formation

Laboratory

- Calorie content of a peanut: Calculation of calories per gram of peanut
- Identifying an unknown metal by determining the specific heat of the metal

Thermochemistry and Hess's law

MCO: Laboratories are to be conducted in groups to develop socialization skills of students as well as demonstrate the nature of science

V. Electronic structure and periodicity *2 Weeks -- Review*

A. Electronic structure
   1. Nature of light
      a. Waves
      b. Quantized energy
   2. Bohr model of the atom
      a. Line spectra
      b. Classical physics approach
      c. Electron energy calculations

      MCO: Students discuss how beliefs, ideas, and current knowledge impact objectivity in accepting "different" ideas than the norm.
   3. Quantum mechanics
      a. Dual nature of matter
      b. Orbitals
      c. Quantum numbers
   4. Electron notations/configurations

B. Periodic table
   1. History
   2. Trends in:
      a. Radius
      b. Ionization energy
      c. Electron affinity energy
      d. Metal-nonmetal characteristics
   3. Irregularities in trends
   4. Explanation of trends and irregularities:
      a. Effective nucleus
      b. Atomic radius
      c. Shielding
      d. Charge density

Laboratory

- Identifying metals using flame test & spectrophotometric line analysis
- Qualitative Analysis: Identification of an unknown anion (I-, Cl-, Br-)in solution
- Activity series: Classify elements according to their relative reactivity

  MCO: Students work cooperatively to prepare results and reports.

IV. Bonding *3 Weeks*

A. Ionic bonds
   1. Born-Haber cycle
      a. Energy diagrams
      b. Related reactions
      c. Energy calculations
   2. Coulomb's Law relationships

B. Covalent bonds
   1. Bond energy
      a. Energy minimum graph

b. Calculations
c. Number, length, & strength of bonds

2. Bond polarity based on Electronegativity
3. Molecular models
    a. VESPR theory
    b. Hybrid orbitals
    c. Resonance
    d. Dipole moment
    e. Geometries
    f. Lewis structures
    g. Sigma and pi bonds

C. Organic chemistry
1. Alkanes, alkenes, alkynes
    a. Structures
    b. Introductory nomenclature
    c. Isomers
2. Functional groups

Laboratory

- VSEPR models and molecular modeling kits
- Grignard synthesis of benzoic acid* *Teacher demonstration
- Synthesis of aspirin
- Ester formation: Production of five esters with fruit fragrances

MCO: Laboratories are to be conducted in groups to develop socialization skills of students as well as demonstrate the nature of science

VII. States of Matter *2 Weeks*

A. Gases
1. Gas laws
    a. Boyle's
    b. Charles'
    c. Avogadro's
    d. Gay-Lussac's
    e. Dalton's (partial pressure)
2. Ideal Gas Law
    a. Calculations and deviations
3. Kinetic molecular theory & energy distribution graphs

B. Liquids and Solids
1. Kinetic molecular descriptions
2. Phase changes
    a. Vapor pressure
    b. Heat of vaporization
    c. Heat of fusion
    d. Heating curves
    e. Phase diagrams
3. Attractive forces/intermolecular forces
    a. Types and associated properties

MCO: Students discuss past ideas of phases of matter and how that influences the results of testing an idea.

C. Solutions
    1. Solution process
    2. Concentration calculations
    3. Solubility
        a. Saturation
        b. Temperature & Pressure effects
        c. Solute-solvent interactions
    4. Colligative properties

Laboratory

- Vapor pressure of a salt solution versus pure water
- Equilibrium constant of an ionic compound

MCO: Laboratories are to be conducted in groups to develop socialization skills of students as well as demonstrate the nature of science

VIII. Kinetics *3 Weeks*

A. Reaction rates
    1. Average rate expressions
    2. Units
    3. Graphs
    4. Stoichiometry
B. Differential rate law
    1. Orders
    2. Rate constants
    3. Concentrations
    4. Calculations
C. Integral rate law
    1. Graphs
    2. Lab applications
D. Collision theory
    1. Activation energy and orientation of particles
    2. Effects of:
        a. Concentration
        b. Temperature
        c. Catalysts
E. Potential energy diagrams
    1. Construction & interpretation
    2. Relation to energy distribution graphs
F. Arrhenius equation
G. Mechanisms

Laboratory

- Reaction kinetics: Viewing a change in reactants' concentration by change in color using an iodine and starch reaction
- Determination of reaction order using $KMnO_4$ and Oxalic Acid
- Clock reactions

MCO: Laboratories are to be conducted in groups to develop socialization skills of students as well as demonstrate the nature of science

IX. Equilibrium *3 Weeks*

A. Gas equilibrium
   1. Equilibrium concepts
      a. Expressions
      b. Constants
      c. Graphs
      d. Calculations
   2. Le Chatelier's Principle
      a. Effects of temperature, pressure, & volume

B. Acid-base equilibria
   1. K_a and K_b (previously introduced)
   2. Common ion effects
   3. Buffers
   4. Titration curves
      a. Shape
      b. Midpoint and equivalence point determinations
      c. Calculations of concentration and pH
      d. Indicators

C. Solubility products
   1. Saturated solutions
   2. Writing reaction equations and K_{sp} expressions
   3. Determining solubility and concentrations
      a. Common ion effect
   4. Determining precipitation from calculations of Q versus K_{sp}

D. Complex ions
   1. Formulas and equation writing

Laboratory

- Determining the common ion effect on the solubility of Potassium Hydrogen Tartrate
- Studying the effect of buffering on the resistance of a solution to pH change
- Beer-Lambert law
- Spectrophotometric determination of Cr^{3+}concentration

MCO: Laboratories are to be conducted in groups to develop socialization skills of students as well as demonstrate the nature of science

X. Part II Entropy and free energy *1 Week*

A. Spontaneous reactions
    1. Thermodynamics versus kinetics
        a. Driving forces

B. Entropy
    1. Second and third laws of thermodynamics
        a. Sign conventions
        b. Calculations
        C. Molecular level interpretations

C. Free energy
    1. Calculations from:
        a. Tables
        b. Thermochemical data
        c. Equilibrium constants
        d. Electrical potential
    2. Interpretation of reaction spontaneity

XI. Nuclear chemistry *1 Week*

A. Particles

B. Nuclear equations
    1. Writing and balancing reactions
    2. Predicting products

C. Half-life calculations

***NOTE: Remaining weeks are used to review. Students are administered simulated AP exams which are based on released items from previous years.**