CHEMISTRY A/P
2023-2024

Document: APChemistrySyllabusDocument.odt

Welcome to ---------- AP/Honors Chemistry![1] Our advanced Chemistry course will be an exciting course for our students. The study of Chemistry is literally the study of how God structured all the matter of the universe, right down to the sub-atomic level. Students will begin by developing their understanding of the macroscopic properties of existing matter, and progress to understanding the structure of the atom, sub-atomic particles, their interactions among themselves and toward other atoms, molecules, and the transformations and energy exchanges that occur.

For our advanced students, this course builds dramatically on the material they encountered during Physical Science Chemistry at an earlier age, taking their level of understanding of the composition of the universe to far greater detail. Paul, writing to the Christians at Rome, boldly proclaimed in his opening statements,

> "For since the creation of the world, God's invisible qualities -- His eternal power and divine nature -- have been clearly seen, being understood from what has been made...."
>
> Excerpted from Romans 1:20

So it is entirely appropriate that we challenge our students with a more detailed grasp of exactly how the substances of the Universe exist and interact, for within that study our students will begin to glimpse the glory of God in ways that cannot be understood the same way in any other field of knowledge.

College Level Investigation

Students entering our AP Chemistry course, and their parents, should know that this is a solidly **college-level course**! We are going to provide an extremely thorough and wide-ranging introduction to Chemistry that will prepare our students well for more advanced Organic, Inorganic or any other college chemistry course; for the study of Chemistry, Chemical Engineering, any of the Engineering disciplines or sciences, or for any health-related course of study. We want our students to have all the opportunities for which God made each individually.

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1 This document will suffice for both the A/P and Honors classes/students. The major difference between the two classifications has to do with the rigor of the testing. Honors students will take tests that are more suited for "high school."

Students should be prepared to provide the required level of attention to the course material and to the laboratories that such a course demands. This is not to say that students cannot pursue a well-rounded set of life activities, but they are cautioned to remember that we are under the authority of the College Board to move ahead and provide material at the required pace and depth.

College Board AP Test

In order to receive the AP designation on their transcript, students are REQUIRED to take the AP Test at the end of the year. If that test is not taken, their transcript entry will not be marked with the AP designation.

The 2024 AP Chemistry test will be administered on Monday May 6, 2024 at 12 PM local time. It is the responsibility of the AP Students to personally register for this test.

In order to obtain the widely-respected "AP" designation, students and parents should be aware that we meet the following required Curricular Requirements -- and indeed, if we don't, there are actions you can take to report our failure. As such, this Syllabus will provide documentation for each requirement.

Calculator

A graphing calculator is now allowed and RECOMMENDED by the College Board for AP Chemistry tests, all sections, beginning with 2023. A graphing calculator is required for portions of the AP Precalculus test and also for the AP Calculus test. For our school, the Texas Instruments TI-84 Plus CE Color Graphing Calculator is required. (See: https://www.amazon.com/gp/product/B00TFYYWQA for example) If a student's family is unable to acquire this calculator, one will be made available for loan to the student.

Curricular Requirements (College Board)[2]

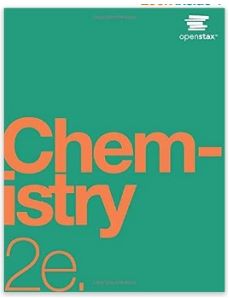
The College Board has very explicit course requirements for our course to be labeled as "AP" on transcripts. We take great care to be certain to meet all of these requirements. For the benefit of students & parents involved in this course, the following information demonstrates the requirements and how we are meeting them:

No.	Requirement	Applicable portions of Syllabus
CR1	The students and teacher have access to college-level resources including a recently published (within the last 10 years) college-level textbook and reference materials in print or electronic format	**Course Materials**, p 5ff
CR2	The course is structured to incorporate the big ideas and required content outlined in each of the units described in the AP Course and Exam Description (CED).	Although our course follows the format of Flowers' text on Chemistry, we cover all required content and all Big Ideas, as demonstrated in **Course Content,** pp 9-19
CR3	The course provides opportunities for students to develop the skills related to Science Practice 1: Models and Representations, as outlined in the AP Course and Exam Description (CED).	See **Coverage of Science Practices**, p 16ff.
CR4	The course provides opportunities for students to develop the skills related to Science Practice 2: Question and Method, as outlined in the AP Course and Exam Description (CED).	See **Coverage of Science Practices**, p 16ff.
CR5	The course provides opportunities for students to develop the skills related to Science Practice 3: Representing Data and Phenomena, as outlined in the AP Course and Exam Description (CED).	See **Coverage of Science Practices**, p16ff.
CR6	The course provides opportunities for students to develop the skills related to Science Practice 4: Model Analysis, as outlined in the AP Course and Exam Description (CED).	See **Coverage of Science Practices,** p16ff.

2 These requirements are explicitly listed in the College Board AP document, "AP Chemistry: Syllabus Development Guide" along with examples of supporting evidence required to meet each of the 11 requirements. Public information about the course can be found at: https://apcentral.collegeboard.org/courses/ap-chemistry The ---------- AP Chemistry Syllabus must conform not only to our ---------- requirements, but also to the College Board AP requirements.

