AP CHEMISTRY COURSE OUTLINE

General information:

Our school has one section of AP Chemistry which meets for three periods every two days (a double period every other day). This allows sufficient time for developing a meaningful laboratory experience and also for developing the students' problem solving skills.

Students must achieve an acceptable score on a school-developed matrix before they can be enrolled in the class, which includes teacher recommendation, grades, and scores on state tests in math and science. This is considered a second-year course in our school, so students will already have completed either Regents or Honors chemistry, which are full-year courses with a strong laboratory component.

Students must maintain a laboratory notebook to record all lab data, as well as submit a full laboratory report for each completed lab. They are graded on teamwork, organization of data, clarity of presentation, accuracy of observations and calculations, answers to applicable questions, and also the accuracy of final results and conclusion. Student labs are taken from college-level lab manuals and teacher-developed labs suitable for the topics being covered.

A test is given at the end of each unit along with a comprehensive final exam at the end of the course.

Student grades are a combination of three factors:

- Tests and quizzes – 50%
- Homework assignments – 25%
- Lab Reports – 25%

Textbook:

Chemistry, 6th Edition, Zumdahl & Zumdahl, Houghton-Mifflin Company, 2003

Laboratory Manuals:

Experimental Chemistry, 2nd Edition, James F. Hall, D.C. Heath & Co., 1989

Laboratory Experiments for Advanced Placement Chemistry,

OUTLINE OF COURSE UNITS

1) Chemical Foundations 1 week

Students review and practice measurement and calculations including: units, uncertainty in measurement and use of significant figures, dimensional analysis and problem solving, measurement of temperature, and calculation of density.

Lab: The Measurement of Temperature, Experimental Chemistry. The students calibrate their thermometers, learn to find freezing and boiling points of compounds using a Thiele tube and capillary tubes, and finally determine the identity of an unknown by measuring density, boiling points or freezing points, and comparing to a list of known substances. The use of chemical reference books is necessary. Time allotment: 3 double periods

2) Introduction to Atoms and Molecules 1 week

Students are introduced to the history of chemistry, and the fundamental chemical laws along with the scientists who discovered them, such as Lavoisier, Dalton, JJ Thomson and Rutherford. The structure of the atom is reviewed as well as an overview of the modern Periodic Table. Students review how to write formulas and name compounds.

Lab: Resolution of Mixtures 1: Filtration and Distillation, Experimental Chemistry. The students learn to separate a mixture of two solids (benzoic acid and charcoal) and also perform a simple distillation of a sodium chloride solution. Time allotment: 2 double periods

3) Stoichiometry 3 weeks

Students review mole calculations, molar mass, percent composition of compounds, and empirical and molecular formula determinations. Students review the types of chemical reactions,

balancing equations and how this relates to stoichiometric calculations of reactants and products. Particular attention is placed on limiting reagent problems as students have had limited exposure to these in the past.

Lab: Percentage of Water in a Hydrate (teacher developed)
The students are given an unknown hydrate and are asked to determine the percentage of water in that compound. They are then given the formula of the anhydrous salt and they must calculate the number of moles of water per mole of anhydrous salt.
Time allotment: 1 double period

Lab: Finding the Ratio of Moles of Reactants in a Chemical Reaction, Laboratory Experiments for AP Chemistry.
The students use the method of continuous variations to determine the optimum mole ratio of reactants in a chemical reaction by measuring the temperature change with each variation. Time allotment: 2 double periods

Lab: Synthesis of Alum, Laboratory Experiments for AP Chemistry.
The students will prepare alum, $KAl(SO_4)_2 \cdot 12H_2O$, from a solution of its ions in water. Time allotment: 1 double period

4) Solution Stoichiometry 2 weeks

Students study the nature of electrolytes, the calculation of molarity, the stoichiometry of precipitation reactions, acid/base reactions, and redox reactions. They learn to balance redox reactions by the half-reaction method including reactions occurring in acidic or basic solution. The writing of ionic equations to describe these solutions is also covered.

Lab: Classes of Chemical Reactions, Experimental Chemistry.
The students perform a series of chemical reactions which illustrate precipitation, acid/base, complexation, and oxidation/reduction. Time allotment: 3 double periods

Lab: Gravimetric Analysis, Experimental Chemistry.
The students perform Choice 1, determining the percentage of chloride in a sample by precipitating the chloride from the sample,

filtration and drying of the precipitate, and calculation of the percent chloride in the precipitate. Time allotment: 2 double periods

5) Gases 2 weeks

The students study units of pressure, the characteristics of an ideal gas, and the kinetic molecular theory of gases. They learn the gas laws of Boyle, Charles, Avogadro, Dalton and the Ideal Gas Law. They study the effusion of gases, molar mass, gas stoichiometry and root mean square velocity. They also learn about the behavior of real gases (van der Waal's equation).

