# AP Chemistry
# COURSE SYLLABUS
# Advanced Placement Chemistry, Grade 11 or 12

Primary Course Materials: The text is **Chemistry & Chemical Reactivity 6th Ed. Enhanced**, J. C Kotz., P. M. Treichel and G. C. Weaver, Thomson Brooks/Cole; United States, 2006 [ISBN 0-495-11450-2]. The laboratory text is **Laboratory Experiments for Advanced Placement Chemistry**, S. A. Vonderbrink, Flinn Scientific, Inc., Batavia, IL, 1995. The Science computer room is used to process data collected by TI-83 data acquisition probes and technology during wet chemistry procedures and for some mathematical modeling. The course is enhanced with various handouts, instructor designed PowerPoint presentations, and classic video productions.

**Course Description**

The College Board sponsors the Advanced Placement Chemistry Program. The College Board sets the standards and tests students against these standards by administering a national exam under strict testing guidelines and procedures. The AP Chemistry course is designed to be the equivalent of the general chemistry course and laboratory taken during the first year of college. The course contributes to the development of the students' abilities to think clearly about the physical nature of chemistry and to accurately express their ideas, orally and in writing, with clarity and logic.

**Course Design**

1. AP Chemistry is a second year chemistry class. Students must complete a first year Honors Chemistry class or have had completed the Academic Chemistry section with their teacher's recommendation.
2. The class meets five times out of every seven days during the entire school year. Four of these meetings are 60 minutes long, and one is 80 minutes long. Labs may be scheduled on either type of day, depending on the amount of time required. Some labs require multiple days.
3. Students are given a course syllabus on the first day of school which outlines the pacing for the year. On nights that students are not working on problem sets, they can expect to be writing pre-lab assignments in their laboratory log notebook or completing post lab computations and conclusions. Students do not receive new homework assignments on the evening before chapter exams.
4. The course demands student initiative. Students are provided with answers to problem sets and must initiate any dialogue around specific problems. Lecture and demonstrations are usually planned for the first day of each unit. Lecture time is extended and demonstrations are added when possible.

**Major Evaluation Strategies (Summary)**

1. Each of the major units contains 1-3 exams, depending on the length of the unit. The format of the exams will vary depending on the type of material covered. Some exams will have a large number of multiple choice questions similar to the type on the AP exam. In addition, an American Chemical Society test bank as well as the one supplied by the text book publisher is used. The preponderance of the questions on unit exams are open response problems and discussion questions. In later units, free response questions from past AP tests are used in order to familiarize students with the type of questions on the AP exam. These AP components never make up the majority of any test—they are a minor but important component of the evaluation strategy.
2. Quizzes are at any time. At first they are announced but after the first month of school, they can be given unannounced. The quizzes are usually quantitative in nature and based on the homework.
3. After every laboratory, the student's laboratory log book is evaluated and returned with comment. At the end of the year each student has a permanent record of their time in the lab. These lab logs have been used by students to get credit for the lab experience when they attend college. There is flexibility in the laboratory program in order to address interests expressed by the class.

4. About once a week, a class activity, lab challenge or calculator free problem is evaluated. Often the activity will be performed by groups of two to three members. A student is chosen by the instructor to present the solution. The class can then ask questions of the individual about the problem. All members of the group receive the same grade.
5. Short writing assignments are also evaluated. Students are routinely asked to observe a demonstration and write a paragraph to describe their observations and explain what took place. Another common assignment is to write in words without numbers how they solved a problem and why they solved it the way they did.
6. During the second semester, at least a dozen class sessions are spent on working "Calculator Free" problems in groups of two to three. The numerical solutions to the problems are easy to establish but the problems themselves are designed to expose weaknesses in student understanding. This requires students to solve problems by zeroing in on the chemistry and not equations, math, or memorization.

**Course Objectives:** Upon completion of all homework assignments, laboratories and challenges:

1. Students prepare for high achievement on the AP Chemistry Exam.
2. Students pursue an in depth college level understanding of chemistry with an emphasis on P. Chemistry principles in a nurturing and reflective environment.
3. Students learn basic and advanced wet laboratory techniques, instrumentation, experimental design, research strategies and computation methods.
4. Read information critically to develop understanding of concepts, topics and issues.
5. Write clearly, factually, persuasively and creatively in Standard English.
6. Speak clearly, factually, persuasively and creatively in Standard English.
7. Use computers and other technologies to obtain, organize & communicate information and to solve problems.
8. Conduct research to interpret issues or solve complex problems using a variety of data and information sources.

| Text Book Sections (chapters should be read before beginning problem sets) | Topics | Problem Set (due the day before the unit exam) |
|---|---|---|
| Chapters 1-2 | • Classification of Matter<br>• Elements and Atom<br>• Compounds and Molecules<br>• Physical and Chemical Properties<br>• Physical and Chemical Changes<br>• Units of Measurement<br>• Making Measurements—Precision and accuracy<br>• Mathematics of Chemistry<br>• Early Atomic Structure<br>• Dalton's Atomic Theory<br>• Early Experiments in Atomic Theory<br>• Atomic Number, Mass Number, and Isotopes<br>• Average Atomic Mass Calculations<br>• The Mole, Molar Mass, and Calculations<br>• Periodic Table Introduction, including Periodic Properties | **CH 1-2:** All blue problems and underlined problems at end of each chapter.<br>Note: Blue problems are roughly the odd problems in the back of the chapter. Answers(but not the explanations) can be found in the book for these problems. |
| Chapter 3 | • Molecular Models<br>• Ionic Compounds: Formulas, Names, and Properties<br>• Molecular Compounds: Formulas, Names, and Properties<br>• Formulas, Compounds, and the Mole<br>• Describing and Calculating Compound Formulas<br>• Hydrated Compounds | **CH 3:** All blue and underlined problems at the end of the chapter. |
| Chapter 4 | • Balancing Equations<br>• Stoichiometric calculations<br>• Limiting Reactant, Theoretical Yield, and Percent Yield<br>• Stoichiometry and formula determination | **CH 4:** All blue and underlined problems at the end of the chapter. |
| Chapter 5, 22.3 | • Ionic Compounds in Water<br>• Common Acids and Bases and Their Behavior in Water | **CH 5**: All blue problems at end of the chapter. |