CR7	The course provides opportunities for students to develop the skills related to Science Practice 5: Mathematical Routines, as outlined in the AP Course and Exam Description (CED).	See **Coverage of Science Practices**, p16ff.
CR8	The course provides opportunities for students to develop the skills related to Science Practice 6: Argumentation, as outlined in the AP Course and Exam Description (CED).	See **Coverage of Science Practices**, p16ff.
CR9	The course provides students with opportunities to apply their knowledge of AP Chemistry concepts to real-world questions or scenarios to help them become scientifically literate citizens.	See **Real World Question**, p19.
CR10	Students spend a minimum of 25% of instructional time engaged in a wide range of hands-on, laboratory investigations to support the learning of required content and development of science practice skills throughout the course. At minimum, 16 labs are performed including at least 6 labs conducted in a guided inquiry format	See **Laboratory Experience**, p 20. Our laboratory experiences will occupy at least 25% of our instructional time, and may indeed incorporate more than the required 25%. We will be completing 16 labs (not including the introductory "Laboratory Safety" lab) and 8 of them will be guided inquiry. These are listed beginning on page 20.
CR11	The course provides opportunities for students to record evidence of their scientific investigations. Evidence can be recorded in lab reports or another appropriate formal manner for inclusion in lab notebooks/ portfolios (print or digital format).	All labtoratory reports will be recorded in physical copy, optionally in digital as well. See **Lab Notebook**, p 22. A format for A/P students' reports is also provided.

COURSE MATERIALS[3] (CR1)



We will be using multiple textbooks. These include:

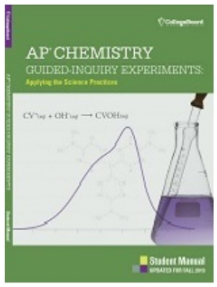
PRIMARY TEXTBOOK

Flowers, Paul, Klaus Theopold, Richard Langley, and William R. Robinson. **Chemistry 2e**. 2nd edition. OpenStax CNX.

Available as a FREE PDF at
https://assets.openstax.org/oscms-prodcms/media/documents/Chemistry2e-WEB.pdf
Please have your student download a copy of this text.

We will also be providing a HARD COVER copy for each student who wishes one.

ADDITIONAL MATERIALS



College Board, AP Chemistry Guided Inquiry Experiments: Applying the Science Practices Student Manual. Available at:
https://store.collegeboard.org/product/detail?sku=160082715

NOTE: A copy of this lab manual has been ordered for your student at no cost if enrolled in ---------- AP or Honors Chemistry.

--------. **Chemistry Lab Manual for Christian Schools**. ----------
(De-identified; herein further referred to as the "Tear Apart Chemistry Lab Manual" for de-identification purposes for the College Board.)

NOTE: A copy of this lab manual has been ordered for your student at no cost if enrolled in ---------- AP or Honors Chemistry.

Georgia Highlands College, Principles of Chemistry (Online help materials) Accessed at:
https://getlibraryhelp.highlands.edu/c.php?g=722488&p=5150888 Excellent online material to help with tougher concepts.

Open Educational Resources Commons: Open Stax Chemistry: Flipped Classroom Reading Guides for General Chemistry (1st Semester). Accessed at:
https://oercommons.org/authoring/21029-openstax-chemistry-flipped-classroom-reading-guide

3 These texts meet the level of college-level Chemistry, and thus meet the requirements of Curricular Requirement 1 (CR1).

Open Educational Resources Commons: Open Stax Chemistry: Flipped Classroom Reading Guides for General Chemistry (2nd Semester). Accessed at: https://oercommons.org/authoring/22441-openstax-chemistry-flipped-classroom-reading-guide

Princeton Review AP Chemistry Premium Prep, (any recent year) Princeton Press. Copyright 2021 or 2022 or 2023. This text provides terse overview of the required principles, and will provide abundant problems at the appropriate level for homework as well as tests. Students should be aware that this is a COLLEGE level course and all test problems will be at the college level. Students should be able to work any applicable problem from these review texts, presented more likely as an open-ended, "show all your work" problem, or possibly as the concise multiple-choice problem. Students should be aware that the Instructor has a much larger pool of questions from which to draw, so a complete grasp of the **principles** is required.

NOTE: Each student must obtain their own copy of this review text.

Additional research sources and instructional materials from suitable internet sources, as appropriate for each section.[4]

COURSE OUTLINE

The ---------- AP Chemistry course is an extremely advanced and accelerated course that provides selected students who have already proven their advanced abilities in earlier coursework. Recognizing that this course is expected normally to be taught as an advanced, five-days-a-week full year course, we provide greatly enlarged opportunities for instruction for our specially chosen students:

Monday 0800-1100	Advanced problem solving and/or Laboratory
Tuesday	50-minute regular class period
Wednesday	50-minute regular class period
Thursday	50-minute regular class period
Friday	50-minute regular class period

Additional instructional time by appointment as needed. Because of our very small class size, we can be more flexible...