Lab: Molecular Weight of a Volatile Liquid, Experimental Chemistry.

Students learn to calculate the molecular mass of an unknown liquid by evaporating it into a known volume and performing calculations using the ideal gas law. Time allotment: 1 double period

6) Thermochemistry 2 weeks

Students will study the nature of energy and work, enthalpy, calorimetry and Hess's Law. They will use standard energies of formation and combustion to determine the enthalpy of reactions.

Lab: Calorimetry, Experimental Chemistry.

Students will calculate a calorimeter constant, determine specific heats of unknown metals, and determine the enthalpy change in an acid/base reaction. Time allotment: 2 double periods

Lab: Hess' Law (teacher developed)

Students measure the enthalpy change in a series of reactions and use these measurements to calculate the total enthalpy change in a reaction incorporating all three reactions. They then compare this to the experimental value of this final reaction. Time allotment: 2 double periods

7) Atomic Structure and Periodic Table 2 weeks

Students study the concept of electromagnetic radiation and its application to the atomic spectrum of the hydrogen atom. The quantum mechanical model of the atom is studied along with the use of the four quantum numbers and the Aufbau principle to explain the probable locations and orbital shapes of the electrons in an atom.

Students review the periodic trends in atomic properties including ionization energy, atomic radius, electronegativity and electron affinity. Properties of particular groups on the periodic table are covered as is the history of the development of the modern periodic table.

Lab: Development of the Periodic Table (teacher developed) Students are given a list of imaginary elements, accompanied by each element's physical data, including atomic mass. They are then asked to construct a possible periodic table from these elements and then predict the characteristics of an unknown element from its probable place on this new periodic table. Time allotment: 1 double period

8) Bonding 3 weeks

Modern theories of bonding are explored including ionic, covalent, and metallic. The partial ionic nature of covalent bonds is explained in conjunction with the concept of polarity of bonds. Students learn to produce Lewis structures of molecules in order to predict the shape of the molecule and its resultant polarity. The VSEPR theory and resonance are reviewed. Hybridization of orbitals, the molecular orbital model, sigma and pi bonds, and paramagnetism are also covered.

Lab: Molecular Shapes (teacher developed)

Students are given a list of molecules. They are to draw the Lewis structure, predict the shape of the molecule using VSEPR theory, build the molecule using a molecular building set, and determine its polarity. Time allotment: 1 double period

9) Liquids and Solids 1 week

Students learn about the forces of attraction among molecules: London dispersion forces, dipole-dipole attraction, and hydrogen bonding. They study how these forces affect the formation and properties of liquids and solids, such as vapor pressure, boiling point, freezing point, etc. The different types of crystalline solids, ionic, molecular, network and metallic, are examined. Students study the variations in phase diagrams for various substances.

10) Solutions 2 weeks

Calculations of solution concentration are studied and practiced including molarity, molality, mass percent, volume percent, parts per million, and mole fraction. The energies of solution formation and the factors affecting solubility are covered. They learn about colligative properties and also the effect of electrolytes on these properties.

Lab: Spectrophotometric Analysis (teacher developed)

Students prepare solution samples of different molarities by the method of successive dilution. They then graph the absorbance and transmittance of these different samples by using a spectrophotometer. Finally, they determine the molarity of an unknown by comparing to their data and graph. Time allotment: 2 double periods

Lab: Freezing Point Depression of Antifreeze (teacher developed)

By varying the concentrations of antifreeze in water solutions and recording the resultant decreases in freezing point, students then calculate the probable molecular mass of ethylene glycol. Time allotment: 1 double period

11) Kinetics 2 weeks

Students study the concept of reaction rates. They learn about the types of rate laws, differential and integral, and how to use one to find the other. They learn to determine the rate law by the initial rates method and also by plotting variations of time vs. concentration to arrive at the correct order of reaction and determination of the rate law constant. Students learn the concept of reaction mechanism and rate-determining step. The potential energy diagram is reviewed and calculations of activation energy are performed.

Lab: Rate Law Determination (teacher developed)

Students prepare a series of different solutions of sodium thiosulfate and react them with an excess of HCl. They then record the amount of time it takes for each solution to turn cloudy from the production of colloidal sulfur. From this data they determine the overall order of the reaction with respect to sodium thiosulfate, the rate law constant, the integral rate law and the differential rate law.