| | | |
|---|---|---|
| Chapter 5, 22.3 (continued) | • Full ionic, Net Ionic, and Molecular Equation Writing<br>• Common Oxidizing and Reducing Agents in REDOX reactions<br>• Molarity and Stoichiometry<br>• Complexes and Ligands<br>• Coordination Number<br>• Formulas | **CH 22**:<br>17 Worksheets on chemical equations from *The Ultimate Chemical Equations Handbook* |
| Chapter 6, 19.1-19.6 | • Heat Transfer Associated with Changes in Temperature and Changes of State<br>• 1st Law of Thermodynamics<br>• State Functions: Enthalpy and Internal Energy<br>• Energy Calculations and Measurement<br>• Entropy and Spontaneity<br>• Predictions of Spontaneity Free Energy | **CH 6**: All blue and underlined problems at the end of the chapter.<br><br>**CH 19**: 3, 5, 11, 15, 19, 23, 27, 29 |
| Chapters 7, 8 | • Electromagnetic Radiation and Properties<br>• Excited Atoms and Light Emission<br>• Particle-Wave Duality<br>• Quantum Mechanics<br>• Quantum Numbers and Atomic Structure<br>• Magnetism and Atomic Structure Determination<br>• Effective Nuclear Charge and Atomic Properties (electronegativity, ionization energy, electron affinity, atomic radius, ion size)<br>• Electron Configurations for Atoms and Ions<br>• Physical Properties of Elements and their Periodic Trends | **CH 7-8**: All blue and underlined problems at the end of the chapter. |
| Chapters 9-10.2 | • Ionic vs. Covalent Bonds<br>• Lewis Structures<br>• VSEPR Theory<br>• Polarity of Bonds and Molecules<br>• Properties of<br>• Covalent Bonds and their Influence on Molecular Structure | **CH 9**: All blue and underlined problems at the end of the chapter.<br>**CH 10**: 1-33 blue, and 42, 44, 48, 52, 54, 56. |

| | | |
|---|---|---|
| Chapters 9-10.2 (continued) | • Valence Bond Theory vs. Molecular Orbital Theory<br>• Hybridization of an Atom in an Ion or Molecule | |
| Chapter 11 | • Organic compound classification<br>• Organic nomenclature<br>• Properties and Molecular Structure including isomers | **CH 11:** All blue and underlined problems at the end of the chapter, except 68, 70, and 72. |
| Chapters 12-13 | • Gas Laws: Boyle's Law, Charles's Law, Avogardo's Hypothesis, Dalton's Law<br>• Ideal gas Law<br>• Gas Laws and Stoichiometry<br>• Kinetic Molecular Theory and Molecular Speeds<br>• Real Gases<br>• Intermolecular Forces and their Effects<br>• Hydrogen Bonding<br>• Properties of Liquids<br>• Unit Cells for Ionic Compounds and their Formulas<br>• Properties of Solids<br>• Phase Diagrams | **CH 12-13**: All blue and underlined problems at the end of each chapter. |
| Chapter 14 | • Units of Solution Concentration<br>• Solution Process<br>• Colligative Properties<br>• Colloids | **CH 14:** All blue and underlined problems at the end of the chapter. |
| Chapter 15 | • Rates of Reaction and the Conditions that Affect the Rates<br>• Integrated Rate Equations, Rate Constant, Reaction Order<br>• Collision Theory of Reaction Rates and Activation Energy<br>• Reaction Mechanisms and Rate Laws | **CH 15**: All blue and underlined problems at the end of the chapter. |
| Chapter 16 | • Chemical Equilibria: Nature and Characteristics<br>• Equilibrium Constant and Reaction Quotient<br>• Equilibrium Constant in Calculations | **CH 16**: All blue and underlined problems at the end of the chapter. |
| Chapter 17 | • Bronsted-Lowry, Arrhenius, and Lewis Theories of Acids and Bases | **CH 17:** All blue and underlined problems at the end of the chapter. |

| | | |
|---|---|---|
| Chapter 17 (continued) | • Chemical Equilibrium and Acids and Bases<br>• Acid and Base Reactions<br>• Structure and Bonding of Acids and Bases and Properties | |
| Chapter 18 | • Common Ion Effect<br>• Buffers and pH Control<br>• pH in Acid-Base Titrations<br>• Solubility of Ionic Compound and Equilibrium | **CH 18:** All blue and underlined problems at the end of the chapter. |
| Chapter 19.7, 19.8, 20 | • Free Energy and the Equilibrium Constant<br>• Free Energy and Product-Favored or Reactant-Favored Reactions<br>• Balancing REDOX Reactions in Acidic or Basic Solution<br>• Voltaic Cells<br>• Electrochemical Potentials and Uses<br>• Electrolysis | **CH 19**: End of chapter problems: 44-47, 54, 58, 72, 74, 78, 88, 90<br>**CH 20:** All blue and underlined problems at the end of the chapter. |
| Chapter 23 | • Radioactive Elements, Natural Nuclear Reactions, and Artificial Nuclear Reactions<br>• Binding Energy<br>• Binding Energy per Nucleon<br>• Radioactive Decay Rates | |
| Chapters 21, 22 | • Formulas and Properties of Compounds and the Periodic Table<br>• Chemistry of Main Group Elements<br>• Transition Elements: Properties | Even numbered Problems at the end of the chapter |