The course includes abundant inquiry-based experience for our students as well as teacher-oriented lecture, including derivations of equations, demonstrations of chemical phenomena, vocabulary related to the content, and most importantly, probing of the students' grasp of the material and the problem solution techniques. The content of the course addresses the following 4 "Big Ideas"[5]:

4 Because classical education is *integrative*, our students will be observing the process of scientific development of these theories, models and applications, using additional material as appropriate. This will better prepare them for future academic or scientific service.

5 These BIG IDEAS are an important component of the College Board AP Course, and Course Audit. They provide our students with an overview lens of looking at the universe from the viewpoint of a chemist.

Big Idea 1 -- Scale, Proportion, and Quantity (SPQ)

Big Idea 2 -- Structure and Properties (SAP).

Big Idea 3 -- Transformations (TRA).

Big Idea 4 -- Energy (ENE)

STUDENT PRACTICE

3-Ring Binder: Students are required to maintain a 3-ring binder for this course, with dividers for relevant sections. Suggestions include: Handouts, Homework, Class Notes. As this will likely overflow, student are encouraged to keep a larger binder at home to which excess material may be moved at the end of each quarter. Binders may be inspected at intervals throughout the year, and inspections will count as a homework grade.

Throughout each unit, students will get a list of important TOPICS and key understanding that must be achieved. There will be presented via the weekly/biweekly "packets" of course scheduling and course problems. They will also be posted in lesson plans using the school's online FACTS system. Students are responsible for being up to date with all aassignments. *In our course, students will normally have homework questions to answer after every lecture and experience*.[6] Our students are very familiar with this process from their time in previous chemistry. These questions will begin at, or reach the A/P level, so that early in the course, every test question is based, in one way or another, on published A/P Exams--setting the *rigor* of the course is easy-- all work must be at college level! It is our policy that all student work is graded absolutely as soon as possible, and *almost always* returned the very next class period so that the students get **immediate and pointed feedback of their progress**. Our work will generally involve multi-step calculations and logical steps. It is our policy that student work is carefully reviewed LINE BY LINE so that very detailed corrections can be made to A/P students' work. While many of the problems of an AP Test involve immediate application of principle and experience from addressing problems in a multiple-choice answer, in general this is not a multiple choice class. Students are very familiar with the requirement that they must be able to provide a logical flow of all solutions, starting from fundamental principles and proceeding step-by-step with all units and conversions demonstrated.

At the end of each Unit or at key points, students will have some form of a Personal Progress Check which may be a homework assignment, or an examination, to allow them to measure and evaluate their performance. These are graded as soon as possible and generally returned the very next period, during which there is extensive review of all the problems. It has only occasionally been a significant issue that this caliber of students enrolled in this A/P class would fall behind, but in that event, individualized tutoring can be provided to bring that student back up to speed. These cases have generally been related not to the caliber of the student, but instead to extracurricular activities that are secondary to the mission of a School. Each student and family must carefully consider their priorities.[7]

6 In a large percentage of the homework problems, selection of a valid mathematical routine to solve the problem will be a key portion of the problem. (SP2.1) The mathematical routine must be applied properly (SP2.2) and in many problems there may be a degree of estimation of reasonable quantities (SP2.3). These will provide many opportunities to satisfy Course Requirement 5 (CR4)

7 In Luke 14:28-32 Jesus is recorded as expecting his subjects to plan wisely and make priority decisions: "For which one of you, when he wants to build a tower, does not first sit down and calculate the cost,*to see* if he has *enough* to complete *it*? Otherwise, when he has laid a foundation and is not able to finish, all who are watching *it* will begin to ridicule him, saying, 'This person began to build, and was not able to finish!' Or what king, when he sets out to meet another king in battle, will not first sit down and consider whether he is strong *enough* with ten thousand *men* to face the one coming against him with twenty thousand? Otherwise, while the other is still far away, he sends a delegation

COURSE CONTENT

The College Board emphasizes the following Scientific Practices that are widely referenced (sometimes with minor variations) in the literature of scientific advancement and education:[8] [9]

SCIENCE PRACTICES

No.	Topic	Description
1	Models and Representations	Describe models and representations, including across scales
	1.A	Describe the components of and quantitative information from models and representations that illustrate particulate-level properties only.
	1.A	Describe the components of and quantitative information from models and representations that illustrate both particulate-level and macroscopic-level properties.
2	Question and Method	Determine scientific questions and methods
	2.A	Identify a testable scientific question based on an observation, data, or a model.
	2.B	Formulate a hypothesis or predict the results of an experiment
	2.C	Identify experimental procedures that are aligned to a scientific question (which may include a sketch of a lab setup).
	2.D	Make observations or collect data from representations of laboratory setups or results, while attending to precision where appropriate.
	2.E	Identify or describe potential sources of experimental error.
	2.F	Explain how modifications to an experimental procedure will alter results.
3	Representing Data and Phenomena	Create representations or models of chemical phenomena
	3.A	Represent chemistry phenomena using appropriate graphic techniques, including correct scale and units.

and requests terms of peace.