Time allotment: 2 double periods

12) Equilibrium 2 weeks

The concept of chemical equilibrium is studied including the characteristics of chemical equilibrium and determination of an equilibrium expression and constant for a reaction using both molarities and partial pressures. Students spend a great deal of time solving problems using the reaction quotient Q to determine equilibrium concentrations of reactants and products. Le Chatelier's Principle is reviewed with the effects of concentration, pressure and temperature on equilibrium systems.

Lab: Determination of an Equilibrium Constant, Experimental Chemistry.
Students determine the equilibrium constant that results when reacting acetic acid with n-propyl alcohol producing n-propyl acetate and water. Time allotment: 2 double periods

Lab: Determination of K_{sp} (teacher developed)
Students determine the solubility product constant of a slightly soluble salt. Time allotment: 1 double period

13) Acids and Bases 2 weeks

Students study the Arrhenius, Bronsted-Lowry, and Lewis theories of acids and bases. They learn to use equilibrium constants as an indicator of the strength of the acid or base. They spend time calculating the pH of various solutions of strong and weak acids and bases, along with percent dissociation. The polyprotic acids are explored with their successive K values, along with the hydrolysis of salts and their effect on pH.

Lab: Acid/Base Titration, Experimental Chemistry.
Students prepare a sodium hydroxide solution and standardize it against KHP. They then use this standardized base to determine the molarity of an unknown monoprotic acid and the concentration of acetic acid in a vinegar sample. Time allotment: 2 double periods

14) Aqueous Equilibria 3 weeks

This is a very comprehensive unit that includes the common ion effect, buffers, indicators, titrations and pH curves of both weak and

strong acids and bases, the calculations of K_A and K_B, solubility equilibria (K_{sp}), selective precipitation and qualitative analysis. Students spend much time solving problems using the Henderson-Hasselbach equation and the role of relative solubilities in precipitation reactions.

Lab: Determination of the K_A of an Unknown Acid – teacher developed.
Students determine the K_A of a weak acid by splitting an acid solution in half, neutralizing the half-sample with sodium hydroxide solution, remixing it with the unneutralized half, and, using a pH meter, determining the pH of the resultant solution which is equal to the pK_A of the acid. Time allotment: 1 double period

Lab: Properties of Buffer Solutions – teacher developed.
Using the buffer solution prepared in the previous lab, students record changes in pH when small amounts of HCl and NaOH solutions are added. They then contrast this to changes in pH when the same amounts are added to distilled water. Time allotment: 1 double period

Lab: Qualitative Analysis of Group 1 Cations, Experimental Chemistry.
Students are first given a solution containing all three cations, Ag^+, Hg_2^{2+}, and Pb^{2+}. They learn to separate the ions using selective precipitation. They are then given an unknown containing one, two or three of these ions and are asked to identify which ions are present in their solution. Time allotment: 3 double periods

15) Free Energy and Spontaneity 2 weeks

Students learn the concept of Gibb's free energy and how it relates to the spontaneity of chemical reactions. They study the concepts of enthalpy, entropy and temperature and how they interact to determine whether or not a chemical reaction will spontaneously occur. The relationship of delta G and K are explored.

16) Electrochemistry 1 week

Students review the principles of oxidation-reduction and how to apply them to the construction of both galvanic and electrolytic cells. They learn to calculate the voltage of galvanic cells using the

Nernst equation, including the voltage of concentration cells. They study the mathematics of electroplating, including mass deposited, time, and current required. Calculated voltage and its relationship to the equilibrium constant K and delta G are explored.

17) Coordination and Nuclear Chemistry 1 week

Students study the basic structure of a coordination compound including coordination number, common ligands, and nomenclature. They review nuclear chemistry which includes nuclear stability, types of radioactive decay and emanations, half-life, nuclear transformations, fission and fusion, effects of radiation and modern applications.

Lab: Nuclear Radiation (teacher developed)

Students compare the effectiveness of various types of shields on the penetrating power of radiation using a Geiger counter. Time allotment: 1 double period

Lab: Preparation of a Coordination Complex of Copper, Experimental Chemistry.

Students prepare the compound tetramminecopper(II) sulfate monohydrate by reacting copper(II) sulfate pentahydrate with ammonia. Calculations of theoretical and percentage yield are performed. Time allotment: 2 double periods

18) Organic Chemistry Review 1 week

Students review the basics of organic chemistry including the homologous series of hydrocarbons, nomenclature, functional groups, and selected organic reactions. The concept of stereoisomerism is introduced.

19) Review 1 week

The week is spent in review for the AP exam.