# Advanced Placement Chemistry
# CONTENT OVERVIEW

| Unit/ Time | Content | Skills | Assessment |
|---|---|---|---|
| UNIT 1: The Basic Tools of Chemistry (4 WEEKS)<br><br>**Chemistry and Chemical Reactivity**, CH 1-4<br><br>A: Matter and Measurement | • Classification of Matter<br>• Elements and Atoms<br>• Compounds and Molecules<br>• Physical and Chemical Properties<br>• Physical and Chemical Changes<br>• Units of Measurement<br>• Making Measurements—Precision and accuracy<br>• Mathematics of Chemistry | The students will be able to:<br><br>• Recognize the different states of matter<br>• State the differences between pure substances and mixtures and homogeneous and heterogeneous mixtures<br>• Understand the basic ideas of the kinetic-molecular theory<br>• Identify the name or symbol for an element, given its symbol or name<br>• Use the terms atom, element, molecule, and compound correctly<br>• List physical properties of matter<br>• Explain the difference between chemical and physical changes<br>• Explain the difference between intensive and extensive properties<br>• Convert between temperatures on the Celsius and Kelvin scales<br>• Recognize and use metric prefixes<br>• Use dimensional analysis to carry out unit conversions | Please note that end of chapter problem assignments consist of only the blue problems in the back of each chapter.<br><br>• Class Discussions<br>• Textbook: end of chapter problems<br>• Marathon Problems (group problems)<br>• Labs:<br>  • Synthesis of Alum<br>  • Identification of Alum<br>  • Determining the Stoichiometry of a Chemical Reaction<br><br>• Quiz:<br>  • Polyatomic ion quiz<br>• 2 Tests:<br>  • Chapters 1&2<br>  • Chapters 3&4 |

| | | | |
|---|---|---|---|
| | | • Define precision and accuracy and calculate percent error<br>• Use significant figures appropriately in measurements and calculations | |
| B: Atoms and Elements | • Early Atomic Structure<br>• Dalton's Atomic Theory<br>• Early Experiments in Atomic Theory<br>• Atomic Number, Mass Number, and Isotopes<br>• Average Atomic Mass Calculations<br>• The Mole, Molar Mass, and Calculations<br>• Periodic Table Introduction, including Periodic Properties | • Explain the historical development of the atomic theory and identify some of the scientists who made important contributions<br>• Describe the basic subatomic particles<br>• Understand the relative mass scale and the atomic mass unit<br>• Define isotope and state the number of subatomic particles in an isotope given isotopic notation<br>• Perform average atomic mass calculations given relative abundances and average atomic mass<br>• Use the molar mass and Avogadro's number in chemical calculations<br>• Identify various parts of the Periodic Table<br>• Recognize similarities and differences in properties of some common elements of a given group | |
| C: Molecules, Ions, and Their Compounds | • Molecular Models<br>• Ionic Compounds: Formulas, Names, and Properties<br>• Molecular Compounds: Formulas, Names, and Properties<br>• Formulas, Compounds, | • Recognize and interpret molecular formulas, condensed formulas, and structural formulas<br>• Explain the formation of cations and anions<br>• Determine the likely charge of monatomic ions<br>• Write formulas for ionic compounds<br>• Give the names or formulas of polyatomic ions, knowing their formulas or names, | |

| | | | |
|---|---|---|---|
| | and the Mole<br>• Describing and Calculating Compound Formulas<br>• Hydrated Compounds | respectively<br>• Name ionic compounds<br>• Describe properties of ionic compounds using Coulomb's Law<br>• Differentiate between molar mass, molecular mass, and formula mass<br>• Calculate between mass, moles, and particles of a given compound<br>• Calculate percent composition<br>• Calculate empirical and molecular formulas<br>• Calculate the formula of a hydrated compound given experimental data<br>• Explain mass spectrometry and its use in determining molar mass | |
| D: Chemical Equations and Stoichiometry | • Balancing Equations<br>• Stoichiometric calculations<br>• Limiting Reactant, Theoretical Yield, and Percent Yield<br>• Stoichiometry and formula determination | • Balance equations and identify the information conveyed by a balanced equation<br>• Identify the significance of the Law of Conservation of Matter in chemical stoichiometry<br>• Calculate the mass of one reactant or product from the mass of another reactant or product<br>• Determine limiting reactant, actual yield, and percent yield<br>• Differentiate between actual yield, theoretical yield, and percent yield<br>• Analyze a mixture using stoichiometry<br>• Determine the empirical formula of an unknown compound using chemical stoichiometry | |