8 The Eight Science and Engineering Practices You Need to Know, Elizabeth Chapman, accessed 8/5/2022 at: https://medium.com/@egchapma/the-eight-science-and-engineering-practices-you-need-to-know-cf813c206879

9 NGSS 8 Science Practices - Definitions and Examples. Instructional leadership for science practices (ILSP). Accessed 8/5/2022, at http://www.sciencepracticesleadership.com/uploads/1/6/8/7/1687518/8_practices_v4.pdf

	3.2	Represent chemical substances or phenomena with appropriate diagrams or models (e.g. electron configurations)
	3.3	Represent visually the relationship between the structures and interactions across multiple level or scale (e.g. particulate to macroscopic).
4	Model Analysis	Analyze and interpret models and representations on a single scale or across multiple scales.
	4.A	Explain chemical properties or phenomena (e.g. of atoms or molecules) using given chemical theories, models and representations.
	4.B	Explain whether a model is consistent with chemical theories
	4.C	Explain the connection between particulate-level and macroscopic properties of a substance using models and representations.
	4.D	Explain the degree to which a model or representation describes the connection between particulate-level properties and macroscopic properties.
5	Mathematic Routines	Solve problems using mathematical relationships
	5.A	Identify quantities needed to solve a problem from given information (e.g. text, mathematical expressions, graphs, or tables)
	5.B	Identify an appropriate theory, definition, or mathematical relationship to solve a problem.
	5.C	Explain the relationship between variables within an equation when one variable changes.
	5.D	Identify information presented graphically to solve a problem.
	5.E	Determine a balanced chemical equation for a given chemical phenomenon.
	5.F	Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (e.g. performing dimensional analysis and attending to significant figures.)
6	Argumentation	Develop an explanation or scientific argument.
	6A	Make a scientific claim
	6.B	Support a claim with evidence from experimental data.
	6.C	Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules.

	6.D	Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification.
	6.E	Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels.
	6.F	Explain the connection between experimental results and chemical concepts, processes, or theories.
	6.G	Explain how potential sources of experimental error may affect the experimental results.

The format of the Course follows the Flowers AP Chemistry 2e text, but includes all the required content described in the AP Course and Exam Description. The following Course materials/topics flow demonstrates how the material of each AP Unit is covered and how the Big Ideas are presented.

Major Topic	AP Unit #	Big Ideas
Chapter 1: Essential Ideas 1.1 Chemistry In Context 2.2 Phases and Classification of Matter 1.3 Physical and Chemical Properties 1.4 Measurements 1.5 Measurement Uncertainty, Accuracy, and Precision 1.6. Mathematical Treatment off Measurement Results.	1	SPQ
Chapter 2: Atoms, Molecules and Ions 2.1 Early Ideas in Atomic Theory 2.2 Evolution of Atomic Theory 2.3 Atomic Structure and Symbolism 2.4 Chemical Formulas 2.5 The Periodic Table 2.6. Ionic and Molecular Compounds 2.7 Chemical Nomenclature	1	SAP
Chapter 3: Composition of Substances and Solutions 3.1 Formula Mass and the Mole Concept 3.2 Determine Empirical and Molecular Formulas 3.3 Molarity 3.4 Other Units for Solution Concentrations	3	SPQ
Chapter 4: Stoichiometry of Chemical Reactions 4.1 Writing and Balancing Chemical Equations 4.2 Classifying Chemical Reactions 4.3 Reaction Stoichiometry 4.4 Reaction Yields 4.5 Quantitative Chemical Analysis	4	TRA,SPQ
Chapter 5: Thermochemistry 5.1 Energy Basics 5.2 Calorimetry 5.3 Enthalpy	6	ENE

Major Topic	AP Unit #	Big Ideas
Chapter 6: Electronic Structure and Periodic Properties of Elements 6.1 Electromagnetic Energy 6.2 The Bohr Model 6.3 Development of Quantum Theory 6.4 Electronic Structure of Atoms (Electron Configurations) 6.5 Periodic Variations in Element Properties	1	SAP
Chapter 7: Chemical Bonding and Molecular Geometry 7.1 Ionic Bonding 7.2 Covalent Bonding 7.3 Lewis Symbols and Structures 7.4 Formal Charges and Resonance 7.5 Strengths of Ionic and Covalent Bonds 7.6 Molecular Structure and Polarity	2	SAP, TRA
Chapter 8: Advanced Theories of Covalent Bonding 8.1 Valence Bond Theory 8.2 Hybrid Atomic Orbitals 8.3 Multiple Bonds 8.4 Molecular Orbital Theory	2	SAP, TRA
Chapter 9: Gases 9.1 Gas Pressure 9.2 Relating Pressure, volume, amount, and temperature: The Ideal Gas Law 9.3 Stoichiometry of gaseous Substances, Mixtures and Reactions 9.4 Effusion and Diffusion of Gases 9.5 The Kinetic-Molecular Theory 9.6 Non-Ideal Gas Behavior	3	SAP, SPQ
Chapter 10: Liquids and Solids 10.1 Intermolecular Forces 10.2 Properties of Liquids 10.3 Phase Transitions 10.4 Phase Diagrams 10.5 The Solid State of Matter 10.6. Lattice Structures in Crystalline Solids	3	SAP

Major Topic	AP Unit #	Big Ideas
Chapter 11: Solutions and Colloids 11.1 The Dissolution Process 11.2 Electrolytes 11.3 Solubility 11.4 Colligative Properties 11.5 Colloids	3	SAP
Chapter 12: Kinetics 12.1 Chemical Reaction Rates 12.2 Factors Affecting Reaction Rates 12.3 Rate Laws 12.4 Integrated Rate Laws 12.5 Collision Theory 12.6 Reaction Mechanisms 12.7 Catalysts	5	TRA, ENE
Chapter 13: Fundamental Equilibrium Concepts 13.1 Chemical Equilibria 13.2 Equilibrium Constants 13.3 Shifting Equilibria: Le Chatelier's Principle 13.4 Equilibrium Calculations	7	TRA, SPQ
Chapter 14: Acid-Base Equilibria 14.1 Bronsted-Lowry Acids and Bases 14.2 pH and pOH 14.3 Relative Strengths of Acids and Bases 14.4 Hydrolysis of Salts 14.5 Polyprotic Acids 14.6 Buffers 14.7 Acid Base Titrations	8	SAP, TRA
Chapter 15: Equilibria of Other Reaction Classes 15.1 Preciptitation and Dissolution 15.2 Lewis Acids and Bases 15.3 Coupled Equilibria	7	SAP, TRA
Chapter 16: Thermodynamics 16.1 Spontaneity 16.2 Entropy 16.3 The Second and Third Laws of Thermodynamics 16.4 Free Energy	9	ENE
REAL-WORLD SCENARIO [In fulfillment of Curricular Requirement 9 (CR9)] (See separate section "Real World Problem.")		

Major Topic	AP Unit #	Big Ideas
Chapter 17: Electrochemistry 17.1 Review of Redox Chemistry 17.2 Galvanic Cells 17.3 Electrode and Cell Potentials 17.4 Potential, Free Energy, and Equilibrium 17.5 Batteries and Fuel Cells 17.6 Corrosion 17.7 Electrolysis	9	ENE
Chapter 20: Organic Chemistry 20.1 Hydrocarbons 20.2 Alcohols and Ethers 20.3 Aldehydes, Ketones, Carboxylic Acids and Esters 20.4 Amines and Amides	2	SAP
Chapter 21: Nuclear Chemistry 21.1 Nuclear Structure and Stability 21.2 Nuclear Equations 21.3 Radioactive Decay 21.4 Transmutation and Nuclear Energy 21.5 Uses of Radioisotopes 21.6. Biological Effects of Radiation	1	SAP, TRA

COVERAGE OF SCIENCE PRACTICES

CR	Science Practice	Examples
3	1 - Models and Representations	1. While the class is in Chapter 6, in class and homework exercises, students will complete the shells and subshells of elements and ions, and relate these to photo electron spectroscopy.. (Science Practice 1) 2. While the class is in Chapter 7, the students will draw multiple Lewis dot structures; in Chapter 9 and 10 work, the students will predict comparisons and contrasts of evaporation rate of different molecules' shown in Lewis dot. The teacher swipes the substances on the lab table to help students observe which evaporate faster and asks them to describe why in terms of the molecular structure (Science Practice 1)
4	2 - Question and Method	1. While in Chapter 6, students will observe a demonstration in which different substances generate different colored flames. They then develop a question that could generate data to explain the phenomenon (Science Practice 2) 2. During study of Chapters 12 and 13, students are given data where a catalyst has been added to a chemical system, and the students are asked to analyze the effect of the catalyst on the reaction. Working in pairs, students will develop an experimental procedure that could be used to study the effect of this, or analogous catalyst on the rate of the chemical reaction, including • what measurements could be made • what equipment is needed and • how the data will be processed (Science Practice 2)
5	3 - Representing Data and Phenomena	1. When writing reactions in Chapters 4, 7, 21 and others, students will also draw particulate representations of the chemical equations (Science Practice 3) 2. In Chapter 8, while students are constructing 3D models of the electronic and molecular geometry for substances, they will be asked to also draw 2D Lewis structures for comparison. (Science Practice 3) 3. In Chapter 14, with the discussion of acid-base titrations, students