| | | | |
|---|---|---|---|
| UNIT 2: CHEMICAL EQUATIONS: PREDICTING PRODUCTS<br><br><u>Chemistry and Chemical Reactivity</u>, CH 5, 22.3<br><br>(1.5 WEEKS)<br><br>A: Reactions In Aqueous Solutions | • Ionic Compounds in Water<br>• Common Acids, Bases, and Their Behavior in Aqueous Solution<br>• Full Ionic, Net Ionic, and Molecular Equation Writing<br>• Common Oxidizing- and Reducing-Agents in REDOX Reactions<br>• Molarity and Stoichiometry | • Differentiate between electrolytes and non-electrolytes<br>• Predict the solubility of ionic compounds in water<br>• Identify the ions formed when acids, bases, or salts dissolve in water<br>• Categorize acids and bases as strong or weak<br>• Predict the products of precipitation reactions and write net ionic equations predict the product of acid-base reactions and write the net ionic equation\<br>• Predict the products in a gas-forming or REDOX reaction<br>• Identify oxidation numbers<br>• Identify common oxidizing- or reducing-agents<br>• Calculate the concentration of solutes<br>• Prepare a solution of known concentration<br>• Identify and perform the steps of a titration | • Class Discussion<br>• End of Chapter Problems<br>• Marathon Problems (group problems)<br>• Worksheets on chemical equations from *The Ultimate Chemical Equations Handbook*<br>• Labs:<br>  • Gravimetric Analysis of a Metal Carbonate<br>  • Activity Series<br>  • Standardization of Sodium Hydroxide using a Primary Standard<br>• Test:<br>  • Chapter 5 with 22.3 |

| | | | |
|---|---|---|---|
| B: Coordination Compounds | • Complexes and Ligands<br>• Coordination Number<br>• Formulas | • Given the formula for a coordination complex, be able to identify the metal and its oxidation state, the ligands, the coordination number, and the overall charge on the complex<br>• Provide the systematic names for complexes and their formulas<br>• Describe the bonding<br>• Predict the formation of a complex | |
| UNIT 3: ENERGY—PART 1<br>Chemistry and Chemical Reactivity, CH 6, 19.1-19.6<br>(3 WEEKS)<br><br>Part A: Energy and Chemical Reactions | • Heat Transfer Associated with Changes in Temperature and Changes of State<br>• $1^{st}$ Law of Thermodynamics<br>• State Functions: Enthalpy and Internal Energy<br>• Energy Calculations and Measurement | • Describe various forms of energy and the nature of heat and thermal energy transfer<br>• Convert between Joules and calories<br>• Define system, surroundings, endothermic, and exothermic<br>• Use specific heat in calculations of heat transfer and temperature changes<br>• Calculate heat changes involved in changes of state<br>• Understand and use the $1^{st}$ Law of Thermodynamics<br>• Describe how calorimetry is used to measure heat transferred in a reaction | • Class Discussion<br>• End of Chapter Problems<br>• Labs:<br>  • Thermochemistry and Hess's Lab<br>  • Titration of Strong Acid/Base<br>  • Synthesis Coordination Compound ($K_3Fe(C_2O_4)_3 \cdot 3H_2O$)<br>  · Analysis of Coordination Compound ($K_3Fe(C_2O_4)_3 \cdot 3H_2O$ |

| | | | |
|---|---|---|---|
| Part B: Entropy and Free Energy | • Entropy and Spontaneity<br>• Predictions of Spontaneity<br>• Free Energy | • Apply Hess's law to find the enthalpy change for a reaction<br>• Interpret energy level diagrams<br>• Calculate the enthalpy for a reaction using the standard molar enthalpy of formation, $\Delta H_f^\circ$<br><br>• Describe how entropy is a measure of disorder<br>• Describe how entropy can be measured experimentally<br>• Calculate entropy given a table of standard values<br>• Determine whether the entropy or enthalpy drives a reaction<br>• Predict spontaneity of a reaction at various temperatures<br>• Calculate the change in Free Energy at standard conditions<br>• Describe the temperature dependence of Free Energy | • Test:<br>  • Chapter 6 with 19.1-19.6 |

| | | | |
|---|---|---|---|
| UNIT 4: STRUCTURE OF ATOMS<br>Chemistry and Chemical Reactivity, CH 7,8 (2.5 WEEKS)<br><br>Part A: Atomic Structure | • Electromagnetic Radiation and Properties<br>• Excited Atoms and Light Emission<br>• Particle-Wave Duality<br>• Quantum Mechanics<br>• Quantum Numbers and Atomic Structure | • Define and use the terms *wavelength, frequency, amplitude,* and *node*<br>• Calculate between wavelength, frequency, and the speed of light<br>• Identify the various types of radiation on the electromagnetic spectrum<br>• Calculate between energy of photon and frequency using Planck's constant<br>• Describe the Bohr model of the atom and its limitations<br>• Describe the allowed energy states for the H atom according to the Bohr model<br>• Use the de Broglie equation to describe the wavelength of a subatomic particle<br>• Identify how an orbital for an electron in an atom corresponds to the allowed energy of that electron<br>• Interpret the Heisenberg Uncertainty Principle<br>• Describe the allowed energy states of the electron using four quantum numbers<br>• Describe the shapes of the orbitals | • Class Discussion<br>• End of Chapter Problems<br>• Labs:<br>  • Gas Discharge Tubes and Atomic Spectra<br>• Test:<br>  • Chapter 7&8 |

| | | | |
|---|---|---|---|
| Part B: Electron Configurations and Chemical Periodicity | • Magnetism and Atomic Structure Determination<br>• Effective Nuclear Charge and Atomic Properties (electronegativity, ionization energy, electron affinity, atomic radius, ion size)<br>• Electron Configurations for Atoms and Ions<br>• Physical Properties of Elements and their Periodic Trends | • Classify substances as paramagnetic or diamagnetic<br>• State Pauli Exclusion Principle, Aufbau Principle, and Hund's Rule and use them to justify orbital-filling diagrams<br>• Determine how the effective nuclear charge affects the properties of atoms<br>• Depict electron configurations<br>• Predict how atomic properties change down a group or across a period of the periodic table | |