		will be given data from a weak acid/strong base titration, and create a titration curve shoring pH as a function of the volume of base added. They will then identify critical points on the graph in group discussion. (Science Practice 3)
6	4 - Model Analysis	1. While teaching Chapter 6 (and referring back to material from earlier chapters), students will graph values for atomic radius, electronegativity, and ionization energy, to predict trends and explain the organization of the periodic table in regard to Coulomb's law, nuclear charge, number of electrons, and shell number. (Science Practice 4) 2. While teaching Chapter 12 (Kinetics), students are given data about an experimental rate law and asked to determine (though guided questions) which mechanism is consistent with that rate law. (Science Practice 4) 3. While teaching Chapter 20 (introduction to Organic), students will draw Lewis dot structures for H_2O, CH_3OH and CH_3CH_2OH. Then, students will predict which will have the highest boiling pint and explain why in terms of the intermolecular forces present. (Science Practice 4)
7	5 - Mathematic Routines	Mathematics are used over and over throughout this course. Examples include: 1. In the course of Chapter 3, students will be provided with mass data for composition of substances and will calculate the empiric and molecular formulae. 2. In the course of Chapter 4, students will be provided with the masses of two reactants (and the associated chemical equation for their reaction). Students will use dimensional analysis and stoichiometry to calculate the maximum yield of the product. (Science Practice 5). 3. In the course of Chapter 9, students will be provided with "before and after" problems involving changing conditions of ideal gasses and resulting changes in volume, pressure, or temperature. (Science Practice 5) 4. In the course of the the Rate Kinetics chapter 12, students will be given data on the thermal decomposition of a substance including concentration versus time, and asked to determine the order of the

		reaction and present their solution. (Science Practice 5)
8	6 - Argumentation	Argumentation will occur naturally and frequently in the course of our year. Here is just one example: In the course of Chapter 16, Thermodynamics, students are given data on ΔS^0 and ΔH^0 of a chemical reaction. Students must make a claim about the temperature conditions under which the reaction is thermodynamically favorable, supporting their claim with a calculation presented on a whiteboard. (Science Practice 6)

Real World Question

Near the conclusion of the 3rd Quarter, students will be given this assignment:

A local utility company created a biomass electrical generation facility several years ago.[10] Students will research the methods by which biomass are accumulated and burned in order to provide electricity. Based on estimations of energy inputs in the transportation and burning, and the energy output, using published information on these processes, they will estimate the CO_2 production per kWhr of electricity and compare it to published data for coal or natural gas, two other fuel sources for this particular plant.[11] They will then present a report on their conclusion about the optimal techniques for this power plant's operation from a reduction of CO_2 greenhouse gas production.

10 This is an actual event in our (deidentified) community.

11 One potential reference for comparison is: https://www.world-nuclear.org/information-library/energy-and-the-environment/carbon-dioxide-emissions-from-electricity.aspx#:~:text=Worldwide emissions of carbon dioxide,and about 20%25 from gas.

LABORATORY EXPERIENCE

Laboratories are extremely important to the development of the chemistry education, giving students practical experience and providing a different way to gain chemistry insights.

Our laboratory experiences will occupy at least 25% of our instructional time, and may indeed incorporate more than the required 25%. Many of these will require "double session" experiments on Monday (normal home-study day at our school).

Guided Inquiry. While chemistry laboratories at our school have typically been created as "cookbook" or "Structured Inquiry," it is important in the setting of AP Chemistry to challenge our students with laboratories written as "Guided Inquiry" where the student must make more decisions about procedures and structure of the investigation. This is very important for their educational development, and also prepares them for the type and level of questions they will face on the AP Test at the end of the year. The College Board provides a very helpful laboratory manual including 16 such laboratories and seven of those have been selected for inclusion within our curriculum.

We will be completing 16 labs (not including the introductory "Laboratory Safety" lab) and 8 of them will be guided inquiry.

Descriptive titles are included below for each lab. **Guided inquiry labs are labeled as GI and separately numbered as well.**

No.	Descriptive Title	Comment
0	Laboratory Safety/Laboratory Procedures	Tear-Apart Lab Manual
1	Relationship between concentration of solution and amount of light transmitted (GI #1)	(In Chapter 1) AP Lab Manual Introduction to spectrophotometer and Guided Inquiry process.
2	Measuring approximate Atomic Size	(In Chapter 2) Tear-Apart Lab Manual
3	Molar Mass of Oxygen & Nitrogen	(In Chapter 3) Tear-Apart Lab Manual
4A	Oxidizing Magnesium	(In Chapter 4) Tear Apart Lab Manual
4B	Stoichiometry of Oxidizing Magnesium	(In Chapter 4) Tear Apart Lab Manual
5	Precipitation Lab	(Near Chapter 4) Tear Apart Lab Manual
6	Applying Green Chemistry to purification (GI #2)	(Near Chapter 4) AP Lab Manual
7	Hand Warmer Design Challenge - Where does the Heat come from? (GI #3)	(In Chapter 5) AP Lab Manual - Calorimetry
8	Spectroscopy Experiment (Bohr Atom)	(In Chapter 6) Tear Apart Lab Manual
9	Measuring Absolute Zero via Gas	(In Chapter 9) Tear Apart Lab Manual

	Observation	
10	Rate Law of Fading of Crystal Violet using Beer's Law (GI #4)	(In Chapter 12) AP Lab Manual
11	Making Colors of the Rainbow - Application of Le Chatelier's Principle (GI #5)	(In Chapter 13) AP Lab Manual
12	How long will the marble statue last? (acid base rates) (GI #6)	(In Chapter 15) AP Lab Manual
13	Buffering capacity of common household products (GI #7)	(In Chapter 15) AP Lab Manual
14	Redox Lab: Corrosion Protection in the United States	(In Chapter 17) Tear Apart Lab Manual
15	What's In The Bottle? (GI #8) (substance identification)	Review - AP Lab Manual
16	Determining the percentage of H_2O_2 in drugstore hydrogen peroxide (GI #8)	AP Lab Manual

LAB NOTEBOOK (CR11)

All students are required to maintain a physical LAB NOTEBOOK including a record of all their laboratory work.[12] *This must be a completely separate notebook from all other materials, suitable for presentation for inspection, by a college or our faculty*. They may additionally maintain some or all of the work in an electronic format if desired. They may utilize provided paperwork, for the more structured-inquiry labs from the "tear-apart lab book," however A/P students should additiionally have in each Laboratory Report:

- Title
- Introduction to the Object/Problem[13]
- Design of the Experiment ("Methods")
- Data ("Results")
  - Calculations, Graphs other analysis including any references to mathematical methods with full reference as in in a scientific paper.
- Conclusions, including weaknesses and strengths of the work, and recommendations for improvements.

For A/P students, we will be utilizing a form of the APA style. In the beginning, students often find it very difficult to separate out Methods from Data and Conclusions. Our practice will help them become ready for formal scientific publishing. Students may provide advanced electronic presentation in addition, but if so, they must be maintained on an available electronic medium, accessible for at least the subsequent 3 years, and providing sufficient privacy for the student. URLs or other identifiers for electronic presentation must be properly provided in their paper laboratory report.

12 This is in compliance with AP Course Requirement 11 (CR11)

13 The Introduction might well include references and explanatory material, footnoted.

Classical Christian Science Teaching

We are at a classical Christian school. Traditionally the theory of classical Christian education revolves around a trivium of Grammar, Logic, and Rhetoric. These categorizations apply well to many of the subjects of the humanities. It has been questioned at times, and also formally discussed, how much difficulty there is in applying these to the Sciences and Mathematics. In my experience, in teaching Chemistry and Physics, we are teaching *all three levels* to each class. The Grammar of Chemistry involves understanding the components of the atom, the fundamental forces that exist in our Universe, the names of elements, and their characteristics. Logic and Rhetoric come on top of this background and at the top, the student can answer complicated questions of theoretical interactions between particles and make articulate argumentation as required by the College Board and the Science Practices. Of note, the brilliant minds of the authors who discovered a large number of the astonishing breakthroughs all the way through those of the atom, were themselves from a classical educational background.[14]

Susan Bauer[15] has provided a framework for evaluating how Science is taught with the principles of classical Christian concepts. Primary in her analysis is that

> **"Classical education is language-focused; learning is accomplished through words, written and spoken, rather than through images (pictures, videos, and television)."**

My classes are very classical in this sense: we will be primarily teaching through lecture, combined with laboratory, rather than entertaining videos/television -- though they may be used where appropriate. The *images* that we use are often drawings or equations, communicating relationships, energy levels, positions and other data that is more easily expressed in graphical form to convey the equivalent of "thousands of words."

Bauer continues,

> **"...follows a specific three-part pattern: the mind must be first supplied with facts and images, then given the logical tools for organization of facts, and finally equipped to express conclusions."**

Our class will involve a LOT of facts and images, and an understanding of laws and principles that explain how our universe works, and will move toward solving problems logically and expressing the conclusions.

Bauer concludes that "to the classical mind, all knowledge is interrelated" She provides explanation:

> **"Astronomy (for example) isn't studied in isolation; it's learned along with the history of scientific discovery, which leads into the church's relationship to science and from there to**

14 Drake, Paul. Classical Christian Education and the Future of Science. Accessed 8/4/2022, https://societyforclassicallearning.org/classical-christian-education-and-the-future-of-science/

15 Bauer, Susan. What is Classical Christian Education? accessed 8/4/2022 at https://www.classicalchristianmb.org/what-is-classical-christian-education

the intricacies of medieval church history. The reading of the Odyssey leads the student into the consideration of Greek history, the nature of heroism, the development of the epic, and man's understanding of the divine."

My classes are VERY classical in this sense. I am constantly trying to help the students understand how these great discoveries of God's universe throughout the course of Chemistry were accomplished by real people, because ***the process of being part of scientific development is important to understand*** Some of our students will end up in advanced science and will be doing scientific research and publishing in their future. Understanding how we move toward great discoveries of God's universe is very important to our students

We will also frequently be relating the material that we are studying to the decisions and outcomes of world peoples, leaders and nations. In view of the current world situation, Chemistry is extremely relevant.