| | | | |
|---|---|---|---|
| UNIT 5: MOLECULAR STRUCTURE<br>Chemistry and Chemical Reactivity, CH 9-11 (3.5 WEEKS)<br><br>Part A: Bonding and Molecular Structure Part I | • Ionic vs. Covalent Bonds<br>• Lewis Structures<br>• VSEPR Theory<br>• Polarity of Bonds and Molecules<br>• Properties of<br>• Covalent Bonds and their Influence on Molecular Structure | • Recognize the role that ionization energy and electron affinity play in the chemistry of the elements<br>• Predict from a formula whether a compound has covalent or ionic bonding<br>• Differentiate between covalent and ionic bonding<br>• Describe how the size and charge of ions affect the basic ideas of ionic bonding<br>• Calculate lattice energy and correlate lattice energy with melting point<br>• Draw Lewis structures for molecular compounds and ions, including expanded octets and resonance structures<br>• Use formal charge to determine accepted Lewis structure<br>• Predict molecular geometry using VSEPR Theory<br>• Predict the polarity of a molecule and explain it in terms of formal charge and electronegativity<br>• Define and predict trends in bond order, bond length, and bond dissociation energy | • Class Discussion<br>• Unit Problem Set<br>• Marathon Problems<br>• Labs:<br>  • Synthesis of Aspirin<br>  • Analysis of Aspirin<br>  • Determination of the Hardness of Water<br>• Test:<br>  • Chapters 9 and 10.1-10.2 Test<br>  • Chapter 11 Test |

| | | | |
|---|---|---|---|
| Part B: Bonding and Molecular Structure Part II | • Valence Bond Theory vs. Molecular Orbital Theory<br>• Hybridization of an Atom in an Ion or Molecule | • Describe the main features of valence bond theory and molecular orbital theory<br>• Define a bond in terms of valence bond theory: an overlap of atomic orbitals<br>• Distinguish between sigma and pi bonds<br>• Predict the hybridization of an atom in a molecule or ion | |
| Part C: Carbon—More Than Just an Element | • Organic compound classification<br>• Organic nomenclature<br>• Properties and Molecular Structure | • Draw structural formulas and name simple hydrocarbons, including alkanes, alkenes, alkynes, and aromatic compounds<br>• Identify possible isomers for a given formula<br>• Name and draw structures with various functional structures with various functional groups | |

| | | | |
|---|---|---|---|
| UNIT 6: STATES OF MATTER<br>Chemistry and Chemical Reactivity, CH 12-14<br>(3.5 WEEKS)<br><br>Part A: Gases | • Gas Laws: Boyle's Law, Charles's Law, Avogadro's Hypothesis, Dalton's Law<br>• Ideal gas Law<br>• Gas Laws and Stoichiometry<br>• Kinetic Molecular Theory and Molecular Speeds<br>• Real Gases | • Describe and make measurements of pressure using mmHg and atm<br>• Apply the gas laws<br>• Understand the origin of the Ideal Gas Law and calculate with it<br>• Calculate the molar mass and density of a known quantity of gas<br>• Perform stoichiometric calculations with gases<br>• Use Dalton's Law of Partial Pressures and collect a gas over water<br>• Predict the behavior of gas molecules at the molecular level using the kinetic molecular theory<br>• Differentiate between diffusion and effusion and calculate using Graham's Law<br>• Predict deviations from ideal gas behavior | • Class Discussion<br>• End of Chapter Problems<br>• Labs:<br>  • Molecular Mass of a Volatile Liquid<br>  • Vapor Pressure and the Enthalpy of Vaporization of Methanol<br>  • Liquid Chromatography<br>• 2 Tests:<br>  • Chapters 12 and 13<br>  • Chapter 14 |
| Part B: Intermolecular Forces, Liquids, and Solids | • Intermolecular Forces and their Effects<br>• Hydrogen Bonding<br>• Properties of Liquids<br>• Unit Cells for Ionic Compounds and their Formulas | • Predict what type of intermolecular forces of attraction (dipole—dipole, H-Bonding, London Dispersion Forces, Dipole-Dipole Induced) exist between to molecules and describe them<br>• Explain how H-bonding affects the properties of water | |

| | | | |
|---|---|---|---|
| | • Properties of Solids<br>• Phase Diagrams | • Explain the process of evaporation and condensation and use enthalpy of vaporization in calculations<br>• Define the equilibrium vapor pressure of a liquid and explain the relationship between the vapor pressure and the boiling point<br>• Define critical temperature and pressure for a substance<br>• Describe how intermolecular attractions affect cohesive forces, surface tension, and viscosity of liquids<br>• Use the Clausius-Clapeyron equation<br>• Characterize different types of solids<br>• Define the enthalpy of fusion and use it in calculations<br>• Identify different points and regions of a phase diagram | |
| Part C: Solutions and Their Behavior | • Units of Solution Concentration<br>• Solution Process<br>• Colligative Properties<br>• Colloids | • Define the terms *solution, solvent, solute,* and *colligative properties*<br>• Calculate solution concentration in terms of: molarity, molality, mole fraction, weight percent, and parts per million<br>• Distinguish between saturated, unsaturated, and supersaturated<br>• Illustrate the terms *miscible* and *immiscible*<br>• Describe the process of dissolving a solute in a solvent, including the energy changes that may occur | |

| | | | |
|---|---|---|---|
| | | • Describe the relationship between lattice energy and enthalpy of hydration to the enthalpy of solution for an ionic solute<br>• Describe the effect of temperature and pressure on the solubility of a solute<br>• Use Henry's law<br>• Apply Le Chatelier's Principle to the change in solubility of gases with pressure and temperature changes<br>• Use Raoult's Law<br>• Calculate the boiling point elevation and freezing point depression caused by a solute in a solvent<br>• Determine the molar mass of a solute using colligative properties<br>• Use the van't Hoff factor in calculations<br>• Distinguish between a homogeneous solution, a suspension, and a colloid | |

| | | | |
|---|---|---|---|
| UNIT 7: KINETICS<br>Chemistry and Chemical Reactivity, CH 15 (1.5 WEEKS)<br><br>A. Kinetics | • Rates of Reaction and the Conditions that Affect the Rates<br>• Integrated Rate Equations, Rate Constant, Reaction Order<br>• Collision Theory of Reaction Rates and Activation Energy<br>• Reaction Mechanisms and Rate Laws | • Explain the concept of reaction rate<br>• Derive the average and instantaneous rates of a reaction from experimental data<br>• List the factors that affect reaction rates<br>• Define the various parts of a rate equation and describe their significance<br>• Derive a rate equation from experimental data<br>• Describe and use the relationships between reactant concentration and time for zero-order, first-order, and second-order reactions<br>• Use graphical methods for determining reaction order<br>• Use the concept of half-life for first-order reactions<br>• Describe the collision theory of reaction rates<br>• Relate activation energy to the rate and thermodynamics of a reaction<br>• Use collision theory to describe the effect of reactant concentration on reaction rate<br>• Understand the effect of molecular orientation on reaction rate<br>• Describe the effect of temperature on reaction rate using the collision theory of reaction rates and the Arrhenius equation<br>• Calculate the activation energy from experimental data | • Class Discussion<br>• End of Chapter Problems<br>• Labs:<br>  • Determination of Rate and Order of a Reaction<br>  • Rate Determination and Energy of Activation<br>• Test:<br>  • Chapter 15 |

| | | | |
|---|---|---|---|
| UNIT 8: EQUILIBRIUM<br>Chemistry and Chemical Reactivity, CH 16-18<br>(5 WEEKS)<br><br>Part A: Principles of Reactivity: Chemical Equilibria | • Chemical Equilibria: Nature and Characteristics<br>• Equilibrium Constant and Reaction Quotient<br>• Equilibrium Constant in Calculations | • Describe the functioning of a catalyst and its effect on the activation energy and mechanism of a reaction<br>• Understand reaction coordinate diagrams<br>• Describe the concept of a reaction mechanism and the relation of the mechanism to the overall, stoichiometric equation for a reaction<br>• Describe the elementary steps of a mechanism and give their molecularity<br>• Define the rate-determining step in a mechanism and identify any reaction intermediates<br><br>• Explain how chemical reactions are reversible and equilibria are dynamic<br>• Calculate the reaction quotient for a chemical reaction and determine if a system is at equilibrium<br>• Write the equilibrium expression recognizing that the concentration of solids, pure liquids, and solvents are excluded<br>• Distinguish between a product-favored and reactant-favored reaction<br>• Distinguish and calculate between $K_c$ and $K_p$<br>• Use the equilibrium constant to calculate the | |

| | | | |
|---|---|---|---|
| Part B: Principles of Reactivity: The Chemistry of Acids and Bases | • Bronsted-Lowry, Arrhenius, and Lewis Theories of Acids and Bases<br>• Chemical Equilibrium and Acids and Bases<br>• Acid and Base Reactions<br>• Structure and Bonding of Acids and Bases and Properties | concentration of all species in a system when it approaches equilibrium<br>• Describe how K changes as different stoichiometric coefficients are used in a balanced equation, if the equation is reversed, or is several equations are added to give a new equation<br>• Use Le Chatelier's Principle to predict the effect of a stress on a system at equilibrium<br>• Define and use the Bronsted concept of acids and bases<br>• Recognize monoprotic and polyprotic acids and bases and write balanced equations for their ionization in water<br>• Explain when a species can be amphoteric<br>• Recognize the Bronsted acid in and base in a reaction and identify their conjugates<br>• Explain the auto-ionization of water<br>• Use the pH concept<br>• Recognize some common weak acids and explain how they can be neutral molecules, cations, or anions<br>• Write equilibrium constant expressions for weak acids and bases<br>• Calculate $pK_a$ from Ka and understand how $pK_a$ is correlated with acid strength<br>• Describe the relationship between $K_a$ for a weak acid and $K_b$ for its conjugate<br>• Write equations for acid-base reactions and determine if they are reactant-favored or product-favored | • Class Discussion<br>• End of Chapter Problems<br>• Labs:<br>  • Determination of the Solubility product Constant for an ionic Compound<br>  • Determination of the Equilibrium constant for the formation of a complex<br>  • Determination of the Dissociation constant for a weak acid<br>  • Preparation and properties of buffer solutions<br>  • Selecting indicators for acid/base titrations<br>• 3 Tests:<br>  • Chapter 16<br>  • Chapter 17<br>  • Chapter 18 |

| | | | |
|---|---|---|---|
| | | • Calculate the equilibrium constant for a weak acid or base from experimental data<br>• Use the equilibrium constant to calculate the pH of a solution<br>• Describe the acid-base properties of salts and calculate the pH of a salt solution<br>• Calculate the pH of a solution of a polyprotic acid or base<br>• Calculate the pH after an acid-base reaction<br>• Characterize a compound as a Lewis base<br>• Explain the connection between the structure of a compound and its acidity or basicity | |
| Part C: Principles of Reactivity: Other Aspects of Aqueous Equilibria | • Common Ion Effect<br>• Buffers and pH Control<br>• pH in Acid-Base Titrations<br>• Solubility of Ionic Compound and Equilibrium | • Predict the effect of the addition of a "common ion" on the pH of the solution of a weak acid or base<br>• Describe the functioning of a buffer solution<br>• Use the Henderson-Hasselbach equation to calculate the pH of a buffer of a given composition<br>• Describe the preparation of a buffer solution with a desired pH<br>• Calculate the pH of a buffer solution before and after adding a strong acid or base<br>• Predict the pH of an acid-base reaction at various points on the titration curve<br>• Distinguish between the titration curves for various acid-base titrations<br>• Explain how an indicator works<br>• Write the equilibrium constant expression for any insoluble salt | |