GRADING

This is an A/P Course. By definition, it is taught, tested, and graded at the College level. Students will be almost continually working A/P / College questions. While there will possibly be some tests that are structured more at the level of "high school" toward the beginning of the year, and for Honors students, for the AP Students, we will transition them quickly to handling the more complicated and timed questions suitable for an AP Test. The "raw scores" on an AP level test can be discouraging to students who are used to 90% correct equaling an "A" -- AP level testing is far more difficult. Nevertheless, our experience is that students adapt quickly to seeing much more difficult questions, knowing that the conversion from "raw score" to ---------- score is more generous. The exact relationship between raw scores on true AP-level questions, and applicable ---------- Grades is subject to adjustment, but begins roughly at this level:[16]

Raw Score	Scaled Score
72%	90% = A
58%	80% = B
42%	70% = C

These levels approximate the "5" "4" "3" levels of AP tests.
Students that consistently score lower than what is appropriate for an A/P Score of 4, should expect to have special discussions with their parents and the Instructor to decide how to proceed.

Homework	25%
Tests and Laboratories *There is a possibility of unannounced quizzes at any time, which will be given the weighting of 1/2 a test, presuming I can make a*	50%

16 See for example: https://blog.prepscholar.com/ap-chemistry-exam

way to make that happen.	
MidTerm and Final Exam	25%

Classroom Behavior

I do not anticipate having any difficulties with classroom behavior. The class will be taught as a college level class, with rigorous lecture, debate, probing questions and laboratories. As our course occurs rightt after Lunch, **I expect students to have attended to normal restroom needs prior to the class**. Emergency needs, however, will be accommodated and should be rare.

Homework

Homework should be completed either on provided sheets of 3-hole punched blank paper with filled-in heading, or on regular 3-hold punched notebook paper with an approximation of the following heading filled in. (This is to make organization & grading easier.)

Student Name	*Applicable Text Section (e.g. Chapter 1 Problems)*
	Due Date: e.g. 01/01/2023
	Completed: e.g. 01/01/2023

Late Work

- An assignment or homework is to be turned in at the class period and time designated by the teacher, typically at the beginning of the period. Teachers are to designate the venue for receiving the assignment or homework, electronic, hard copy, or other.
- Work not turned in as the manner delineated above will be late. The table below lists the points to be deducted per day late.

Days Late	One Day	Two Days	Three Days	Four or More
Logic & Rhetoric	- 11 percent	- 21 percent	- 31 percent	Not Accepted
	LATE homework cannot be guaranteed to be graded to the same standard as homework turned in on the appropriate day, and cannot be guaranteed to be graded or returned in the same timely fashion as appropriately completed work.			

- As an example, Rhetoric homework assignment turned in one day late, and receiving a grade of 80% will then be reduced to 69% (reduced by 11 percent) for being turned in late.
- There are two exceptions to this standard:
  - If a student has an unplanned, but excused, absence, the due date will be extended by the number of days the student was absent.
  - If a student has a planned, but excused, absence the due date may be extended by half the number of days the student was absent.

- I reserve the right to extend additional grace in very unusual situations.

Redo Policy

Life does not always provide make-overs for crucial testing events. *There is a trap in allowing students to feel that they will always have the chance to repeat an effort for which they did not devote sufficient planning, effort and time. As a parent, I've observed this work to the detriment of some of my own children.* Therefore, only on **rare occasions** will retakes or repeat work be allowed. In this class, students should expect that any re-do work will be at an accelerated level even for A/P.

Why do we have tests? There is an important Christian answer to this question. It is because of the Fall. Humans are innately flawed as a result of the Fall, and now we must have objective measures of accountability to guarantee performance on required studying.

Honesty and Plagiarism

I expect honesty at all times. Students may alway obtain help and advice for all homework, including from the Internet, parents, other students, and even me. ***However, the work that they submit should reflect their own understanding in their own words.*** Lab work will often be done as a group and I encourage students to collaborate -- but the work handed in should reflect the student's individual presentation unless otherwise indicated.

Make-up Policy

Excused absence/s due to sickness will merit the Make-up Policy. One day of extension is given for each day of absence.

Students who have a scheduled trip or a planned absence are expected to submit completed work upon return to class. This is also true to quizzes or tests. Participation in a sport activity is proof of ATTENDANCE of that day of school per school rules, and therefore does not excuse a student for their responsibilities toward the PRIMARY goal of Christian Education: which is Education.

Early notice and arrangement should be made for convenience and order.

RECOMMENDATIONS

Students are encouraged to remember me when they need to file letters of recommendation or have character references. With my background I have dealt with tens of thousands of patients and families and many many other professionals. My friends are often leaders in law or public service, or education. It will do our students good to get to know quality examples of Christian Leaders in our community who have stood the test of time and can accurately evaluate the character and performance of aspiring young people who have an entire life ahead them and important choices to make. Everyone deserves a good recommendation for the effort they have put forward, and everyone has their own set of God-given gifts -- we are not the same! Finding the niche for which God developed each and every one of us is part of the Christian walk, and if I can help a student with that, it's great.

By signing below, you are signifying that you understand and agree to the above terms of education at AP Chemistry

_____ _____

Student Signature Date

_____ _____

Parent(s) Signature Date