| | | | |
|---|---|---|---|
| UNIT 9: ENERGY II<br>Chemistry and Chemical Reactivity, CH 19.7, 19.8, 20, 23<br>(4 WEEKS) | | • Calculate $K_{sp}$ values from experimental data<br>• Estimate the solubility of a salt given its $K_{sp}$<br>• Calculate the solubility of a salt in the presence of a common ion<br>• Decide whether a precipitate will form given ion concentrations<br>• Calculate the minimum ion concentrations required for precipitation<br>• Describe the effect of the formation of a complex ion on the solubility of an insoluble salt<br>• Use $K_{sp}$ as an experimental method of separation of ions. | |
| Part A: Free Energy | • Free Energy and the Equilibrium Constant<br>• Free Energy and Product-Favored or Reactant-Favored Reactions | • Describe the relationship between the free energy change and equilibrium constants<br>• Calculate K from $\Delta G^{\circ}_{rxn}$<br>• Integrate all theories of thermodynamics | |

| | | | |
|---|---|---|---|
| Part B: Principles of Reactivity: Electron Transfer Reactions | • Balancing REDOX Reactions in Acidic or Basic Solution<br>• Voltaic Cells<br>• Electrochemical Potentials and Uses<br>• Electrolysis | • In a voltaic cell, identify the half-reactions occurring at the anode and cathode, the polarity of the electrodes, the direction of electron flow, and the direction of ion flow<br>• State examples of every-day batteries and explain the chemistry of them<br>• Explain the process by which standard reduction potentials are determined and identify the standard conditions applied to electrochemistry<br>• Identify the standard electrode and how it is used to measure standard potentials<br>• Use standard values to determine cell voltages for cells under standard state<br>• Use the standard reduction potential table to rank the strengths of oxidizing and reducing agents and to predict reactions<br>• Use the Nernst equation to calculate the cell potential under non-standard state conditions<br>• Explain how cell voltages relate to ion concentration and explain how this allows the determination of pH<br>• Calculate between cell voltage and free energy and cell voltage and the equilibrium constant for the cell reaction<br>• Describe electrolysis and identify the factors that determine which species are oxidized and which are reduced<br>• Relate the amount of a substance oxidized or reduced to the amount of current and the time the current flows | • Class Discussion<br>• End of Chapter Problems<br>• Labs:<br>  • Electrochemical Cells<br>  • Electrolysis<br>• 2 Tests:<br>  • Chapter 20 with 19.7 and 19.8<br>  • Chapter 23 |

| | | | |
|---|---|---|---|
| Part C: Nuclear Chemistry | • Radioactive Elements, Natural Nuclear Reactions, and Artificial Nuclear Reactions<br>• Binding Energy<br>• Binding Energy per Nucleon<br>• Radioactive Decay Rates | • Identify alpha, beta, and gamma radiation<br>• Write balanced nuclear reactions<br>• Predict the decay method of a radioactive isotope<br>• Understand the origin of gamma radiation<br>• Define binding energy per nucleon<br>• Calculate the binding energy per nucleon and energy per nucleon and recognize the significance of a graph versus mass number<br>• a graph versus mass number<br>• Use the half-life to estimate the time required for an isotope to decay | |

| | | | |
|---|---|---|---|
| UNIT 10: CHEMISTRY OF ELEMENTS<br>Chemistry and Chemical Reactivity, CH 21,22<br>(1 WEEK) | | | |
| Part A: The Chemistry of the Main Group Elements | • Formulas and Properties of Compounds and the Periodic Table<br>• Chemistry of Main Group Elements | • Predict reactions of main group elements<br>• Predict similarities and differences of elements in a given group<br>• Identify abundant elements, describe how they are obtained, and list common properties<br>• Identify uses of common elements and compounds and understand their chemistry | • Class Discussion<br>• Quizzes:<br>• Chemistry of Elements<br>• Labs:<br>• Separation and Qualitative Analysis of Cations<br>• Separation and Qualitative Analysis of Anions |
| Part B: The Chemistry of the Transition Elements | • Transition Elements: Properties | • Identify the general classes of elements: transition elements, lanthanides, and actinides<br>• List properties of common transition metals<br>• Explain the electrochemical nature of corrosion<br>• Explain why substances are colored and predict colors when you know the color of light absorbed | |

| | | | |
|---|---|---|---|
| UNIT 11: AP EXAM REVIEW (1 WEEK) | • All Content Previously Taught | • Integration of all concepts | • Daily Quizzes – 1 FR question per topic and 1 90 minute MC quiz. |

## Laboratory Experiments

The following laboratory experiments will be conducted in a wet lab during a regular or long block, depending on the length of the lab.
Labs listed under "Year 1" were completed in the Honors Chemistry course, a prerequisite to AP Chemistry. (Other labs were also conducted in Honors Chemistry, but these ones specifically fit the AP criteria)

**Year 1 (Honors Chemistry)**

1. **Determing the Composition of a Mixture of 2 Hydrates (Using weighted averages)**
2. **Flame Test of Cations**
3. **Redox Titration – Determining the % of $H_2O_2$ in Solution using $KMnO_4$**
4. **Determining the Empirical Formula for Magnesium Oxide**
5. **Using Colorimetry and Beer's Law to determine the % of Copper in a Penny**
6. **Determining the Molar Volume of a Gas**
7. **Determining the Molar Mass of Butane**
8. **Epsom salts – Calculating Heat of Solution and using Hess' Law**
9. **Calculating the Molar Mass of Antifreeze by Freezing Point Depression**
10. **Titration of Vinegar with a Strong Base**

**Year 2 (AP Chemistry)**

1. **Synthesis of Alum**
2. **Identification of Alum** - *Determination of the Percent Water in a Hydrate, Melting Point Determination*
3. **Determining the Stoichiometry of Chemical Reaction –** *Finding Mass/Mole Relationship in a Chemical reaction by Continuous Variation*
4. **Activity Series**
5. **Standardization of a Sodium Hydroxide Solution using a Primary Standard**
6. **Thermochemistry and Hess's Law**
7. **Titration of Strong Acid/Base**
8. **Synthesis of Coordination Compound ($K_3Fe(C_2O_4)_3 \cdot 3H_2O$)**
9. **Analysis of Coordination Compound ($K_3Fe(C_2O_4)_3 \cdot 3H_2O$)**- *Standardization of $KMnO_4$ and subsequent Redox Titration to determine purity of compound*
10. **Spectroscopy of Gas Discharge Tubes**
11. **Synthesis of Aspirin**
12. **Analysis of Aspirin**
13. **Determination of the Hardness of Water**
14. **Determining the Molar Mass of a Volatile Liquid**
15. **Vapor Pressure and Heat of Vaporization** - Clausius-Clayperon Relationship

**16. Liquid Chromatography**
**17. Determination of the Rate and Order of a Chemical Reaction (Potassium Iodide/Iron(III)chloride)-** Measurement of Instantaneous Rate and Determination of Rate Law by Colorimetric Methods
**18. Rate Determination and Energy of Activation (Crystal Violet/Sodium Hydroxide Reaction)** – *Beer's Law, ln k vs. 1/T*
**19. Determination of Solubility Product Constant of Calcium Hydroxide**
**20. Determination of Keq for $FeSCN^{2+}$**-*Colorimetric Analysis*
**21. Determination of Ka of a Weak Acid**-*Half Titration*
**22. Preparation and Properties of Buffer Solutions**
**23. Selecting Indicators for Acid-Base Titrations**
**24. Electrochemistry: Voltaic Cells**- *Measurement of Cell Potentials, Identification of an Unknown Metal, Nernst Equation*
**25. Electrochemistry: Electrolysis**
**26. Separation and Qualitative Analysis of Cations**
**27. Separation and Qualitative Analysis of Anions**

**AP CHEMISTRY LABORATORY FORMAT FOR LAB WRITE UP**

**2010**

**You are to use the following format unless directed to do otherwise. When you are writing the report, you are writing as if your reader knows nothing about your experiment. The reports must be in ink and written on perforated quad ruled paper.**

**1. TITLE:** Every lab has one.

**2. PURPOSE:** This is simply the question that you are trying to answer by the investigation. Make sure this is in the form of a question.

**3. INTRODUCTION:** The introduction is one of the most important parts of the pre-lab assignment. It is in this section where you address those concepts or techniques that are being introduced by the experiment or exercise. These concepts or techniques may be new or unfamiliar to you. You may use diagrams to help explain a point or show a technique. The purpose for this section is for you to get a good introduction to the concepts behind the experiment. The clearer this is to you, then the clearer you will understand why you are doing what you are. This section should also offer a solution or a hypothesis to the purpose question or problem. This section should be at least two paragraphs long and it must be complete.

**4. PROCEDURE:** In this section you are to make a vertical ruled line 1/3 from the left side of the page and write your detailed procedure on the right side of the line; the left side of the line is for future notes or any possible corrections regarding the lab. At the beginning of the procedure you should place a list of the materials that the lab will use.

**5. DATA TABLE:** You need to construct a data table with the appropriate properties labeled. In your data table you are to note only those quantities that are directly measured by an instrument. These quantities do not include derived quantities, which are calculated. When your data is completed in the lab, it should be written in ink and **must be initialed** by me before the block ends. This is your ticket for your lab report to be corrected. **We will not initial your lab report until your station is clean and organized**.

**6. DIAGRAM:** When appropriate, a labeled diagram of the apparatus should be included.

Everything up to this point must be done before coming to class on the day of the lab. You may not bring the lab handout or your textbook into the lab bench area.

**7. CALCULATIONS:** In this section, you are to include all calculations. These calculations must show all units, significant figures, and usually uncertainties. Your calculations must show labels so that anyone can understand what you are measuring or doing.

**8. QUESTIONS:** Many labs will have a number of questions to answer. You are to answer these in complete sentences. If you are to do any calculations, then you must show them as explained above.

**9. CONCLUSION:** Every lab report will include a personal conclusion. In this section you should answer the purpose question and such questions as: What did you learn? Was your hypothesis correct? What are the sources of error? (Calculation errors are not an acceptable source of error.) Was there anything in the experiment that surprised you? What would you want to do different and does this experiment pose any other questions?

## A WORD OF WISDOM:

Laboratories are a time where you and your partner/s will work in structured fashion to obtain data to answer a question or solve a problem. When in the lab it is helpful to discuss and talk to one another regarding the problem set before you. It is also helpful to work through ideas as to how to solve these questions and problems. However, when it comes time for you to write up your individual lab report or part of a lab report, then originality must be evident and clearly shown. This part of your write up is not part of the "collaboration" of the lab. Calculations and wording must show that you have done original work in your own way and not "copied" another's work as part of your own.